The Scientific Committee
Danish Society of Occupational and Environmental Medicine

Osteoarthritis in the hip and knee.

Influence of work with heavy lifting, climbing stairs or ladders,
or combining kneeling/squatting with heavy lifting.

Review

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January 2006

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Forord

Dansk Selskab for Arbejds- og Miljømedicin (DASAM) har i december 2004 etableret en videnskabelig komité, som har til opgave løbende at formidle udbud med henblik på udarbejdelse af opdateret videnskabelig dokumentation vedrørende arbejdsbetingede sygdomstilstande samt forestå redigeringsprocessen af det videnskabelige dokument.

Komiteens oprettelse var foranlediget af, at Arbejdsskadestyrelsen har ønsket en række referencedokumenter om det videnskabelige grundlag for at antage, at særlige arbejdsmæssige påvirkninger kan være årsag til bestemte sygdomme. Komiteen står til rådighed for andre rekvirenter af lignende referencedokumenter. Komité-medlemmer blev udpeget af DASAM efter indkaldelse af forslag ved offentligt opslag.

Komiteen består af

Overlæge, dr. med. Sigurd Mikkelsen, Arbejdsmedicinsk Klinik, Glostrup (formand).
Overlæge, ph.d. Johan Hviid Andersen, Arbejdsmedicinsk Klinik, Herning
Overlæge, ph.d. Henrik Kolstad, Arbejdsmedicinsk Klinik, Århus Sygehus.
Forskningschef, dr.med. Jørgen H. Olsen, Kræftens Bekæmpelse,
Professor, overlæge ph.d. Staffan Skerfving, Institutionen för yrkes- och miljömedicin, Lund,
Reservelæge ph.d. Susanne Wulff Svendsen, Psykiatrisk Hospital i Århus.

De første opgaver har været udbudt per e-mail og over internettet til relevante forskningsinstitutioner i Norden, og komiteen har blandt kvalificerede ansøgere udvalgt den bedst kvalificerede til at løse opgaven.

Det foreliggende referencedokument er nummer 3 af de udbudte opgaver. Det vedrører spørgsmålet om det videnskabelige grundlag for at antage, at tungt løftearbejde, trappegang/stigegang og knæliggende/hugsiddende arbejde i kombination med tunge løft kan forårsage slidgigt i hofter og knæ. Opgavens indhold har været beskrevet af Arbejdsskadestyrelsen, der har finansieret udarbejdelsen af dokumentet.

Graden af evidens for en årsagsmæssig sammenhæng er rubriceret efter en standard, som DASAM's videnskabelig komite har udarbejdet på baggrund af internationale standarder. Den anvendte standard er vist i Appendix 1.

Opgaven er løst af Overlæge ph.d. Lilli Kirkeskov Jensen, Arbejdsmedicinsk Klinik, Sygehus Viborg. Opgaven har været uafhængigt bedømt af to særligt sagkyndige reviewere, professor David Coggon, Southampton MRC Environmental Epidemiology Unit, Southampton General Hospital, England og Overlæge dr.med. Stig Sonne-Holm, Ortopædkirurgisk Afdeling, Hvidovre Hospital, og der er herudover indhentet skriftlige bemærkninger fra komiteens medlemmer. Dokumentet er efterfølgende gennemgået og drøftet på et heldags-møde med reviewerne, komiteen og forfatteren. Sluttelig har forfatteren revideret referencedokumentet i forhold til de fremkomne bemærkninger.

Komiteen kan tiltræde dokumentets konklusioner og de præmisser, der ligger til grund herfor. Komiteen har fundet anledning til at fremsætte en særskilt kommentar om vurderingen af graden af evidens for en årsagsmæssig sammenhæng mellem tungt løftearbejde og slidgigt i hofter.

København januar 2006

Sigurd Mikkelsen
Formand for DASAM's Videnskabelige Komite.

Komiteens bemærkninger vedrørende graden af evidens for en årsagsmæssig sammenhæng mellem hofteartrose og tungt løftearbejde

Komiteen ønsker i princippet et eksplicit valg mellem de forskellige grader af evidens, men er for den konkrete sammenhæng mellem løftearbejde og hofteartrose af den opfattelse, at evidensen bedst beskrives som 'moderat' til 'stærk'.

Komiteen finder, at der meget konsistent og i mange studier er påvist en positiv sammenhæng mellem hofteartrose og belastninger med tungt løftearbejde, ligesom der i nogle studier er påvist en sammenhæng mellem graden af tungt løftearbejde og risikoen for hofteartrose (eksponerings-respons sammenhæng). Disse forhold peger på en grad af evidens for en årsagsmæssig sammenhæng, der er stærkere end blot 'moderat'.

Der er imidlertid for de enkelte studier nogle svagheder, der selv om de er noget forskellige, trækker fra i den samlede vurdering af graden af evidens for en årsagsmæssig sammenhæng. Der er endvidere efter komiteens opfattelse en lidt for sparsom og usikker dokumentation af, hvordan risikoen for hofteartrose stiger med stigende grad af tungt løftearbejde. Disse forhold indebærer, at det er vanskeligt at beskrive graden af evidens for en årsagsmæssig sammenhæng som 'stærk'.

Komiteen finder derfor, at evidensen for en årsagsmæssig sammenhæng mellem tungt løftearbejde og hofteartrose bedst beskrives som 'moderat' til 'stærk'.

Sigurd Mikkelsen
Formand for DASAM's Videnskabelige Komite

Contents

Resumé

Slidgigt (artrose i hofter og knæ, hofteartrose, knæartrose) er karakteriseret ved røntgenforandringer samt smerter og stivhed primært ved bevægelse, og siden også når man sidder stille og om natten. Hofte- og knæartrose er meget almindelige i befolkningen, knæartrose hyppigere end hofteartrose med en samlet forekomst (prævalens) på mellem 0.5 og 6% for symptomgivende artrose (røntgenforandringer og smerter de fleste dage). I 2004 blev der i Danmark foretaget omkring 4.500 operationer med indsættelse af kunstige knæ og 6000 operationer med indsættelse af kunstige hofter. Andelen af personer med artrose vil stige over de næste årtier, i takt med at befolkningen bliver ældre.

Formålet med denne litteraturgennemgang har været at vurdere betydningen af påvirkningerne: Tungt løftearbejde, knæliggende/hugsiddende arbejde i kombination med tunge løft og trappegang/stigegang i relation til slidgigt i hofter og knæ. Der er tillige foretaget en gennemgang af konkurrerende sygdomsårsager. Opgavens indhold og afgrænsninger er beskrevet af Arbejdsskadestyrelsen, der har finansieret udarbejdelsen af dokumentet.

Der er foretaget en litteratursøgning i relevante databaser: Medline, Embase, HSE-line og NIOSHtic, og undersøgelser vedrørende sammenhæng mellem arbejdsbetingede belastninger samt knæ- og hofteartrose blev identificeret ved anvendelse af følgende søgekriterier: [Hip and (osteoarthritis or osteoarthrosis) and (work or occupation)] and [knee and (osteoarthritis or osteoarthrosis) and (work or occupation)]. Følgende inklusionskriterier blev anvendt: 1) et af formålene med studiet var at undersøge sammenhængen mellem hofte- eller knæartrose og de arbejdsbetingede belastninger: tungt løftearbejde, knæliggende/hugsiddende arbejde i kombination med tunge løft og trappegang/stigegang; 2) litteraturen var publiceret på engelsk, tysk, dansk, svensk eller norsk); 3) det var en fuld-tekst artikel; 4) de undersøgte havde a) fået påvist hofte- eller knæartrose ved røntgenundersøgelse; b) en diagnose-kode efter international sygdomsklassifikation (ICD 8 eller ICD 10), der angav at der var tale om knæ- eller hofteartrose; c) de havde fået foretaget en operation med indsættelse af et kunstigt hofte- eller knæled; eller d) var på venteliste til en af disse operationer; 5) undersøgelsen havde et kontrolleret design.

Graden af evidens for en årsagsmæssig sammenhæng mellem hofte- og knæartrose og de anførte belastninger blev vurderet efter en standard, som DASAM's (Dansk Selskab for Arbejds- og Miljømedicin's) videnskabelige komite har udarbejdet (se Appendiks I). Graden af evidens er opdelt i 5 kategorier:

1. Stærk evidens for en årsagsmæssig sammenhæng (+++)
2. Moderat evidens for en årsagsmæssig sammenhæng (++)
3. Begrænset evidens for en årsagsmæssig sammenhæng (+)
4. Utilstrækkelig evidens for en årsagsmæssig sammenhæng (0)
5. Evidensen tyder på, at der ikke er nogen årsagsmæssig sammenhæng (-)

Kriterierne for evidensgraden beror primært på hvor sandsynligt det er, at resultaterne samlet set kan forklares ved tilfældigheder eller systematiske fejl i studierne, og at eventuelle positive sammenhænge derfor ikke skal tolkes som årsagssammenhænge.
'Stærk evidens' udtrykker således, at det anses som meget sandsynligt, at undersøgelsesresultaterne samlet set er udtryk for en årsagsmæssige sammenhæng. Det skal bemærkes, at denne grad ikke indebærer, at det er hævet over enhver tvivl, at sammenhængene kan forklares på en anden måde, - det anses blot som meget lidt sandsynligt.
'Moderat evidens' betyder, at de påviste sammenhænge peger på en årsagsmæssig sammenhæng, idet resultaterne ikke umiddelbart ser ud til at kunne forklares ved svagheder i studierne, En sammenhæng er dog mindre veldokumenteret end ved 'stærk evidens'.
'Begrænset evidens' betyder, at de påviste sammenhænge meget vel kan forklares ved svagheder i studierne.
'Utilstrækkelig evidens' betyder, at der ikke foreligger tilstrækkelige data til at vurdere, om der kan være en årsagsmæssig sammenhæng.

Hofteartrose

I alt 14 undersøgelser beskrev sammenhængen mellem hofteartrose og tunge løft, 14 undersøgelser omhandlede hofteartrose blandt landmænd og 6 blandt bygge-anlægsarbejdere, (begge erhverv, der indebærer tunge løft). I alt 13 af de 14 undersøgelser vedrørende tunge løft viste en positiv sammenhæng, og i 11 af undersøgelserne var der en statistisk sikker forhøjelse af risikoen med en odds ratio (OR), der svarer til at risikoen var mindst fordoblet. I 8 undersøgelser sammenlignede man 'lav' med 'høj' belastning, og i 6 undersøgelser anvendtes antal løftede kilo. Flere af undersøgelserne peger på en sammenhæng mellem eksponeringens størrelse og risikoen for hofteartrose, således at risikoen stiger med stigende grad af tungt løftearbejde. Der er imidlertid ikke tilstrækkelige data til en mere præcis belysning af tungt løftearbejde ud fra kombinationen af hyppighed af løft (antal gange per dag), varigheden af løft (år) og løftede vægte (kg). De foreliggende undersøgelser peger på, at der skal være tale om løft af vægte på mindst 10-20 kg i mindst 10-20 år før der er en klart øget risiko for hofteartrose. Det er ikke muligt at definere et tilsvarende mindste-niveau for hyppigheden af sådanne løft.
Der fandtes også en sammenhæng mellem det at arbejde som landmand og udvikling af hofteartrose, især for arbejde mere end 10 år, hvor risikoen ligeledes er mindst fordoblet. Blandt andre erhvervsgrupper fandtes tillige en øget risiko for hofteartrose, herunder for bygge-anlægsarbejdere, men sammenhængen er i disse undersøgelser ikke lige så stærk. Den øgede risiko for hofteartrose blandt landmænd og byggearbejdere kan tolkes som en støtte til antagelsen om, at tungt løftearbejde indebærer en øget risiko for hofteartrose, fordi tunge løft ofte forekommer i disse erhverv, men overrisikoen i disse erhverv kan måske også skyldes andre ukendte forhold.

Det er en potentiel svaghed ved flere af undersøgelserne, at oplysningerne om belastningsgraden er indhentet ved interview eller spørgeskema efter at diagnosen er konstateret. Dette kan påvirke svarene og muligvis skabe falsk positive sammenhænge mellem belastningsgraden og risikoen for hofteartrose. For undersøgelser baseret på sundhedsvæsenets registrering af hofteartrose kan der være en potentiel svaghed ved, at personer der udvikler hofteartrose får flere smerter, hvis de har tungt løftearbejde, og derfor hyppigere søger hjælp i sundhedsvæsenet end personer med lettere arbejde. Omvendt er diagnosen i flere studier baseret på metoder eller kriterier, som i dag ikke anses som optimale. Sådanne unøjagtigheder vil få en reel sammenhæng mellem tungt løftearbejde og hofteartrose til at se svagere ud end den faktisk er (hvis den er der).

Ud fra en samlet vurdering er der en ganske stærk grad af evidens for en årsagsmæssig sammenhæng mellem tungt løftearbejde og hofteartrose, men der er som anført visse metodemæssige svagheder, der kan indebære skævheder i resultaterne. Evidensen for en årsagsmæssig sammenhængen kan derfor knapt nok betegnes som 'stærk' men den er mere end 'moderat' og vurderes derfor som moderat til stærk (++(+)).

For kvinder er der påvist en lignende sammenhæng, men evidensen er betydeligt mindre. Traditionelt har kvinder ikke været beskæftiget i større omfang i erhverv med tunge løft. De fleste undersøgelser inkluderede få kvinder, især i de udsatte grupper med meget løftearbejde, hvilket kan være medvirkende til de negative resultater. Den utilstrækkelige evidens for en årsagssammenhæng mellem tungt løftearbejde og hofteartrose beror således på, at problemstillingen er utilstrækkeligt undersøgt (og måske irrelevant). Der er ikke grundlag for at tro, at kvinder har lavere risiko for at udvikle hofteartrose end mænd, såfremt de er udsat for en tilsvarende belastning.

Der var 5 undersøgelser, der beskrev en evt. sammenhæng mellem udvikling af hofteartrose og stige eller trappegang. Undersøgelserne var hovedsagelig foretaget blandt personer, der enten var opereret eller ventede på en operation. Resultaterne var inkonsistente, og den mest velgennemførte undersøgelse (hvor der var foretaget røntgenundersøgelse) viste ikke signifikante resultater. Der er derfor utilstrækkelig evidens til at vurdere, om der er en årsagsmæssig sammenhæng mellem hofteartrose og stige/trappegang.
Der fandtes ingen undersøgelser, der beskrev en evt. sammenhæng mellem tunge løft og knæliggende/ hugsiddende arbejde og udvikling af hofteartrose. Der er således ingen dokumentation for en sammenhæng ud over den, der foreligger for belastningen af tunge løft i sig selv.

Andre risikofaktorer i relation til udvikling af hofteartrose omfatter arv (generaliseret artrose), overvægt, især betydelig overvægt (Body Mass Index >30), tidligere hofte-traumer, elite sports aktiviteter (løb og evt. fodbold), medfødt hofteluksation, og visse andre hoftesygdomme (Legg-Calve-Perthe's sygdom, og epifysiolyse).

Der er ingen undersøgelser, der beskriver prognosen for hofteartrose i forbindelse med tunge løft, hvad enten det er i kombination med knæliggende/hugsiddende arbejde eller ved stige/trappegang. Erfaringsmæssigt medfører ledbelastninger øgede symptomer ved artrose og dermed i praksis en dårligere prognose med hensyn til arbejde og funktion. Hvis belastningerne har et niveau, der indebærer risiko for udvikling af hofteartrose, må man forvente, at den samme belastning også indebærer en dårligere prognose for sygdommen som sådan.

Knæartrose

I alt 16 undersøgelser omfattede sammenhængen mellem tunge løft og knæartrose, hertil kom 11 undersøgelser, der omhandlede erhverv, hvori der indgik arbejde med tunge loft og evt. knæliggende/hugsiddende arbejdsstillinger. Alle studierne vedrørende tunge løft viste en positiv sammenhæng, men der var kun signifikante forskelle i 7 af de 16 undersøgelser med en odds ratio (OR) mellem 1.4-7.3. I 9 undersøgelser sammenlignede man 'lav' med 'høj' belastning og i 7 studier anvendtes løftet mængde i kg. Der synes at være en tendens til eksponerings-respons-sammenhæng mellem belastning og udvikling af knæartrose, således at risikoen stiger med stigende grad af tungt løftearbejde. Ligesom for hofteartrose er der imidlertid ikke tilstrækkelige data til en nærmere belysning af betydningen af kombinationen af hyppigheden af løft (antal gange per dag), varigheden af løftearbejdet (år) og vægten af det enkelte løft (kg). De foreliggende undersøgelser peger som for hofteartrose på, at der skal være tale om løft af vægte på mindst 10-20 kg i mindst 10-20 år før der er en øget risiko for knæartrose. Det er ikke muligt at definere et tilsvarende mindste-niveau for hyppigheden af sådanne løft.
Der fandtes også en sammenhæng mellem at arbejde som minearbejder (2 undersøgelser), som gulvlægger (to undersøgelser), og som bygge-anlægsarbejder (4 undersøgelser). Den øgede risiko for knæartrose blandt disse minearbejdere og byggearbejdere kan tolkes som en støtte til antagelsen om, at tungt løftearbejde indebærer en øget risiko for knæartrose, fordi tunge løft ofte forekommer i disse erhverv, men det er muligt at andre forhold end tunge løft kan spille en rolle i disse undersøgelser, hvor man bruger job-kategorien som belastningsmål.

Ud fra en samlet vurdering forekommer det mindre sandsynligt, men ikke usandsynligt, at de påviste sammenhænge mellem tungt løftearbejde og knæartrose kan forklares kan forklares som et tilfældigt resultat eller som et resultat, der skyldes metodemæssige problemer. Evidensen for en årsagssammenhæng mellem tungt løftearbejde og knæartrose vurderes derfor som moderat. (++).
Problemstillingen for kvinder er fuldstændig den samme med hensyn til knæartrose som for hofteartrose (se ovenfor).

I 4 undersøgelser indgik kombineret belastning med tunge løft og knæliggende/hugsiddende arbejde. I alle disse undersøgelser fandtes en stærkere sammenhæng mellem knæartrose og belastning end i undersøgelser, hvor belastningen kun var udtryk for tunge løft uden knæliggende/hugsiddende arbejde. Der foreligger dog ingen undersøgelser, der har inkluderet vægt af det enkelte løft, frekvens af løft, varighed af løftearbejdet eller andelen af knæliggende arbejde (pr dag eller antal år). Der foreligger ingen undersøgelser, der beskriver en evt. eksponerings-respons-sammenhæng. Det er således muligt, at tungt løftearbejde i forbindelse med knæliggende/hugsiddende arbejde udgør en større risiko for udvikling af knæartrose end tungt løftearbejde uden knæliggende/hugsiddende arbejde, men der er ikke sikre holdepunkter for dette. Evidensen for, at tungt løftearbejde kombineret med knæliggende/hugsiddende arbejde udgør en risiko for udvikling af knæartrose vurderes derfor ikke som anderledes end for tungt løftearbejde alene, det vil sige som moderat evidens for en årsagssammenhæng.

I alle 4 undersøgelser, der omhandlede knæartrose og arbejde med stige/trappegang fandtes en positiv sammenhæng med en OR varierende mellem 1.2 og 6.1. I 3 af undersøgelserne var resultaterne signifikante for både mænd og kvinder. Eksponeringen varierede fra undersøgelse til undersøgelse og i ingen af undersøgelserne blev evt. eksponerings-respons-sammenhæng undersøgt. Evidensen for en årsagsmæssig sammenhæng mellem knæartrose og stige/trappegang vurderes derfor som begrænset.

Andre risikofaktorer i relation til udvikling af knæartrose omfatter arv (generaliseret artrose), overvægt, især massiv overvægt (Body Mass Index >30), tidligere alvorligere knætraumer, og elite sports-aktiviteter (løb og fodbold).

I enkelte undersøgelser er forskellige faktorers betydning for prognosen for knæartrose beskrevet. Risikoen for forsnævret ledspalte/brusktab øges ved høj body mass index (BMI), generaliseret artrose (slidgigt i flere led), fund af Heberden's knuder, daglig brug af smertestillende medicin, og tidligere udtømning af ledvæske. Der er ingen undersøgelser, der beskriver prognosen for knæartrose i forbindelse med tunge løft, hvad enten det er i kombination med knæliggende/hugsiddende arbejde eller ved stige/trappegang. Erfaringsmæssigt medfører ledbelastninger øgede symptomer ved artrose og dermed i praksis en dårligere prognose med hensyn til arbejde og funktion. Påvist artrose forsvinder næppe igen, men symptomerne kan aftage såfremt man nedsætter belastningerne.

Samlet vurdering

Den samlede vurdering af graden af evidens for en sammenhæng mellem hofte- og knæartrose ved tungt løftearbejde, ved tungt løftearbejde kombineret med knæliggende/hugsiddende arbejde, og ved stige/trappegang fremgår af ovenstående og af Tabel A.

Tabel A. Graden af evidens for en årsagsmæssig sammenhæng mellem hofte- og knæartrose og tungt løftearbejde, tungt løftearbejde kombineret med knæliggende/hugsiddende arbejde og ved stige/trappegang.*

Belastning	Hofteartrose	Knæartrose
Tungt løftearbejde	++(+)	++
Tunge løft og knæliggende/hugsiddende	0**	++
Stige/trappegang	0	+

* evalueringen er baseret på litteraturen, der er angivet i Tabel 2-9.
** der er ingen information om risikoen ved denne kombination af belastninger

Der er en moderat til stærk evidens for en årsagsmæssig sammenhæng mellem tungt løftearbejde og udvikling af hofteartrose. Flere studier peger på en stigende risiko for hofteartrose med graden af tungt løftearbejde. Der er imidlertid ikke tilstrækkelige data om kombinationen af hyppighed (antal gange per dag), varigheden (antal år) og løftede vægte (kg) til fuldt ud at karakterisere eksponerings-respons relationen. Med hensyn til de enkelte elementer ser det ud til, at vægte skal overstige 10-20 kg og varigheden skal være mindst 10-20 år før der er en klart forøget risiko (hvis der reelt er en sådan risiko ved tungt løftearbejde). Det er ikke muligt at angive et tilsvarende niveau for hyppigheden af daglige løft. For landmænd ser risikoen for hofteartrose ud til at være fordoblet efter 10 års arbejde i landbruget, muligvis på grund af løftearbejde og, tungt fysisk arbejde, men dette er usikkert.
Hvis lidelsen accepteres som en erhvervssygdom vil det være nødvendigt at etablere kriterier for anerkendelse/afvisning af, at lidelsen er arbejdsbetinget for den enkelte person. For den enkelte person må man i så fald antage, at sandsynligheden for at lidelsen er arbejdsbetinget øges med stigende grad af tungt løftearbejde. Der er imidlertid ikke en fast evidensbaseret definition af, hvad man skal forstå ved 'tungt løftearbejde' som risikofaktor for hofteartrose ud over, at det inkluderer de kombinerede aspekter af vægten af løftede byrder, hyppigheden af løft og varigheden af løftearbejdet. I arbejdsskade-sammenhæng må begrebet 'tungt løftearbejde' derfor defineres administrativt/politisk.

Der er ingen information om hvorvidt risikoen for hofteartrose ved tungt løftearbejde er ændret, hvis der samtidigt forekommer knæliggende/hugsiddende arbejde.
Der er utilstrækkelig evidens til at vurdere om hofteartrose kan forårsages af stige/trappegang.

Der er moderat evidens for en årsagsmæssig sammenhæng mellem tungt løftearbejde og udvikling af knæ-artrose. Der er ikke sikre holdepunkter for, at denne sammenhæng er anderledes, hvis tungt løftearbejde foregår i kombination med knæliggende/hugsiddende arbejde.
Der findes begrænset evidens for, at knæartrose kan forårsages af stige/trappegang.

Summary

Osteoarthritis (OA) of the hip and knee includes degenerative changes of the knee and hip joint characterised by radiographic changes, stiffness upon movement, and pain. The conditions are common in the general population, knee OA being more common than hip OA. The purpose of the study was to evaluate the evidence for an association between hip and knee OA and exposure to heavy lifting, heavy lifting combined with kneeling or squatting, and climbing stairs or ladders.
The relevant literature was searched in Medline, Embase, HSE-line and NIOSHtic, studies on the relationship between work load and hip and knee OA being identified by using the following keywords: [Hip and (osteoarthritis or osteoarthrosis) and (work or occupation)] and [knee and (osteoarthritis or osteoarthrosis) and (work or occupation)].

For hip OA a total of 14 studies on the relationship between heavy lifting, 14 studies on farming, 6 on construction work, and 5 studies on climbing on stairs or ladders were included in this review. Overall moderate-strong evidence was found for men for a causal association between heavy lifting and hip OA. There are not enough data on the combination of frequency (times/day), duration (years) and lifted weights (kg) to characterise fully the exposure response relation. It seems that weights should be at least 10-20 kg, and the duration at least 10-20 years to give a clearly increased risk of hip OA. It is not possible to define a corresponding threshold for frequency of lifting.
There was also moderate-strong evidence for a causal association between hip OA and farming. The excess of risk for farming >10 years was at least doubled. Among construction workers the risk for hip OA was increased too, but less consistently. All the studies revealed more significant results for men than for women. One of the explanations for this may be that many of the studies had too few female participants. In general, women do not have work-tasks with the same degree of physically heavy work-loads in their occupations as men do, and they 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 are equal to men if they have the same exposure.
Insufficient evidence was found for a causal association between hip OA and climbing stairs or ladders. No information were found for this review dealing with an association between heavy lifting combined with kneeling/squatting, and the evidence for an association is unchanged in relation to heavy lifting alone.
Other risk factors for developing hip OA include inheritance (polyarticular OA), obesity (BMI>30), previous hip injuries, elite sports activities (running and soccer), congenital dislocation, and other hip disorders (Legg-Calve-Perthe's disease, and slipped femoral capital epiphysis).

Sixteen studies on the relationship between heavy lifting, and 11 studies on occupations with heavy lifting and kneeling/squatting, 4 studies on kneeling/squatting combined with heavy lifting, and 4 studies on climbing stairs or ladders, were included in relation to knee OA. The 16 studies dealing with the associations between knee OA and heavy lifting revealed a positive association between knee OA and heavy lifting compared to no/low exposure, but only 7 studies reported a significant association with odds ratios ranging between 1.4 and 7.3. Studies among workers from the construction industry support the results of the studies on heavy lifting. Four of the studies included results of combined exposure to 'heavy lifting and kneeling'. For all these studies, the association between 'heavy lifting and kneeling' for men showed a stronger association compared to exposure to 'heavy lifting' alone with an excess of risk that was at least doubled. All the studies revealed more significant results for men than for women. The numbers of women in occupations which had heavy work loads have been few in many of the studies, probably one of the reasons for the non significant results. In general, women do not have work-tasks with the same degree of physically heavy work-loads in their occupations as men do, and they traditionally work in other trades. The most plausible conclusions are that women are at least as susceptible to lifting heavy work loads as men and that the risk of getting knee OA is equal to men if they have the same exposure.
In all four studies on the association between knee OA and climbing stairs or ladders, there was a positive association, with OR ranging between 1.2 and 6.1. No dose-response relationship has been investigated.

Overall, moderate evidence for a causal association between frequent lifting and knee OA was found for men. For the combination of kneeling/squatting and heavy lifting, the association seemed stronger than for kneeling/squatting or heavy lifting alone, but only few studies were found on this relationship. Therefore the degree of evidence for a causal association was considered as moderate also for this combined exposure. The evidence of a causal association between knee OA and climbing stairs or ladders is considered to be limited. Other factors which increase the risk of developing knee OA are inheritance (polyarticular OA), obesity (BMI>30), previous major knee injuries, and elite sports activities (running and soccer).

Introduction

Osteoarthritis can be characterized as severe localized damage to joint cartilage and underlying subchondral bone. When it is extensive, this loss is visible on radiographs as joint-space narrowing, bone changes with increased sclerosis of the underlying bone, osteophyte formation and occasional subchondral cysts. Osteoarthritis (OA) is one of the most common joint disorders in the world and is a major source of disability in developed countries. OA is common in the knee and hip and OA is the most common reason for total hip and knee replacement. In Denmark in 2004, 4.500 total knee replacements and 6.000 total hip replacements were carried out [1]. The proportion of people with osteoarthritis (OA) increase over the next decades as the population ages.

Kellgren and Lawrence have found radiographic hip OA in 16% of men and 6% of women[1;2] aged 55-74 years. In a population survey ''NHANES I'', the overall prevalence estimates for radiological hip OA for adults aged 25-74 years are 1.3%. For persons with moderate and severe radiological hip OA, the estimates are 0.5%[3]. Data suggest that symptomatic hip OA (pain on most days plus positive radiological findings) occurs in approximately 0.7-4.4% of all adults[3-5] and in 5% aged 65 years or older[6]. The age- and gender-standardized incidence rate of clinical symptomatic hip OA was in United States calculated to 88 per 100.000 person-years[7].

The prevalence of knee OA increases with age from negligible in those aged 25-34 years to 20-40% in those aged 75 or older[8]. In a population survey ''NHANES I'', the overall prevalence estimates for radiological knee OA for adults aged 25-74 years are 3.8%. For persons with moderate and severe radiological OA, the estimates are 0.9% [3]. Studies from Europe have shown prevalences of knee OA grade 2-4 ranging from 12 to 22% and grade 3-4 from 3 to 9% [8]. In general, there are wide geographical differences in the prevalence of knee OA. Race influences the rate of OA: the prevalence is lowest in Asians, followed by black Africans, and it is highest in white Europeans[9]. For subjects age 25-40 years reporting symptomatic knee pain, only 2% had radiographic changes[10]. Among subject with knee OA grade ≥2, only 47% reported knee pain. Data suggest that symptomatic knee OA (pain on most days plus positive radiological findings) occurs in approximately 6% of adults age 30 or more [3-5] and in approximately 10% aged 55 years or more[11]. The age- and gender-standardized incidence rate of clinical symptomatic knee OA in the United States was 240 per 100.000 person-years[7].

This review focuses on epidemiological studies which have investigated the association between hip and knee OA and an exposure to heavy lifting, climbing stairs or ladders and exposure to heavy lifting combined with kneeling or squatting. Many occupations involve heavy lifting. Therefore, studies on the relationship between such occupations and hip and knee OA are also considered. The association between kneeling or squatting and knee OA has not been included in this review.

Methods

The relevant studies were identified through searches in the following literature databases: Medline (1966-June 2005), NIOSH-tic (1990-June 2005), Embase and HSEline (1990-June 2005). The following keywords were used: [Hip and (osteoarthritis or osteoarthrosis) and (work or occupation)] and [knee and (osteoarthritis or osteoarthrosis) and (work or occupation)]. Further relevant literature was found by screening the reference lists of all relevant articles identified. In addition, the search included all relevant reviews of work-related osteoarthritis in the hip or knee, and these reviews were checked for further relevant material.
All the abstracts were reviewed, and relevant articles were retrieved. A study was selected for a more detailed review if it fulfilled the following criteria: 1) one of the aims of the study was to investigate an association between hip OA or knee OA and the physical demands 'heavy lifting, heavy lifting combined with kneeling/squatting , or climbing stairs or working on ladders'; 2) the literature was published in English,

[1] Reported to the Central Register for Arthoplasty (Personal communication Orthopaedic department Viborg hospital)

German or one of the Scandinavian languages (Danish, Swedish, or Norwegian); 3) it was a full text article; 4) the subjects studied had a) radiological verified hip or knee OA; b) a diagnostic code (ICD 8 or ICD 10) for knee or hip OA); c) had a total hip or knee replacement or d) were on a waiting list for a hip or knee replacement; 5) the study had a controlled design.
The strengths and the weaknesses of the studies were evaluated and the following aspects were included in the evaluation: design and material (description of: inclusion/exclusion criteria; size of study group; participation rates; and healthy worker effect); potential confounders or modifiers (e.g. age, weight and BMI, sports activities, and earlier traumas); measurement of outcome (clinical and paraclinical examination methods, blinded assessments); measurement of exposure (qualitative/quantitative; observation methods);and data presentation and statistical analysis.

Identification and selection of the epidemiological literature

Hip osteoarthritis

The electronic search in Medline, Embase, HSEline and NIOSHtic retrieved 381 references dealing with hip OA. Some of the references were duplicates, and some of the articles were reported in all of the databases leaving a total of 261 references. 4 reviews dealt with hip OA[12-15], 8 with both knee and hip OA[4;8;16-22], and one dealt only with hip OA in farmers[23]. All of these publications were used to extract data for this review. Of the 261 references, there were 14 epidemiological studies with a controlled design which investigated an association between hip OA and heavy lifting[24-38]; 14 studies on hip OA and occupations involving heavy lifting as farmers [24;25;29;33;35;36;38-45] and 6 on construction workers[24;25;33;35;36;41]; 5 studies investigated the relationship between hip OA and climbing stairs or working on ladders[24;25;30;37;38]; and no study dealt with hip OA and heavy lifting combined with kneeling/squatting. For some of the studies, there was more than one publication[20;31;34;35;46]. Some of the studies dealt with more than one physical demand and more than one outcome; for example, ”knee and hip OA caused by heavy lifting, kneeling/squatting or climbing flights of stairs’’ and a study can therefore be cited as a reference more than once.

Knee osteoarthritis

The electronic search in Medline, Embase, HSEline and NIOSHtic retrieved 652 references dealing with knee OA. Some of the references were duplicates, and some of the articles were reported in all of the databases, leaving 424 references. A total of 13 reviews were found dealing with work-related knee OA; of these, 5 reviews only dealt with knee OA[47-51]; and 8 dealt with both knee and hip OA[4;8;11;16;18;20;22;52]. For some of the studies, there was more than one publication[31;34;35;46]. All publications were used to extract data for this review.
Of the 424 references, there were 16 epidemiological studies with a controlled design which investigated an association between knee OA and heavy lifting[30;35;36;53-65]; 11 studies investigated occupations involving heavy lifting[35;36;41;62;65-71]; four studies investigated heavy lifting combined with kneeling/squatting[55;56;59;64]; and four studies investigated climbing stairs or ladders[30;56;72;73]. Some of the studies dealt with more than one physical demand and more than one outcome; for example, ”knee and hip OA caused by heavy lifting, kneeling or climbing flights of stairs’’ and a study can therefore be cited as a reference more than once.

Hip osteoarthritis

Case definition

In clinical practice, a diagnosis of osteoarthritis of the hip is normally based on the combination of typical symptoms of pain, restricted hip movements on clinical examination, and changes on the radiographs. Similarly, in assessing the need for surgical intervention, most account is taken of the extent of pain and disability combined with the radiographic findings of severe osteoarthritis.
The clinical symptoms of hip osteoarthritis are joint pain and functional impairment. A typical description is of pain during physical activity, and relief of pain at rest. Pain is usually aching in character, initially pain occurs with motion; pain at rest, and particularly at night, is found as the disease advances. Stiffness occurs particularly in the morning, or after inactivity during the day, limitations in motion develop as the disease progresses. Physical signs include localized tenderness and crepitus of the joint, particularly with motion. There are no specific diagnostic laboratory abnormalities, and synovial fluid examination reveals normal findings.
For the hip, moderate to severe OA is normally defined as a minimal joint-space (shortest distance from the margin of the femoral head to the acetabulum) or more seldomly by the criteria defined by Kellgren and Lawrence (moderate to severe = grade 3-4)[74]. When comparing different radiographic measures, minimal joint-space has in earlier studies been evaluated as the best radiological criterion of hip osteoarthritis for use in epidemiological studies[75]. Reijman et al. 2004 [76] have compared the validity and reliability of three definitions of hip osteoarthritis in a random set of X-Rays taken in a cohort study of 3585 people in Rotterdam, aged ≥55 years. 148 X-Rays selected at random from the study population were evaluated by the criteria for radiological definitions of osteoarthritis used by Kellgren and Lawrence, by minimal joint space narrowing (JSN), and by Croft's grade[2]. The interrater reliability was similar for the Kellgren and Lawrence and minimal joint space narrowing (Kappa statistics is 0.68 and 0.62, respectively), but a little lower for Croft's grade (Kappa statistics 0.51). The Kellgren and Lawrence criteria and 'minimal joint space' showed the strongest associations with clinical symptoms of hip osteoarthritis. The Kellgren and Lawrence grade showed the highest predictive value for total hip replacement at follow-up. In a study by Jacobsen et al. 2004 a minimum joint space width (JSW) ≤ 2 mm was associated with self-reported pain in the hip[77].

In this review, epidemiological studies using a case definition including radiological joint space narrowing or the Kellgren & Lawrence criteria for hip OA, total hip replacement or waiting for a hip replacement, and being hospitalised or getting a disability pension with a diagnostic code ICD8[3] =713.00 or ICD10=M16 (= hip OA), are discussed in detail.

Exposure definition

There are different methods of obtaining information about the exposure in epidemiological studies on hip osteoarthritis. 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 a relevant measure of exposure. Many studies classify the level of exposure by job title, and this exposure-measurement used alone may lead to misclassification. Classification of occupations into heavy and light with no further differentiation gives only little more of information. For more detailed information, questionnaires or interviews are used. In those studies with retrospective data, it is difficult for the subjects to remember the level of exposure precisely, especially many years after the event, and misclassification due to memory-deficit (recall bias) can occur. In studies using self-reported questionnaires or interviews, the self-evaluation may in addition lead to information bias, because subjects with hip- or knee-pain have a tendency to over-

[2] Croft Grade definition: 0 is no change, 1 is definite osteophytes only, 2 is Joint space narrowing (JSN) only, defined as minimal joint space ≤2.5 mm); 3 is presence of two of following: JSN, osteophytes, subchondral sclerosis of >5 mm, cysts formation; 4 is presence of three of following: JSN, osteophytes, subchondral sclerosis of >5 mm, cysts formation; and 5 is grade 4 + deformity of the femoral head or total hip replacement due to osteoarthritis verified by record review.
[3] ICD= International Classification of Diseases (WHO)

estimate their physical work load. The most exactly exposure measurement is direct observation of the exposure e.g. by video-recordings, a very comprehensive and time-consuming method.
The measurement of heavy lifting in relation to the development of hip OA may preferably include three dimensions to illustrate the exposure most convincingly: 1) definition of the individual loads in kg, 2) the number of lifted loads every day, and 3) the duration of exposure (in years). For climbing stairs, the exposure should include the number of stairs climbed every day, and the duration of the exposure (in years). Only few studies have included all these dimensions.
Studies including all type of exposures: job-title, classification in low and high exposure, and further description of the physical activity using questionnaire or interviews are discussed in detail in this review. Farmers and construction workers may have heavy physical work demands such as heavy lifting combined with kneeling/squatting and climbing stairs, and studies dealing with these occupations are therefore included in the review.

Major non-occupational risk factors

Several studies have confirmed that predisposition to hip OA in the general population can be inherited. Subjects whose parents have OA have an increase risk of getting OA themselves. The risk is highest if the disease is polyarticular or if the onset is in the middle age or earlier. Persons with hand OA may also be at high risk of developing incident or progressive hip OA. In a sibling study from the United States, the genetic component of the risk for total hip replacement caused by hip OA was calculated to 53%[78]. The presence of hand OA appears to increase the risk of hip OA around three-fold [79]. The best clinical marker of such a predisposition is the presence of Heberden's nodes. Men and women who have definite Heberden's nodes were reported to be more likely to have hip OA with OR 1.6, 95% CI 1.2-2.2 in a study by Cooper[6] and an OR 3.4, 1.2-10.0 (men only) in a study by Croft[40].

Congenital dislocation, Legg-Calve-Perthe's disease, and slipped femoral capital epiphysis result in an increased risk of hip OA later in life. It tends to occur at a relatively young age (35-55 years) and to progress rapidly. However the incidence is relatively low in the general population, and accounts for only a very small proportion of hip OA. It has been suggested that acetabular dysplasia, a mild variant of congenital dislocation in which acetabulum is shallow, may increase the risk of developing hip OA. In a systematic review, in which 9 studies were included, the association between acetabular dysplasia and hip OA has been investigated[80]. Six studies reported a positive association, but only one study reported significantly increased risk, with an odds ratio 2.8 (1.0-7.9). In the Japanese population, where acetabular dysplasia is more prevalent, they appear to have a lower rate of hip OA than in the Western population[81]. The conclusion of the review was that the evidence for an association is limited.

The prevalence of osteoarthritis in hip is correlated with age and increases from negligible before the age of 50 years to approximately 5% in subjects aged more than 65 years. Osteoarthritis has a higher prevalence and is more often generalised in women than in men. By the age >50 the female: male ratio for symptomatic hip OA is 2:1[7]
The relationship between increased body weight and hip OA is not as strong as it is with knee OA[40;82]. In a cross-sectional population-based study among men, those in the highest third of the distribution of adiposity (weight >78.3 kg) had a 2.6-fold risk of getting hip OA. In NHANES-1, an association was found between obesity and bilateral hip OA[82]. Flugsrud et al. [27] showed in a cohort study on more than 50,000 subjects an association between hip OA and body weight with an age-adjusted relative risk for men ranging from RR=1.4-1.5 (< 85 kg) and RR=2.2(≥ 85 kg) and for women RR=1.8 (<65 kg), RR=2.3 (65-72 kg), and RR=3.5 (>72 kg). In a recent review investigating the association between obesity and hip OA, 9 studies were found with exact data of the outcomes[83]. All studies showed a positive association between obesity and hip OA. In five studies, the association was statistically significant, indicating that subjects with a body mass index higher than 25 have an increased risk of developing hip OA. In three studies, a dose-response relationship was shown[6;84;85]. At BMI 25-27, the OR for hip OA has been found to be approximately 1.3-1.5 while the OR at BMI>28-30 has been found to be around 2[83].

There is a higher risk for developing hip OA among people who have sustained lower limb injuries. particularly if these are severe enough to result in fracture or dislocation[86]. Previous hip injuries have been reported to be associated with an overall 4.3-fold increase in the risk of developing hip OA, the risk being greater among men OR 24.8 (95% CI 3.1-199) than among women OR 2.8 (95% CI 1.4-5.9). The risk was most pronounced for unilateral, as compared to bilateral involvement[6]. Severe traumas are associated with 5-10% of all cases of hip OA and around 30% of patients with severe traumas around the hip will develop hip OA over a 20 year period. In a study by Lau et al. 2000[30] an association between severe traumas and development of hip OA (THR) was found with an OR 15.6, 95% CI 3.4-70.5 (men), and OR 32.7, 95% CI 10.0-106.6 (women).

Elite athletes appear to be at increased risk for hip OA in later life[87-93]. In a review on the association between hip OA and sports activity, 22 studies was evaluated[94]. Nineteen studies showed exact data on the outcomes. Fourteen studies showed a positive association between hip OA and sports activities, of which 5 were statically significant[89;93;95-97]. Two of these studies investigated former soccer players[95;97], one study investigated 'former elite athletes' [89], and two studies 'high versus low exposure' to a combination of sports activities[93;96]. The review found moderate evidence for a causal association between hip OA and a 'combination of sports activities' and 'running'. There was conflicting evidence for soccer players and ballet dancers, and limited evidence for an association for athletics[94].

Several epidemiological studies provide evidence that oestrogen replacement therapy is associated with a reduction in the risk of hip OA in women after the age of 50 years[62;85;98-102], but this result could not be confirmed in a study by Oliveria, 1996[103]. In one study, women who had taken contraceptive pills for 1 year or more before the age of 50 are reported as having a higher risk of developing hip OA with a relative risk RR 1.6, 95% CI 1.0-2.3[85].

A significantly lower risk of hip OA has been found among subjects who were current smokers when compared with those who had never smoked in several studies [6;30;42], but a tendency to an increased risk of hip OA among smokers and ex-smokers compared to non-smokers with a relative risk, RR=1.5 (95% CI=1.0-2.1) was found in one study by Vingård et al. 1997[85].

Results

Epidemiological studies

The number of references that remained after applying the inclusion criteria on the search, the diagnostic criteria, and the exposure assessment used in studies of hip OA are shown in Table 1a. As diagnostic criteria, 38.5% of the studies on hip OA have used radiographic OA. It has been most common to use joint-space narrowing as the criterion, but with the cut-off point ranging from 1.5 to 4 mm for defining OA. Total hip replacement or waiting for one was used as diagnostic criterion in 38.5% of the studies, while 23% of the studies used the diagnoses leading to hospitalisation or disability pension. As the exposure measurement, 49% of the studies used job title, and 51% a more detailed questionnaire or interview on physical work load.

Heavy lifting and/or work including heavy lifting

Heavy lifting

Fourteen epidemiological studies[24;25;29;33;35;36;38-45] focused on the relationship between hip OA and heavy lifting. The studies are listed in Table 2 with information on study population, age of the participants, participation rate, exposure assessment, the diagnostic criteria, adjustments, results, and study design.

Typpö, 1985 [33] made a study consisting of two series of patients, the first included 401 patients and the second comprised 518 patients, 919 subjects (416 females, 503 males). Subjects in the first part of the study

was selected if there was a radiograph available in which the hips were well visualised and subjects for the second part of the study were selected among surgical and medical out-patients who had undergone radiography. The radiological findings were classified into mild (JSN <3 mm), moderately severe (narrowed joint space and osteophytes 6-10 mm), and severe (narrowed joint space and osteophytes>10 mm, deformation of acetabular base). Exposure was measured by questionnaires and divided in four alternative exposures: mental (sic), light manual, moderate manual, and heavy manual and the occupation were divided in different alternatives. 26 (38%) white collar workers had hip OA, 94 (48%) light or moderate manual workers had hip OA, and 131 (54%) heavy manual workers had hip OA.
The prevalence of hip OA for farmers was 90 (56%), for construction workers 22 (61%) compared to office workers 37 (41%) and 224 (45%). This study is mostly descriptive, the participation rate is not described, there is no statistical testing and no adjustment for potential confounders. The association between occupational work load and hip OA is only reported for subjects who participated in the second part of the study. The study is not discussed further in this review.

Jacobsson et al. 1987[29] made a case-control study in an area of Sweden. OA cases were men on a waiting list for total hip replacement (THR) (n= 85) and subjects with radiographs showing a JSN <3 mm (N=21). Controls were 262 men who have had an intravenous urogram for prostatic hyperplasia and had no hip OA (JSN<3mm). Exposure was measured by a questionnaire about heavy labor, especially as farmers, in forestry, industrial work or with heavy lifting. Ninety (85%) of cases compared to 165 (70%) of controls reported that they were employed in heavy work, 90 (85%) cases and 166 (70%) controls reported that their work involved heavy lifting, and 61 (58%) cases and 95 (40%) controls reported working as farmers. No further analyses have been made in the paper. The study is poorly described (missing participation rate, inclusion, and exclusion criteria). The exposure is described as heavy lifting (yes/no) without including duration of time, frequency or weight lifted. The study is not further described in this review.

In a case-control study by Vingård et al. 1991[34] the study population comprised all Swedish men, age 50-70 years living in the areas of four hospitals in Stockholm. Cases were men receiving the first total hip replacement during 1984-1988. Subjects with malformations, sequelae after poliomyelitis, rickets, or trauma to the trunk or lower extremities were excluded. The case-group consisted of 233 men. The controls were randomly selected from the study population during the study period and consisted of 322 men.
The exposure was quantified by questionnaire about kilograms lifted per week, and number of times lifting heavy weights (>40kg) collected from start of the occupational career until the year of the interview or the year of the OA-diagnosis. The level of exposure was divided in three groups: low, medium, and high exposure. To investigate possible recall bias in relation to the measurement of exposure, patients who were treated for myocardial infarction in the same hospitals, 335 men were also included.
The relative risks of getting a total hip replacement was calculated and the results were controlled for potential confounders (age, body mass index, smoking habits, and sports activities). Men with high exposures to heavy lifting (measured as lifted tons) up to the age 49 years had a relative risk 1.84, 95% CI 1.12-3.03, and those with medium exposure 1.58, 95% CI 0.93-2.66. For the subgroup with high exposure to lifted weight >40 kg in the age-group 30 to 49 years the relative risk was 3.31, 95% CI 1.97-5.57; with medium exposure, the relative risk was 1.60, 95% CI 0.81-3.15 compared to those with low exposure.

Vingård et al. 1991 [36] made a cohort study in which the study population comprised subjects born between 1905 and 1945, living in 13 counties in Sweden, who reported the same occupation in 1960 and 1970. The blue-collar occupations were classified by two experienced health physicians as having high or low exposure to dynamic and static forces acting on the lower extremities. The population consisted of 116,581 males and 18,434 females classified with high exposure and 91,057 males and 24,145 females with low exposure. 914 males and 109 females (classified with high exposure) and 320 males and 112 females (classified with low exposure) were hospitalised during the period 1981-1983 due to hip OA (ICD 8 diagnostic-code = 713.00). The relative risk for hospitalisation due to hip OA in high versus low exposure occupations was for males (born 1905-1924) RR=2.2 (95% CI 1.6-2.8) and (born 1925-1945) RR=2.0, 95% CI 1.6-2.3. For females (born 1905-1924) the relative risk was RR=1.6, 95% CI 0.9-3.1 and (born 1925-1945) RR=1.1, 95% CI 0.9-1.5. The relative risk for hospitalisation due to hip OA were for farmers RR=3.78, 95% CI=2.91-3.88 and for construction workers 1.66 (95% CI=1.32-1.87) when compared to the low exposure group. For females the only significant risk for hospitalisation due to hip OA was found in letter-carriers RR=3.83, 95% CI=1.19-12.05.

In a case-control study by Vingård et al. 1992[35] the study population (1307 subjects) comprised a random sample of Swedish men born between 1915-1934, living in Stockholm county and receiving a disability pension. 140 had the diagnosis of hip OA. The diagnoses were collected from the physicians' certificates. The control group consisted of men from the general population in Stockholm in the same age-group (n=298). Cases and controls with known psychiatric disorders, trauma, rheumatic diseases, and congenital malformations were excluded. The work histories were obtained from personal interviews and each occupation classified according to the Nordic Occupational Classification system without knowledge of the diagnoses. A panel of four experienced persons classified the level of physical work load for each occupation (low, rather low, rather high, and high work load). A score consisting of the degree of exposure combined with the duration of the exposure was made, and the exposure categories were divided into low, medium and high. The relative risk to receive disability pension due to hip OA for persons with medium exposure was RR=4.1, 95% CI 2.4-7.1 and for high exposure: RR=12.4, 95% CI 6.7-23.0 compared to those with low exposure. The relative risk to receive disability pension for farmers (at least 10 years) was RR= 13.8, 95% CI 4.0-18.1, and for construction workers RR=5.3, 95% CI 2.6-10.6 compared to those never exposed to any of 20 most exposed occupations.

All men (age 60-75 years) who have had an out-patient intravenous urogram at two English hospitals in the period 1982-87 were identified in a case-control study by Croft et al. 1992 [25]. Cases were defined as subjects who had a total hip replacement or those with JSN≤2.5 mm in at least one hip. Severe cases were defined as JSN≤1.5 mm. The control group comprised those whose joint space were ≥3.5 mm. Exposure was assessed by interviews and included lifetime occupational history with specified physical activity and occupation. The study included 245 cases and 294 controls. Lifting or moving objects >25.4 kg (number of lifts or frequency not further described) 1-19 years or ≥20 years showed no differences for all OA cases. For severe cases (JSN≤1.5mm), the risk was increased for the men employed >20 years in jobs which required heavy lifting OR 2.5, 95% CI 1.1-5.7. For 'all OA cases' and for 'severe OA cases' the analysis showed no significant associations with climbing ladders (defined as climbing ladders 1-19 and ≥20 years) or climbing flights of stairs (defined as >30 flights of stairs/day 1-19 years or ≥20 years). Odds ratios were adjusted for age and hospital group. For severe cases of hip OA, the odds ratio were elevated (but not significant) for farmers with more than 10 years of employment OR 2.0, 95% CI 0.9-4.4.

In a case-control study by Roach et al. 1994 [32], 99 male patients with primary hip OA from outpatient clinics in the United States, and 233 controls were selected. The cases were identified from a radiology database of all patients who received a radiograph because of hip complaints or had a total hip replacement during the period January 1989 to June 1990.
The case definition was age>40 years, complaints of hip pain, and radiological Grade 3 or 4 OA related to the Kellgren & Lawrence criteria. The controls were chosen from the population of patients who received an intravenous pyelogram in the same period. Controls were excluded if they had JSN <1.5 mm. Cases and controls were excluded if they had a history of injuries, polyarthropathy, avascular necrosis, lower extremity fractures, amputation or neurological disorders. The exposure were assessed by a questionnaire and included number of years they had worked in occupations with light work standing, work sitting, heavy work standing, work kneeling or crouching, work walking. The work load was afterwards classified as light (sitting, and light work standing), intermediate (between light and heavy) and heavy work (heavy work standing, work walking, and work kneeling/crouching).
The results of the relationship between physical work load and development of hip OA showed a significant positive association with an odds ratio for intermediate versus light work OR =1.9, 95% CI 1.0-3.8, and for heavy work OR=2.4, 95% CI 1.3-4.3. Odds ratios were controlled for weight at the age of 40 years, history of cancer, and sports activities (football, running). The risk for hip OA increased with increasing length of exposure to heavy work up to 34 years. Exposure to heavy work for 15-24 years resulted in an OR=2.2, exposure 25-34 years OR = 3.0, and exposure >34 years OR=2.2 (CI not shown).

Vingård et al. 1997[37] made a case-control study that comprised 230 women with total hip replacement (THR) and 273 women without hip problems, age 50-70 years, living in five counties in Sweden and in the areas of five hospitals. Subjects with arthritis or severe trauma to the leg were excluded. Controls were randomly selected from the local population in the same area and matched by age, and by county hospital. Controls with known hip disorders were excluded. Exposure information was collected by interviews for the period between 16-50 years. The exposure for the individuals were aggregated throughout life. For each exposure three subgroups were defined: low exposure (the 25% with the lowest exposure), medium (the 50% between), and high (the 25% with the highest exposure). The relative risk for having a THR in women exposed to medium heavy lifting was RR=1.1, 95% CI=0.7-1.7 and for those with high exposure RR=1.5, 95% CI=0.9-2.5 compared with those with low exposure. For the exposure to climbing stairs, the relative risk for having a THR in women with medium exposure was RR=1.3, 95% CI=0.8-2.0 and for high exposure 2.1, 95% CI=1.2-3.6. The results were adjusted for age, body mass index, smoking, sports activities, number of children, and hormone therapy.

In a case-control study by Coggon et al. 1998[24] cases comprised residents of two English health districts, who were placed on a waiting list for THR for hip OA over an 18-month period. Subjects with a history of lower limb fractures, rheumatoid arthritis, ankylosing spondylitis, and other documented causes of secondary OA were excluded. Controls were selected from the general population and individually matched by age, sex, and general practice. Controls with earlier surgery for hip OA were replaced. The exposure was measured by interviews. For each job (from leaving school) that entailed lifting weights of 10 kg, 25 kg, and 50 kg more than 10 times in an average working week, the duration in years was reported. 210 men and 401 women, mean age 70 years (45-91 years) were included in the analysis (cases and controls) (participation rate 55%). After adjustment for body mass index, presence of Heberden's nodes, and a history of injury, men who lifted weights more than 10 times in an average week, had an increased risk of hip OA with an odds ratio OR=2.3, 95% CI 1.2-4.2 (at least 10 years of exposure), and an OR=1.8, 95% CI 1.0-3.4 (≥ 20 years of exposure) compared to those who had never done such lifting. For lifting weights ≥25 kg the odds ratio was OR=2.7, 95%CI 1.4-5.1 (at least 10 years of lifting), and OR=2.3, 95%CI 1.3-4.4 (≥20 years). For lifting weights ≥ 50 kg there also was an increased risk of hip OA with an odds ratio 2.9, 95% CI 1.3-6.4 (at least 10 years of exposure), and OR=3.2, 95% CI 1.6-6.5 (≥20 years of exposure). No associations between heavy lifting (10kg, 25 kg, or 50 kg) and hip OA was apparent in women. For the exposure of climbing stairs (climbing more than 30 flights of stairs during an average working day) the odds ratios for males were OR=1.3, 95% CI 0.7-2.5 (<10years), OR=2.3, 95%CI 1.1-4.9 (10-20 years), and OR=1.8, 95% CI 0.9-3.4 (>20 years of exposure). For women there were no significant associations at any level of exposure. Men who reported that the job involved heavy lifting >25 kg worked typically as agricultural workers (19 cases, 8 controls) and as construction workers (23 cases, 18 controls). This data is not further analysed in the paper.

From Zagreb city records, a sample aged more than 45 years were selected 1981-1983 by Cvijetic et al. 1999[26]. Of all invited subjects (number not specified), 678 agreed to participate in the study. After exclusion of subjects having rheumatoid arthritis or gout the material consisted of 292 women, mean age 64 years and 298 men, mean 63 years. From a structured questionnaire, the exposure was classified in 4 categories: 1) most sedentary (>80% sitting), 2) most standing (>80% standing) , 3) non sitting (>80% frequent walking, or standing, only lifting light work loads <5kg), 4) high physical strain (>80% frequent walking, standing, lifting and carrying weights >5kg). Radiographs of the right hip were taken and graded by the scale described by Kellgren & Lawrence. Grade 2-4 were considered to be definite signs of osteoarthritis. The association between hip OA and physical working demands were positive for men and women, but not significant for subjects in all categories (2, 3, and 4) compared to category 1), the odds ratios ranging between 1.5 (category 2) and 1.15 (category 4). The odds ratios were not controlled for confounders.

Yoshimura et al. 2000[38] carried out a case-control study in two health district in a Japanese city. Cases consisted of 11 men and 103 women, aged ≥45 years listed for THR due to OA during one year. Subjects with rheumatoid arthritis, ankylosing spondylitis, congenital dislocation of the hip, and acetabular dysplasia were excluded. Controls (103 women and 11 men) were selected randomly from the general population and individually matched by age, sex, and district of residence. Exposure was measured by a structured

questionnaire. For each job (lifetime) the study listed whether the work entailed lifting weights of at least 10 kg, 25 kg, and more than 25 kg once during an average week.
The association between hip OA and heavy lifting was significantly positive for lifting >25 kg (first job: unadjusted OR=3.6, 95% CI 1.3-9.7; main job: OR= 1.6, 95% CI 0.8-3.2, and for lifting >50 kg (first job unadjusted OR 5.4, 95% CI 1.2-25.4, main job: OR 4.0, 95% CI 1.1-14.2. No significant associations were found for lifting >10 kg. Among cases 1 man and 18 women, and among controls 2 men and 15 women were agricultural workers or fishermen, and 3 men and 21 women (cases) compared to 1 man and 17 women (controls) were construction workers. These results were not further analysed. For the association between hip OA and climbing stairs (>30 flights of stairs in an average week) no significant relationship was shown: first job unadjusted OR 0.8, 95% CI 0.4-1.6, main job OR 1.0, 95% CI 0.5-1.9.

Lau et al. 2000[30] made a study with a similar design including subjects from Hong Kong. Hip OA cases (n=138, 30 men, 108 women) represented patients who attend hospitals over a three year period for total hip replacement. Subjects with earlier hip fracture, rheumatoid arthritis, ankylosing spondylitis, a history of Perthes disease, congenital dislocation, slipped capital epiphysiolysis were excluded. To avoid mis-classification, only THR-patients with grade 3-4 hip OA on radiographs according to the criteria made by Kellgren & Lawrence were included. Controls, 90 men and 324 women, were consecutive subjects from eight practices located in the same region as the hospitals. Each case was matched with 3 controls by sex and age. Patients with self-reported OA of the hip or knee or pain or stiffness in hip or knee which lasted for a week or more were excluded from the study.
The exposure was measured by a structured questionnaire. For each job held for a year or more they had to describe the physical activity, including periods with heavy lifting (loads weighing ≥10 kg, and ≥50 kg 1-10 times or >10 times each week) and climbing stairs (≥15 flights of stairs each day).
The association between hip OA and heavy lifting was not significant for lifting ≥10 kg 1-10 times/week for men or for women, but was significantly increased in both men and women for lifting weights ≥10 kg more than 10 times/week OR=5.3, 95%CI 1.8-15.8 (men) and OR=3.0, 95% CI 1.8-5.1 (women) and for lifting weights ≥50 kg 1-10 times OR=8.5, 95% CI 1.6-45.3(men), and OR=2.0, 95% CI 0.9-4.6 (women), and more than 10 times/week OR=9.6, 95% CI 2.2-42.2 (men) and OR=2.9, 95% CI 1.5-5.6 (women). The associations persisted when adjusting for potential confounders. The association between hip OA and climbing stairs was significant increased for men, with an odds ratio 8.7, 95% CI 1.8-42.7 and for women 2.5, 95% CI 1.0-5.9.

A cohort study by Flugsrud et al. 2002[27] used data from a cardiovascular screening (1977-1983) from 3 Norwegian counties and matched them with 9 years of national data on total hip replacement (1989-1998). Questions regarding physical activity at work were answered by a questionnaire during the cardiovascular screening. The question was: 'During the last year, have you had: Mostly sedentary work (e.g. office work, watchmaker, mounting of instruments); Moderate: Work leading to much walking? (e.g. shop assistant, light industrial work, education); Intermediate: Work leading to much walking and lifting? (e.g. postman, heavy industrial work, construction); Intensive: Heavy manual labour? (e.g. forestry work, heavy farm work, heavy construction work).
50,034 subjects, born between 1925 and 1942, participated in the cardiovascular screening during the period 1977-1983. 672 subjects from the Norwegian Arthroplasty Register were included in this study (only subjects who also attended the cardiovascular screening were included in this study).
The association between hip OA and physical activity at work was: for men with moderate work load RR= 1.5, 95% CI=1.0-2.2; with intermediate work load RR= 1.7, 95% CI= 1.1-2.4; with intensive work load RR= 2.1, 95% CI 1.5-3.0. For women, the association between hip OA and heavy lifting was significantly increased for women with the highest work load with RR= 1.1, CI= 0.8-1.6 (moderate work load); RR= 1.4, 95% CI= 0.9-2.0 (intermediate work load); RR= 2.1, 95% CI= 1.3-3.3 (intensive work load). The results are adjusted for age at screening, height, body mass index, physical activity in leisure, marital status, and smoking habits.

Jacobsen et al. 2004[28] used data from The Copenhagen City Heart Study, a longitudinal health survey of an adult population in a county of Copenhagen, Denmark. The cohort 1991-1994 consisted of 10,135

participants. 2,949 subjects with ≥4 positive answers to questions about musculoskeletal complaints and 1202 with <3 positive answers were selected for radiography, including the hips.
The exposure (nature and duration of occupation) since leaving school was measured by questionnaires. The exposure was placed in the following categories:1) primarily seated occupation, 2) standing, walking occupation, no repeated lifting, 3) daily repeated lifting equivalent to 50 x 20 kg, or 20 x 50 kg, 4) repeated daily lifting equivalent to 50-100 x 20 kg, or 20-50 x 50 kg, 5) repeated daily lifting equivalent to 100-250 x 20 kg, or 50-100 x 50 kg, and 6) repeated daily lifting equivalent to 250-500 x 20 kg, or 100-250 x 50 kg. Cases were defined as subjects with radiographic joint space narrowing ≤2mm, which was found among 105 men and 167 females. No significant relationship was found between radiographic features (not further defined) and heavy lifting (results not shown).

Occupations which involve heavy lifting

Farming

Fourteen epidemiological studies [24;25;29;33;35;36;38-45] focused on the relationship between hip OA and farming. The studies are listed in Table 3 with information on the study populations, age of the participants, participation rate, exposure assessment, the diagnostic criteria, adjustments, results, and study design.
Some of the studies have been described in detail in relation to heavy lifting[24;25;29;33;35;36;38], and only the conclusions specifically about farmers are repeated.

In the study by Typpö, 1985[33], 56% farmers were found to have hip OA compared to 41% of office workers. Jacobsson et al. 1987[29] made a case-control study in an area of Sweden. 58% hip OA- cases and 40% controls reported working as farmers. Vingård et al. 1991[36] found a relative risk for hospitalisation due to hip OA for farmers RR=3.78, 95% CI=2.91-3.88. The relative risk to receive disability pension (after at least 10 years of farming) was RR= 13.8, 95% CI 4.0-18.1 compared to those never exposed to any of 20 most exposed occupations in a study by Vingård et al.1992 [35]. Croft, 1992[25] showed an elevated, but not significant risk for farmers with more than 10 years of employment OR 2.0, 95% CI 0.9-4.4 for severe cases of hip OA. In a study on heavy lifting, Coggon et al. 1998[24] found 19 cases compared to 8 controls who were agricultural workers (no further analysis reported). In a study in Japan by Yoshimura et al. 2000[38] on hip replacement one man and 18 women, and among controls 2 men and 15 women were agricultural workers or fishermen (no further analysis reported).

In a case-control study by Thelin, 1990 [43] a total of 105 men, aged 50-70 years who have had a THR because of hip OA were selected from hospitals in two cities of Sweden. As controls 222 men living in the same area were randomly selected from the national register of the Swedish population.
Exposure was assessed by using a questionnaire to obtain the occupational history from the age of 15 years. The association between hip OA and work as a farmer showed positive associations for farmers working 1-10 years as a farmer OR=2.1, 95%CI=1.1-4.3, and working >10 years as a farmer OR=3.2, 95%CI=1.8-5.5. There was also found an association between hip OA and work including tractor driving OR=2.2, 95%CI=1.3-3.9, and work with milking OR=2.2, CI=1.3-3.7 (not adjusted for confounders).

In a cross-sectional study Croft et al. 1992[40] selected men, aged 60-76 years from a list from five rural general practitioners at random. 890 answered the questionnaire. A total of 289 men (defined as cases) reported having worked at some time in farming, and 123 had spent their entire careers in office work (defined as controls). Earlier total hip replacement was confirmed by hospital notes. Where a radiograph showing the hips was taken in the past 6 months, the film was reviewed. Other participants were invited to a new x-ray examination. Hip joint space narrowing ≤1.5 mm in at least at one hip was classified as hip OA. 167 male farmers (farming> 1 year)(28 with hip OA) and 83 sedentary workers (20 with OA) were available for the analyses. The association between hip OA and work as a farmer was increased for both working as a farmer 1-10 years OR=5.8, 95%CI 1.1-31.5 and for exposure to farming ≥10 years of farming OR=10.1, 95% CI 2.2-45.9 (results adjusted for age). The significant differences remain significant when adjusted for height, weight, and presence of Heberden’s nodes.

Axmacher et al. 1993[39] made a study among 16,250 farmers in a county of Sweden. By questionnaire, farmers reported if they had had a X-ray examination. 440 colon examinations and 472 urograms were available for review. 50 cases (47 men, 3 women) of hip OA were found (defined by joint space narrowing <4 mm). The prevalence of hip OA was calculated for male and female farmers and compared to males and females in the general population (taken from an earlier population study). The results for males were: age 45-49 years 3.9 % (farmers) and 0.4% (controls); age 50-54 years 6.4% (farmers) and 0.8% (controls); age 55-59 years 13.4% (farmers) and 1.2% (controls); age 60-64 years 16.9% (farmers) and 1.6% (controls), and for age 40-64 years 8.0% (farmers) and 0.8% (controls). For females the results for age 40-64 years was 1.3% for female farmers and 0.8% for females from the general population.

Jensen et al. 1994[41] made a register linkage between a Danish Hospitalisation Register and registers on occupational status, income, taxation, and education. (The Danish Occupational Hospitalisation Register). The Register included 1,251,590 men, and 1,022,282 women with an occupation. Cases were defined as those hospitalised with a diagnostic code ICD8 713.00 (= hip OA). The validity of the diagnostic code have been investigated and for surgical diagnoses was shown to be 85%. (first diagnostic code). Occupations (by job-title) were used to rubricate the level of exposure. Among 63,990 male farmers, 1,131 with a diagnostic code 713.00 (hip OA) were found during the period 1981-90. The standardized hospitalisation rate (SHR) for farmers was SHR=273, 95% CI 258-290, and for farmers' assistants SHR 134 (110-163).

In a case-control study, Thelin et al. 1997[42] selected all radiological examinations of the pelvis and the hip joint performed during 1986-1988 at three departments of radiology in a Swedish county. The radiographs were re-evaluated and only subjects <70 years of age were included. Cases were defined as hip OA with joint space narrowing <3mm. 216 of these completed a questionnaire including questions about previous occupations. For each case, two controls were selected from a local population register and matched for age, sex (all were males), and place of residence. 479 controls answered the questionnaire.
The risk of hip OA was increased for working more than 10 years as farmers compared to farmers working <1 year. For 11-20 years of farming the OR= 2,81, CI= 1,31-6,03, for 21-30 years farming OR= 7,35, CI= 2,87-18,8, for >30 years farming OR= 3,82, CI= 2,41-6,06. The risk was also increased for farm workers, with OR= 2,53, CI= 1,36-4,72 (11-20 years of farming); OR= 4,41, CI= 1,31-14,8 (21-30 years of farming), and OR= 6,43, CI= 1,83-22,5 (>30 years farming).

The risk of hospitalisation due to hip OA was investigated in a cohort study by Tüchsen et al. 2003[45]. Four consecutive cohorts of all gainfully employed Danish men, aged 20-59 years, were followed-up in relation to hip OA. Exposure was classified by job-title (most important occupation in 1980, 1985, 1990 and 1993). Subjects were followed in relation to first hospital admission with hip OA (diagnostic code (ICD-8=713.00 or ICD-10=M16) from 1981 to 1985, 1986 to 1990, 1991 to 1993, and 1994 to 1999, respectively. The standardized hospitalisation ratios (SHR)were calculated for different occupations. The results showed that self-employed farmers had a significant increased SHR, ranging from 281 to 286 in the four cohorts (time-periods). Employed men in agriculture had a significant increased SHR ranging from 138, 160 to 189 in the three cohorts (1986-90, 1991-1993, and 1994-1999, respectively).

In a case-control study by Thelin et al. 2004[44] 369 (321 men, 68 women) farmers with total hip replacement or had x-ray verified hip OA with a JSN <3mm comprised cases. The controls (389 farmers) were selected among members of the Swedish Farmers' Safety and Preventive Health Association and were matched by age, sex, and residential area. The average age was 62 years (40-71 years) for cases and controls. Controls who had visited a doctor because of hip symptoms were excluded and replaced by a new control. Exposure was measured by structured interviews. There were questions about type of farming, animal handling, type of animals, tractor driving, working hours for specific tasks, and working conditions when young. The work situation was noted when they had the first symptoms of hip disorders, and when they were 30, 40, or 50 years old. Farmers working >5 h /day in livestock buildings (OR= 1.6), and those who had farrowing work with sows, (OR= 1.5) were over-represented among cases, and farmers working on large farms >100 ha were under-represented among cases, (OR= 0.6). When adjusted for different kinds of work tasks the significant differences increased.

Construction work

The association between hip OA and employment as a construction worker have been investigated in six studies[24;25;33;35;36;41]. To provide an overview of the studies on construction workers, the study population, age of the participants, participation rate, exposure assessment, the diagnostic criteria, adjustments, results, and study design are presented in Table 4. The studies have already been described in relation to heavy lifting and only the conclusions specifically about construction workers are repeated.

Typpö, 1985[33] showed a prevalence of hip OA for construction workers 61% compared to office workers 41% (Results not further analysed). In a cohort study by Vingård et al 1991[36] the relative risk for hospitalisation due to hip OA for construction workers was increased with a RR=1.66, 95% CI 1.32-1.87 when compared to a low exposure group. The relative risk to receive disability pension for construction workers was RR=5.3, 95% CI 2.6-10.6 compared to subjects never exposed to any of 20 most exposed occupations in another study by Vingaard et al. 1992[35]. Croft et al. 1992[25] showed significantly increased hip OA among workers with employment 1-9 years OR= 3.3, CI= 1.2-9.2, but not for ≥10 years of employment in construction work OR= 0.5, CI= 0.1-2.3. Jensen et al. 1994[41] found among 3,281 construction workers (unskilled) 30 with hip OA, which leads to a SHR 151, 95% CI 102-216 compared to the general working population. Coggon et al 1998[24] reported in a case-controls study among the men who reported that the job involved heavy lifting >25 kg 23 cases and 18 controls that were construction workers.

Climbing stairs or ladders

As a part of the study, five studies investigated the relationship between climbing flights of stairs or ladders and hip OA[24;25;30;37;38]. The studies are described in detail in relation to the description of heavy lifting and the study population, age of the participants, participation rate, exposure assessment, the diagnostic criteria, adjustments, results, and study design are shown in Table 3. Only the conclusions on climbing stairs are repeated.

Croft et al. 1992[25] showed no significant associations between 'all OA cases' and 'severe OA cases' and climbing ladders (defined as climbing ladders 1-19 and ≥20 years) or climbing flights of stairs (defined as >30 flights of stairs/day 1-19 years or ≥20 years). Vingaard et al. 1997[37] investigated women and showed positive association between hip OA and climbing stairs for medium exposure versus low exposure RR= 1.3, 95%CI 0.8-2.0 and for high exposure versus low exposure RR= 2.1, 95%CI 1.2-3.6. For the exposure of climbing stairs (climbing more than 30 flights of stairs during an average working day) the odds ratios for males were OR=1.3, 95% CI 0.7-2.5 (exposure <10years), OR=2.3, 95%CI 1.1-4.9 (10-20 years), and OR=1.8, 95% CI 0.9-3.4 (>20 years) in a study by Coggon et al. 1998[24] For women, there were no significant associations at any level of exposure. For the association between hip OA and climbing stairs (>30 flights of stairs in an average week) no significant relationship was shown: first job unadjusted OR 0.8 (95%CI 0.4-1.6), main job OR 1.0 (95%CI 0.5-1.9) in a study by Yoshimura et al. 2000[38]. Lau et al. 2000[30] showed that the association between hip OA and climbing stairs was significantly increased for men with an odds ratio 8.7, 95%CI 1.8-42.7 and for women OR=2.5, 95% CI 1.0-5.9.

Summary

All but one[28] study revealed a positive association between hip OA and heavy lifting compared to no or low physical work-load (defined in various ways). The OR ranged between 1.5-12.4. Eleven studies reported a statistically significant outcome with an odds ratio range of OR 2.0-12.4[24;25;27;29-36;38].
In eight studies, the exposures were reported as low versus high exposure[27;29;32-37], while in six studies, it was defined as kilograms lifted[24-26;28;30;38].
14 studies investigated the association between farming and hip OA[24;25;29;33;35;36;38-45]. All the evaluated studies showed a positive association between farming and development of hip OA, especially for a history

of farming ≥10 years. The outcomes range between OR 2-13.8. The results showed an association for self-employed farmers and for farm workers.
In six studies, the risk for hip OA in relation to construction work have been investigated[24;25;33;35;36;41]. All studies showed a positive association with odds ratios range of 1.5-7.0, but it was only significant in four of the studies [25;35;36;41].
Three of five studies showed a significant association between climbing stairs and hip OA[24;30;37]; in two studies, an association was found for men with OR range of 2.3[24] (exposure 10-19 years for climbing more than 30 flights of stairs every day) and 3.9[30] (climbing >15 flights of stairs every day), and in one study a positive association was found for women [37] with OR 2.1 (high exposure versus low).

Knee osteoarthritis

Case definition

Osteoarthritis of the knees is characterized as localized damage on joint cartilage and underlying subchondral bone. When it is extensive, this loss is visible on radiographs as joint-space narrowing (JSN), bone changes with increased sclerosis of the underlying bone, osteophyte formation and occasional subchondral cysts. In the knee, medial tibiofemoral osteoarthritis is most common, and osteoarthritis in the lateral part of the knee is less common. In clinical practice, a diagnosis of osteoarthritis of the knees is normally based on the combination of typical symptoms of restricted knee movements on clinical examination, and changes on the radiographs. Similarly, in assessing the need for surgical intervention, most account is taken of the extent of pain and disability combined with the radiographic findings of severe osteoarthritis.
The clinical symptoms of knee osteoarthritis are joint pain and functional impairment. Pain is usually aching in character, initially pain occurs with motion; pain at rest, and particularly at night, is found as the disease advances. Stiffness occurs particularly in the morning, or after inactivity during the day, limitations in motion develop as the disease progresses. Physical signs include localized tenderness and crepitus of the joint, particularly with motion. Joint enlargement and fluid may be observed with acute flares. Referred pain, and pain in the nearby structures, is common (pes anserinus syndrome). Medial joint osteoarthritis (OA) is significantly associated with disability. Also patellofemoral joint OA is often associated with disability and can occur in the absence of tibiofemoral joint disease[104]. There are no specific diagnostic laboratory abnormalities, and synovial fluid examination reveals normal findings.
In 1986, the American Rheumatism Association developed clinical classification criteria for symptomatic knee OA [105]. The combination of findings with the highest sensitivity and specificity was knee pain and radiographic osteophytes and one of following criteria: age >50 years, morning stiffness <30min; and/or crepitus on active motion. These criteria have been criticised because the control group included a large extent of patients with rheumatoid arthritis, which might be the reason that osteophytes and high age and not joint-space narrowing were defined as the optimal discriminative features.
In 1963, Kellgren & Lawrence [74] established the most used radiographic criteria, in which OA is graded from zero to four: grade 0 is normal, 1 is doubtful narrowing of joint-space with possible osteophytes, 2 is definite osteophytes with absent or questionable narrowing of joint space, 3 is moderate osteophytes with definite narrowing, some sclerosis, and possible deformity; and 4 is large osteophytes with marked narrowing, severe sclerosis, and definite deformity. Others, and especially surgeons, mostly use the criteria established by Ahlbäck[106] when evaluating if there is an indication for knee replacement. The anterior-posterior, bilateral weight bearing radiograph of the knee in extension, taken with the patient in a standing position with the toes pointing straight ahead and with equal weight on both feet has been the normal recommended procedure for detecting knee OA.
There is incomplete concordance between the radiographic findings and clinical symptoms. Only 30-40% of those with radiographic changes have symptoms[2]. Kellgren and Lawrence showed[69] that while 7% of subjects (miners and non-miners) without radiological changes had complaints of pain in the knees, 19% of those with slight x-ray changes had knee pain, and 70% of the subjects with severe X-ray changes. 55-85% of those with Kellgren & Lawrence grade 3-4 knee osteoarthritis have symptoms[107]. In general the

concordance increases with the severity of radiographic findings. Because of the difficulty in describing symptomatic osteoarthritis, many of the epidemiological studies of work-related osteoarthritis have used radiographs as the criteria defining the disease.
In this review, epidemiological studies using a case definition including the Kellgren & Lawrence criteria for knee OA, grade 2-4, total knee replacement (TKR) or waiting for a knee replacement, and hospitalised/ getting a disability pension with a diagnostic code ICD 8 =713.01 or ICD10=M17(= knee OA) are discussed in detail.

Exposure definition

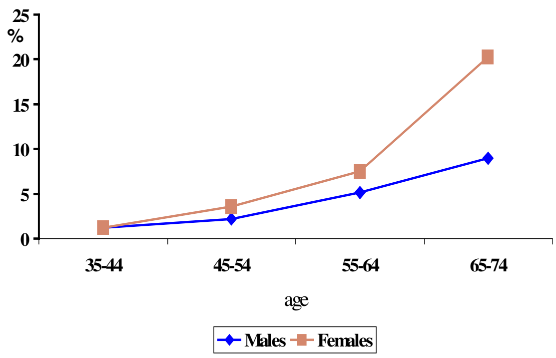
The methods of obtaining information about the exposure in epidemiological studies on knee osteoarthritis are similar to the methods used in general in epidemiological studies on ergonomic demands including those for hip OA. The measurement of heavy lifting in relation to the development of knee OA should preferably include three dimensions to illustrate the exposure: 1) definition of the individual loads in kg, 2) the number of loads lifted every day, and 3) the duration of exposure (years). For climbing stairs the exposure should preferably include the number of stairs climbed every day and the duration of the exposure. The exposure measurement for kneeling/squatting should include the time spent every day in kneeling working position and the duration of years with kneeling/squatting. Only a few studies have included all three dimensions; studies including all type of exposures, including use of job-title are discussed in detail.

Major non-occupational risk factors for knee osteoarthritis

Subjects whose parents had OA have an increase risk of getting OA themselves. Persons with hand OA may also be at high risk of developing incident or progressive knee OA. A sibling study on the risk for developing knee OA reported a double risk for knee OA in siblings compared with the general population (OR 2.9 for tibiofemoral OA and OR 1.7 for patellofemoral OA)[108]. The best clinical marker of such a predisposition may be the presence of Heberden's nodes. Subjects who have definite Heberden's nodes were more likely to have knee OA with OR 1.7, 95% CI 1.0-3.2 (men) and OR 3.8, 95% CI 1.8-7.7 (women) in a study by Coggon et al[72].

The prevalence of OA in knees is correlated with age, and women are more often affected with knee OA than men, especially after the age of 50 years, as shown in Figure 1 (based on data from Anderson and Felson, 1988[53]). By the age >50 the female: male ratio for symptomatic knee OA is described as 2:1[7]

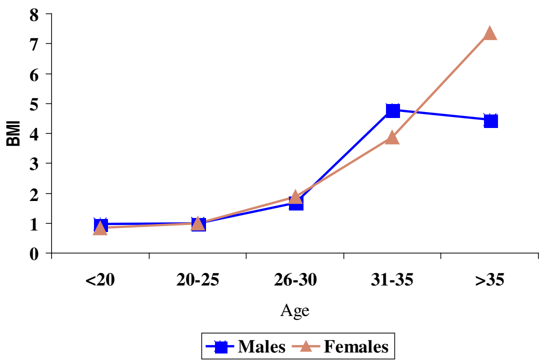
Figure 1. Knee osteoarthritis; by age and gender[53].



Overweight persons more often develop knee OA than do persons who are not overweight regardless of whether it is symptomatic OA or radiographic tibiofemoral or patellofemoral OA[109;110]. In a big population study, the Framingham study, a significant association was shown between knee OA and BMI >30 with an odds ratio OR>2 for men and women[53]. In another big population study, NHANES I, obese women with

BMI >30 had almost four times the risk of knee OA as women whose BMI was <25. For men with BMI>30 the risk was increased 4.8-fold compared with men with BMI<25[53]. Figure 2 shows the association between BMI and knee OA for men and women (based on data from Anderson and Felson, 1988[53]). Coggon et al. 2000[72] found an association between knee OA and BMI for men OR=2.4, 95% CI 1.4-4.3 (BMI 25-29), and OR=6.3, 95% CI 2.8-14.3 (BMI ≥30) and for women: OR= 4.3, 95% CI 2.5-7.3 (BMI 25-29), and OR=11.1, 95%CI 5.9-20.9) compared to subjects with a BMI<25. Coggon et al. 2001 showed that the risk for developing knee OA was increased to an OR 6.8 (95% CI 4.4-10.5) in people with a BMI>30. They also found that in people with a combination of obesity, definite Heberden's nodes, and previous knee injury, the relative risk for developing knee OA greatly increased to RR of 78 (95% CI 17-354)[111].

Figure 2. Knee osteoarthritis; by body mass index (BMI) and gender[53].



Weight loss may prevent disease in the knees, and those who are overweight are at high risk of disease progression, and are likely to have a progressive disease course[112].

Earlier cruciate ligament damage or meniscal tears are strongly associated with subsequent knee OA. A number of recent publications have documented long-term follow-up of radiographic changes after meniscectomy[113-115]. Meniscectomy has been shown to cause a 6-fold increase in the relative risk for developing knee OA compared with not-operated controls[116-118]. All who have undergone a total meniscectomy are at high risk[119;120], but people who have had only a partial resection also appear to be at increased risk, but partial resection results in less radiographic changes over time than does total meniscectomy[116;121]. A history of previous major knee injuries are shown to increase the risk of knee OA[1;122;123]. In the Framingham study, men with a history of a major knee injury have 5-6 times the risk of knee OA compared with those without such a history; for women the risk was >3 fold[124]. A study by Cooper at al., 1994[56] showed that a history of knee injury acted independently of occupational knee bending as a factor for OA (subjects with an knee injury, OR=7.8, 95% CI 3.0-20.2, and subjects with a knee injury and kneeling OR 7.6, 95% CI 2.1-26.9). Coggon et al. 2000[72] found an association between earlier knee injuries and knee OA for men OR=6.9, 95% CI 3.6-13.1, and for women OR= 3.1, 95% CI 1.7-5.5. Nearly the same result was shown by Lau et al. 2000[30] and Holmberg et al. 2004[67]. Lau et al. 2000[30] also showed an association for subjects exposed to both joint injury and lifting weights (>10 kg >10 times/week) with an odds ratio 25.9, 95% CI 8.1-82.4, which may suggest that there may be an interaction between joint injuries and load bearing in the aetiology of knee OA. The results were confirmed by a study of Enderlein & Kasch[122].

Elite runners appear to be at increased risk for knee OA in later life[87-93]. Moderate regular running has low, if any, risk of leading to knee OA[90;125]. Compared with controls, soccer players have in some studies an increased risk of knee OA even if they have not had former major knee injuries[117;126;127]. In one study of elite football players from England, 13% of ex-football players and 2% of controls reported having hip OA[128]. The risk is much higher in elite than in non-elite soccer players in a study by Roos et al. 1994[117]. The prevalence of knee OA among non-elite soccer players was 4.2%, among the elite soccer players 15.5%, and among controls 1.6%. Among elite soccer players without diagnosed earlier injuries, the prevalence of knee OA was 11%. After excluding subjects with known knee injuries, there was no difference between non-elite soccer players and controls, but still a higher rate of knee OA among elite players. In a study by Kujula et al. 1995[126] of former top-level athletes, the prevalence of knee OA was 3% in shooters, 29% in former soccer players, 31% in former weight lifters, and 14% in former runners. Soccer players had the highest prevalence of tibiofemoral OA (26%) and weight lifters the highest prevalence of patellofemoral OA (28%). By logistic regression analysis, the risk of knee OA was increased in subjects with previous knee injuries OR 4.73, 95% CI 1.32-17.0, in subjects with a high BMI at age 20 OR 1.76 (95% CI 1.26-2.45), in subjects with previous participation in heavy work OR 1.08 per work-year, and in subjects with work load including kneeling or squatting OR 1.1 per work-year.

Several epidemiological studies provide evidence that oestrogen replacement therapy is associated with a reduction in the risk of knee OA in women after the age of 50 years[62;85;98-102]. In a study by Sandmark et al. 1998[129], the risk of developing knee OA did not seem to be influenced by the use of contraceptives.

In some studies, smoking is reported to decrease the prevalence of knee OA[30;65;70;100;109;130]. In all the studies, there was a tendency to dose-response-relationship; smokers had a stronger inverse relation than light smokers. Two of the possible explanations are that chemicals in the cigarette smoke may change the cartilage or bone nutrition, or that smokers have more frequent breaks in their work. No other biological plausible explanation for that association has been found. Schouten et al. 1992 showed that current smoking was not a prognostic factor for cartilage loss in a 12-year follow-up study (OR= 0.96, 95% CI 0.34-2.75).

Results

Epidemiological studies

Table 1b shows the number of epidemiological studies that remained after applying the inclusion criteria on the search divided on knees and the relevant work demands, the diagnostic criteria, and the exposure assessment used in studies.
For knee OA, the diagnostic criteria in 60% of the studies were defined by radiographs using the criteria from Kellgren and Lawrence [74]. Disease was defined as radiographic findings of grade ≥2, and for severe osteoarthritis grade ≥3. In 26% of the studies, total knee replacement or waiting for one was used as the diagnostic criterion, and in 14% of the studies the diagnoses leading to hospitalisation or disability pension were used.

Heavy lifting and/or work involving heavy lifting

Heavy lifting

The association between knee OA and heavy lifting have been investigated in16 studies[30;35;36;53-65]. Study - population, age of the participants, participation rate, exposure assessment, the diagnostic criteria, adjustments, results, and study design are shown in Table 6.

Anderson & Felson, 1988[53] used data from the United States first National Health and Nutrition Examination Survey 1971-1975 (HANES I), and included 5,193 participants aged 35-74 years of whom 315 had radiological knee OA grade 2-4 according to the criteria used by Kellgren & Lawrence. The radiographs were single non-weight-bearing x-ray for both knees. Exposure was obtained by using current occupation. For each occupation, the physical demand measures for each occupation was coded in following categories: 1, sedentary; 2, light work; 3, medium work; 4 heavy work; or 5, very heavy work. The occupation was grouped in seven categories (professional/technical, manager/ administrative, sales, clerical, craftsman, operative/transport, labour/service worker).

The association between knee OA and physically heavy work was positive, but not significant, for men aged 55-64 years, OR 1.88, 95% CI 0.88-3.99. For women the association was significant at age 55-64 years OR 3.13, 95% CI 1.04-9.39, while no associations were shown in younger age groups (adjusted for race, education level, and body mass index.

As a part of the Framingham Heart Study (1983-85), subjects participated in the Framingham Knee Osteoarthritis Study, a longitudinal cohort study, including 1,376 subjects (569 men and 807 women) with a mean age of 73 years. Knee osteoarthritis was defined as grade 2-4 changes (Kellgren & Lawrence) on weight-bearing radiographs. Severe knee OA was defined as ≥ grade 3 OA. 176 men and 279 women had knee OA grade 2-4, and 90 men and 123 women had severe knee OA (≥grade 3).
Exposure was defined by current occupation (the occupation that they had from examination 1 (1948-51) through examination 6 (1958-61) when examined in the Framingham Heart Study. For each occupation the physical demand measures for each occupation was coded in following categories: 1, sedentary (lifting maximum 5 kg, only occasionally walking/standing); 2, light work (lifting maximum 10 kg with frequent lifting or carrying 5 kg, frequent walking/standing); 3) medium work (25 kg maximum with frequent lifting or carrying of up to 12.5 kg); 4) heavy work (lift 50 kg maximum with frequent lifting or carrying of up to 25 kg); or 5, very heavy work (lift more than 50 kg with frequent lifting or carrying more than 25 kg). Each job has also been coded in relation to knee bending (0= no knee bending, 1=knee bending, kneeling, or couching, or crawling). The occupation was grouped in the categories (professional/technical, manager/administrative, sales, clerical, craftsman, operative/transport, labourers/service worker) housewives, and no single occupation or unemployed.
The association between knee OA and lifting showed no significant differences either for men or for women. Men in occupations which required knee bending and at least medium physical demands had higher rates of radiological knee OA (grade 2-4) with an OR =2.22, 95% CI 1.38-3.58, and of severe knee OA≥ grade 3 an OR=1.98, 95% CI 1.08-3.64. For women no significant differences were shown.

In a cohort study by Vingård et al. 1991 [36] the study population comprised subjects born between 1905 and 1945, living in 13 counties in Sweden, who reported the same occupation in 1960 and 1970. Subjects hospitalised during the period 1981-1983 for osteoarthritis in the knee (ICD 8 diagnostic-code = 713.01). The study is described in detail in relation to hip OA and heavy lifting. The population consisted of 116,581 males and 18,434 females classified with high exposure and 91,057 males and 24,145 females with low exposure. During 1981-1983, 321 males and 66 females (classified with high exposure) and 200 males and 48 females (classified with low exposure) were hospitalised due to osteoarthritis of the knee. The relative risk for hospitalisation due to knee OA in high versus low exposure occupations were for males (born 1905-1924) RR=1.2 (95% CI 0.9-1.5) and (born 1925-1945) RR=1.4, 95% CI 1.1-1.9. The relative risk for females (born 1905-1924) was RR=1.4, 95% CI 0.6-3.2 and (born 1925-1945) RR=1.9, 95% CI 1.3-2.9. For construction workers the relative risk was 1.36, 95% CI=1.13-1.79, and for farmers RR=1.46, 95% CI 1.23-1.98 when compared to the low exposure group. For females, the only significant risk for hospitalisation due to knee OA were found in female cleaners RR=2.18, 95% CI=1.26-3.00. The relative risks have been adjusted for age, county, and the degree of urbanisation.

Bagge et al. 1991[54] studied sub-samples of 79-year-olds within a longitudinal prospective study of 70-year-old people in Göteborg. The population comprised 70-year old people (n=1148) which was followed-up at age 79 years (the survivors n=538). A second cohort was established and re-examined at age 79 years (n=538). From this two samples of 79-year-old a random sample of 136 men and 207 women were selected for radiological examination (weight-bearing anterior-posterior radiographs) and cases was defined as grade ≥2 knee OA according to the criteria of Kellgren & Lawrence.
Previous occupational physical activity was defined in four categories: 0=sedentary, 1=light(occupations including daily walking), 2=moderate (occupation including daily walking, climbing stairs, or lifting, and 3=heavy. The variable (numbers from 0 through 3) was multiplied by the number of years in which the subjects had been active in these occupations and divided by 10, giving a maximum score of 16 (equal to 53 years in a heavy occupation). The exposure information was collected by interview of the 79-year old.

68% of male subjects had knee OA grade ≥2 (score 0-1) compared to 39% (score 2-3), 58% (score 4-9), and 47% (score 10-16). For women the results were 48% (score 0-1), 56% (score 2-3), 69% (score 4-9), and 67% (score 10-16).

In a case-control study of Vingård et al. 1992[35] the study population comprised a random sample of Swedish men born between 1915-1934, living in Stockholm county and receiving a disability pension (1307 subjects) due to knee OA during the years 1979-1984 (181 subjects). The study is described in detail in relation to hip OA and heavy lifting. The diagnoses were collected from the physicians' certificates. The control group was 298 men from the general population in Stockholm in the same age group. The relative risk of receiving disability pension due to knee osteoarthritis for persons with medium and high exposure to physical work loads was compared to those with low exposure and were increased for medium exposure: RR=4.5, 95% CI 2.6-7.6, and high exposure: RR=14.3, 95% CI 8.1-25.4. The relative risk of receiving disability pension for farmers (at least 10 years) compared to those never exposed to any of 20 most exposed occupations was RR= 5.3, 95% CI 1.4.-19.7, for construction workers RR=5.1, 95% CI 2.6-10.6, and for carpet layers and painters RR=23.1, 95% CI 3.0-178.3.

Schouten et at, 1992[63] made a 12-year follow-up on all subjects born after 1909 who had a radiograph (weight-bearing) of the knee taken in a population survey carried out in Holland during the period 1975-1978. Subjects with a grade ≥2 knee OA at baseline answered a questionnaire including detailed occupational history, number of years employed, heavy lifting, and knee-bending activities. At baseline, 422 subjects had radiological grade ≥2 knee OA. At the follow-up radiographs from 233 subjects were re-evaluated. Only 121 of the 233 subjects who in the first study were deemed with knee OA were now judged to have grade ≥2 OA at baseline and 21 to have grade ≥3 knee OA. At follow-up, 69 of the 142 subjects (58 males, 84 females) were graded as grade ≥3 and 48 with cartilage loss. Only 105 of the 142 subjects have been or were still employed.
The results showed that cartilage loss developed between baseline and follow-up was not associated with earlier employment in occupations with medium or heavy lifting (unadjusted, or adjusted for age, gender, and body mass index).

A study by Cooper et al. 1994[56] comprised 2,101 men and women, aged 55 years or more, from general practice in England. The subjects had to answer a questionnaire including a question: 'Have you had pain in or around a knee on most days for at least a month, at some time during the past year?'. 273 (65%) of the subjects who responded positively and 240 of those who responded negatively to the question were examined by radiographs (weight-bearing, anterior-posterior and lateral). Tibiofemoral as well as patello-femoral OA was assessed. Of those with knee pain, 109 (30 men, 79 women), aged 55-90 years (mean 73 years) had radiological changes of at least grade 3 according to the Kellgren & Lawrence criteria (moderate to severe OA). Controls were selected among those without knee pain and with not more than grade 1 knee OA. Exposure was assessed by interviews of life-time occupational history with details of the main job entailed eight specific physical activities, including, heavy lifting, kneeling, and climbing stairs.
The association between knee OA and heavy lifting (lifting weights over 25 kg in an average working day) was positive (not significant) with an OR 1.4, 95% CI 0.5-3.7. For climbing stairs (>10 flights/day) the OR was 2.7, 95% CI 1.2-6.1. The interaction between occupations involving heavy lifting and repetitive knee flexion (kneeling, squatting or climbing stairs) on the risk of knee OA showed an OR 5.4, 95% CI 1.4-21, adjusted for age and Heberden's nodes.

Elsner et al. 1996[58] made a case-control study during 1989-93 including 115 men and 86 women with radiological knee OA. Cases were defined by joint space narrowing, subchondral sclerosis, and osteophytes at the radiographs (not further defined and not scored in categories). Patients without knee pain from a general practitioner and an eye-specialist were chosen as controls, 95 men and 87 women. Cases and controls were asked to fill out a diary on daily working activities during all the years they have been employed and to classify the jobs as including heavy lifting (5-20 kg, or >20 kg).
83% of cases and 54% of controls were >45 years of age. The risk of developing knee OA in relation to heavy lifting >20 kg was not significantly increased, either for men OR= 1.3, 95% 0.73-2.35, or for women

OR=1.5, 95% CI 0.56-4.18. Among the reported occupations only metal workers had an increased frequency of knee OA, especially if they have been employed >10 years OR = 3.8, 95% CI 1.38-10.5.

Sahlström & Montgomery, 1997[61] made a study on occupational factors involved in knee OA From the archives of the Department of Diagnostic Radiology at the Malmö University Hospital all radiographs of weight-bearing knees from the period 1982-1986 were reassessed. 266 subjects with at least grade 1 OA according to the criteria by Ahlbäck were found, and a reduction of joint space on at least 3 mm was used as case definition. Controls constituted of 463 age- and sex-matched subjects from a general population register from the same area (2.6% with radiographic knee OA). Exposure was assessed in two ways; the subjects answered by questionnaire for each occupation if the occupation involved walking, lifting objects weighing at least 15 kg from one level to another, climbing stairs, climbing ladders or jumping. Four experienced hygienists assessed the exposure from job-title and grouped in three classes:1) light knee moment: sitting, walking, carrying, 2) medium: lifting with bent knee and carrying, climbing stairs and ladders with/without carrying objects, 3)heavy: as 2) with additional jumping with and without carrying objects. There was a tendency to classify knee movement as being heavier from questionnaires compared with the industrial hygienists.
The results showed an association between knee OA and weight-bearing knee bending (medium plus heavy) with an OR 1.9, 95% CI 1.4-2.7. The association disappeared (OR=1.1, 95% CI 0.7-1.8) when adjusting for sitting, overweight, and knee injuries.

In a case-control study by Coggon et al. 2000[55], 518 patients (205 males, 313 females) listed for surgical treatment during a two-year period for knee OA (total knee replacement, TKR) was compared with an equal number of controls. The study population comprised subjects from three English districts. The participation rate was 55%. Subjects were aged 47-93 years (mean 72 years). Radiographs for each cases were reviewed and 78% of the cases had knee OA, grade 3-4 according to the criteria by Kellgren & Lawrence. Exposure was collected by interviews of life-time occupation and classified by different physical activities, including heavy lifting (≥10 kg >10 times/week, ≥25 kg > 10 times/week, and ≥50 kg >10 times/week). They were also asked about climbing stairs (>30 times/day).
The association between knee OA (placed on a waiting list for TKR) and heavy lifting was positive (odds ratio ranged between 1.2 to 1.9) for lifting >10 kg, >25, and >50 kg for men and women, but it was only significant for >10 kg (men and women), and for lifting >25 kg (only women). The association became more pronounced for subjects employed in occupations which involved both heavy lifting and kneeling/squatting with an odds ratio for men OR= 2.9, 95%CI 1.3-6.6 and for women OR= 4.2, 95% CI 1.5-12.1.
For climbing stairs OR=2.3, 95%CI 1.3-4.0) (men) and OR=0.7, 95%CI 0.3-1.6(women) was found. All results were adjusted for body mass index, Heberden’s nodes, and previous knee injuries.

Lau et al. 2000[30] carried out a study in Hong Kong. Patients with knee OA were recruited over a 3-months period from the orthopaedics units of seven regional hospitals. All patients were diagnosed as having primary knee OA, the radiographs were reviewed and only patients with grade 3-4 knee OA according to the criteria made by Kellgren & Lawrence were included in the study. Patients with reumatoid arthritis or ankylosing spondylitis or other causes of secondary arthritis were excluded. Controls were consecutive patients who in the same period attended eight public-sector general practice clinics from the same area. Controls were matched by age and sex and residential area. Only controls without complaints of pain or an earlier history of self-reported arthritis were included (34% were excluded for this reason). 166 men and 492 women were included as cases (and the same number of controls). The exposure data were collected by interviews with a structured questionnaire. Subjects were asked about each job they had held for at least one year if they had had physical activities lifting loads (≥10 kg; ≥50 kg/day) for 1-10 times or >10 times/week. They were also asked if they had climbed ≥15 flights of stairs/day.
The association between knee OA and heavy lifting was significantly increased for lifting weights of ≥10 kg (men: OR5.8, 95% CI 3.1-10.8; women OR 3.0, 95% CI 2.2-4.1) and ≥50 kg (men: OR 7.1, 95% CI 3.1-16.2; women: OR=2.9, 95% CI 1.9-4.5) when lifting >10 times/week. The association was weaker for lifting < 10 times/week. The association between knee OA and climbing stairs was also significantly increased with

an odds ratio for men OR=4.1, 95%CI 2.1-8.2, and for women OR=6.1, 95% CI 3.5-10.8. The differences remained significant when adjusted for body mass index, knee injury, and smoking habits.

In a case-control study by Sandmark et al. 2000[73] men and women, aged 55-70 years living in 14 counties in Sweden who had undergone a total knee replacement 1991-1993 because of primary knee OA were defined as cases. Controls were men and women randomly selected from a central population register and matched by age and sex. Subjects with earlier trauma or surgery of the knee, rheumatoid arthritis, poliomyelitis, rickets, and musculoskeletal malformations were excluded. 325 male and 300 female cases and 264 male and 284 female controls participated in the study.
The information of exposure (life-time) was collected 1-4 years after TKR by questionnaire and the questions included details about the duration of exposure, stairs climbed in number/day, and lifting (frequency and weight). The exposure was accumulated for each physical activity and classified in low, moderate, and high exposure. The exposure measurement also included job-title. Workers in certain occupations were considered to involve the highest physical load according to criteria earlier described by Vingård et al.[36].
Men and women who had a job-title considered to involve heavy physical loads to the knees for at least 10 years had an increased risk of developing knee OA compared to workers unexposed to heavy jobs with an odds ratio 2.5, 95% CI 1.7-3.6 for men and OR=2.5, 95% CI=1.6-3.9 for women. Male construction workers, farmers and forestry workers all showed significantly high risks of getting knee OA.
Lifting was associated with an increased risk of getting knee OA in men (high exposure: OR= 3.0, CI=1.6-5.5, and medium exposure OR= 2.5, CI=1.5-4.4) and for women (only high exposure OR=1,7, CI= 1.0-2.9). Climbing stairs was positively associated with knee OA in men and women (odds ratio ranged between 1.2 and 1.7), but the result was only significant for medium exposure in women. All results are adjusted by age, body mass index, and smoking.

A case-control study by Seidler et al. 2001[64] included 195 subjects (105 males, 90 females), aged 25-80 years (mean 55 years) with radiographic knee OA (grade 1-4, not further defined) and 325 controls, aged 25-80 years (mean 35 years) with radiographic excluded OA and 108 chosen as a random sample (only men, mean age 57 years) from the general population in Frankfurt/Main. Subjects with earlier meniscus lesions were excluded.
Information about exposure was collected by questionnaire, and was classified by job-title, duration of the employment in the occupation and the duration of different work loads such as lifting (in weight 5-20 kg, 20-50 kg, and >50 kg) and the duration in years. They also had to state whether they have had work which involved daily kneeling (no, 1-10 years, or >10 years).
The association between knee OA and heavy lifting was positive only for daily lifting of >50 kg for men (OR=3.4, 95% CI 0.7-17.2) and women, but none of the results showed significant differences, as shown in Table 6. The association between knee OA and daily lifting or working daily in kneeling working positions was increased with an odds ratio 2.7, 95% CI 1.0-7.1 for men, but not significant for women (only few participants with physical work loads). Male construction workers had an increased risk of getting knee OA with an odds ratio 5.1, 95%CI 1.3-20.1, while there was no other occupations showing significant differences. The odds ratios were adjusted for age, body mass index, sports activities, and sex.

Dawson et al. 2002[57] made a case-control study including women, aged 50-70 years from England. Cases were defined as women who reported at least moderate knee pain on most days in the past month and who had been placed on a waiting list for a TKR during the previous 12 months. Controls were chosen from local general practice and matched by age. Subjects reporting knee pain during the past 3 years were excluded as controls. Cases and controls were excluded if they had had earlier knee surgery, rheumatoid arthritis, psoriasis, Paget's disease, or other joint diseases. Of 246 potential study participants, 59 were defined as potential cases and 187 as potential controls. 29 cases (participation rate 49%), and 82 controls (44%) were included in the study. Exposure assessment were made by interviews of physical work loads for each occupation held more than 1 year. The question was ' did this job in your life involve any of the following activities on a regular basis (at least two days per week)?'. The activities included among others: lifting (not further defined).

The association between knee OA (TKR) and lifting was calculated by comparing subjects with <24 years of lifting with subjects lifting 24-33 years, and >33 years. The results showed a positive association between TKR and heavy lifting, but the result was only significant for lifting 24-33 years with odds ratio 7.31, 95% CI 2.01-26.7. The odds ratios were adjusted for age, and general practitioner.

In three health districts in Japan, Yoshimura et al. 2004[65] made a case-control study including women, aged 45 years or more, with knee pain, walking difficulties, and radiographic knee OA classified as grade 3 or more according to the criteria made by Kellgren & Lawrence. Subjects with a history of knee injury the previous year, rheumatoid arthritis or ankylosing spondylitis were excluded. Controls were randomly selected from the general population and matched by age and residence. 101 cases (participation rate 84%) and 101 controls (participation rate 59%) were included in the study. For exposure assessment a questionnaire was used which asked about eight types of physical activity in the initial job and in the job at which the subject had worked longest. Lifting was divided in lifting weights ≥10 kg, ≥25 kg, and ≥50 kg more than once during an average working week.
A positive, but not significant association between knee OA and lifting ≥25 kg in their main job was shown with an odds ratio 1.91, 95% CI 0.92-3.96. The prevalence of construction workers among cases was 35%for the first job and among controls it was 17% (OR=2.62, 95% CI 1.37-5.03). For the main job the OR was 1.3, 95% CI 0.69-2.46.

Occupations involving heavy lifting an/or kneeling/squatting

The association between knee OA and occupations involving heavy lifting have been investigated in 11studies[35;36;41;62;65-71]. Some of the studies have been described in detail in relation to heavy lifting, and only the results on the relationship between knee OA and occupations involving heavy lifting and/or kneeling/squatting are repeated. Study population, age of the participants, participation rate, exposure assessment, the diagnostic criteria, adjustments, results, and study design are shown in Table 7.

Vingård et al 1991[36] found a relative risk RR=1.36 (95% CI=1.13-1.79 for hospitalisation due to knee OA in construction workers, and RR=1.46, 95% CI 1.23-1.98 for farmers when compared to a low exposure group. For females the only significant risk for hospitalisation due to knee OA were found in female cleaners RR=2.18, 95% CI=1.26-3.00. The relative risk for receiving disability pension was increased for farmers (at least 10 years) compared to those never exposed to any of 20 most exposed occupations RR= 5.3, 95% CI 1.4.-19.7, for construction workers RR=5.1, 95% CI 2.6-10.6, and for carpet layers and painters RR=23.1, 95% CI 3.0-178.3 in a study by Vingård et al.1992[35]. Male construction workers, farmers and forestry workers all showed significantly high risks of getting knee OA in a study by Sandmark 2000[73]. Yoshimura 2004[65] showed a prevalence of 35% construction workers among cases (first job) and among controls it was 17%. (OR=2.62, 95% CI 1.37-5.03) and an OR= 1.3, 95% CI 0.69-2.46 (main job). Jensen et al. 1994[41] made a study using the Danish Occupational Hospitalisation Register with 1,251,590 men included (7588 knee OA). Cases were defined as those hospitalised with a diagnostic code ICD8 713.01 (= knee OA). In skilled construction workers, the standardized hospitalisation rate (SHR) was SHR=159, CI=117-217, and SHR for carpenters SHR=144, CI=101-201.

Kellgren and Lawrence, 1952[69] made a study on 84 miners, 45 manual workers, and 42 office workers. Radiological examination included X-rays on the low back, neck, hands, and the knees (AP and lateral views of the right knee).Knee OA was defined in five categories (0=no changes, 1=doubtful, 2=minimal , 3= moderate , and 4= severe). Doubtful and minimal were grouped together as slight, and moderate and severe as severe. 40% of miners, 20% of manual workers, and 14% of office workers had slight knee OA, and 6% miners, 2% manual workers, and 0% office workers had severe knee OA.

A study by Wickström et al. 1983[71] comprised 252 active concrete reinforcement workers and 231 painters aged 24-64 years. Radiographs were taken and classified into no, mild, moderate, and severe knee OA. Both groups were video-taped, and the results showed that reinforcement workers lifted weights >20 kg six times/hour and painters seldom lifted such work loads. The painters worked kneeling or squatting 12% of the work time compared to concrete reinforcement workers who worked in kneeling or squatting positions 6% of the work-time. JSN was shown in 2% of both groups and degenerative changes (all OA) were found in 22% of concrete reinforcement workers compared to 20% of painters.

In a cross-sectional study with a cross sectional design, Kivimäki et al. 1992[70] included 168 floor layers and 146 painters(controls) aged 25-45 years. Weight bearing (AP and lateral) radiographs were taken and knee OA (TFJ and PFJ) was assessed by two physicians, and osteophytes and JSN was determined.
Exposure was assessed by using video-recordings for 12 hours including both carpet layers, floor layers, and painters. The exposure assessment included kneeling working positions, but not heavy lifting.
The results showed no differences in JSN of the patello-femoral joint or the medial tibiofemoral joint in carpet- and floor layers compared to painters. The prevalence of knee osteophytes was 58% among carpet- and floor layers, and 41% among painters.

500 50-year-old miners with at least 25 years employment as miners and 500 controls without knee straining sports activities or work loads were included in a cross-sectional study by Greinemann 1997[66]. Radiographs of the knees and clinical examination were used for classifying osteoarthritis in the patello-femoral joint (PFJ) and the tibio-femoral joint (TFJ). For exposure the job-titles were used.
TFJ knee OA was shown in 13% of the miners compared to 1% of the control group and PFJ OA was shown in 11% of miners compared to 3% of the controls.

Jensen et al. 2000[68] made a study on male floor layers and carpenters compared to a control group of graphic designers without physically demanding work loads. 133 floor layers, 506 carpenters, and 327 graphic designers, aged 26-72 years without earlier knee traumas answered a questionnaire which included number of years in the occupation. 50 floor layers, 51 carpenters, and 49 graphic designers were chosen at random (2/3 reporting knee pain, and 1/3 reporting no knee pain from each occupational group) for radiological examination (non-weight-bearing AP and lateral projections). The x-rays were assessed independently by two radiologists and classified according to the criteria of Kellgren & Lawrence. OA cases were defined as grade ≥2. Video-recordings of representative work tasks were carried out for floor layers and carpenters to measure the time spent in kneeling working positions. No measurements were made in relation to heavy lifting. Floor layers had a high frequency of kneeling working positions, and carpenters a moderate amount, compared to the controls without kneeling working activities. The amount of heavy lifting was assumed to be the same for floor layers and carpenters and to be none for graphic designers. Prevalence estimates for knee OA was 14% for floor layers, 8% for carpenters, and 6% for graphic designers. Prevalence estimates for symptomatic knee OA in workers aged ≥50 years was 64% for floor layers, 22% for carpenters, and 6% for graphic designers.

Holmberg et al. 2004[67] made a case-control study on 778 subjects having radiographically verified knee OA (TFJ) (joint space narrowing ≤3 mm, earlier TKR or X-rays diagnosed by a radiograph as advanced, severe or moderate) and 695 controls from three counties in Sweden. Cases with chronic inflammatory joint disease were excluded. Exposure measurement was by job-title. The association between knee OA and work showed only a significant risk for knee OA in men, who had worked for 11-30 years as construction worker with an OR= 3.7, 95% CI 1.2-11.3 and for women who had worked as farmers 11-30 years with an OR=2.1, 95% CI 1.0-4.5 (after adjustment for heredity, overweight, smoking, civil status, self-employment, knee injury, meniscal lesion, and sports activity). For men working <11 years as construction workers or farmers there was no significantly increased risk either for men or for women.
For men and women working as farmers >1 year there was a significantly increased risk of getting knee OA if they had a body mass index ≥26 compared to those with a lower body mass index with an adjusted OR=3.1, 95% CI 1.4-6.7 (men) and OR=4.4, 95% CI 2.2-8.6 (women).

Heavy- lifting and kneeling/squatting

The association between knee OA and kneeling combined with heavy lifting have been investigated in 4 studies investigating heavy lifting combined with kneeling/squatting[55;56;59;64]. The following studies have been described earlier in detail in relation to heavy lifting, and only the conclusions about heavy lifting in combination with kneeling/squatting are repeated. Study population, age of the participants, participation rate, exposure assessment, the diagnostic criteria, adjustments, results, and study design are shown in Table 8. As a part of the Framingham Heart study, Felson et al. 1991[59] showed that men in jobs which required bending, kneeling, crouching, or crawling and at least medium physical demands had a increased risk of developing radiological knee OA (grade 2-4) with an OR =2.22, 95% CI 1.38-3.58, and of severe knee OA≥ grade 3, OR=1.98, 95% CI 1.08-3.64. For women, no significant differences were shown. The interaction between occupations involving heavy lifting and repetitive knee flexion (kneeling, squatting, or climbing stairs) and the risk of knee OA showed an OR 5.4, 95% CI 1.4-21, adjusted for age and Heberden's nodes in a study by Cooper et al. 1994[56]. Coggon et al. 2000[55] showed an association between knee OA and subjects employed in occupations which involved both heavy lifting and kneeling/squatting with an odds ratio for men OR= 2.9, 95%CI 1.3-6.6 and for women OR= 4.2, 95% CI 1.5-12.1. Seidler et al. 2001[64] found an odds ratio for knee OA OR=2.7, 95% CI 1.0-7.1 for men, and not significant for women (amongst only few participants with physical work loads) for daily lifting or working daily in kneeling working positions.

Climbing stairs

Four studies have investigated the association between knee OA and climbing stairs or ladders[30;56;72;73]. The studies have been described in detail in relation to heavy lifting, and only the conclusions about exposure involving climbing stairs are repeated. Study population, age of the participants, participation rate, exposure assessment, the diagnostic criteria, adjustments, results, and study design are shown in Table 9.
Cooper 1994[56] found an association between knee OA and climbing stairs (>10 flights/day) with an OR 2.7, 95%CI 1.2-6.1, adjusted for age and Heberden's nodes. In a study by Sandmark et al. 2000[73] climbing stairs was also positively associated with knee OA in men and women (odds ratio ranged between 1.2 and 1.7), but the result was only significant for medium exposure in women. All results were adjusted by age, body mass index, and smoking ([73]). Coggon, 2000[55] showed an positive association between knee OA and climbing stairs with an odds ratio OR=2.3, 95% CI 1.3-4.0 (men), but not positive for women OR=0.7, 95%CI 0.3-1.6. All results were adjusted for body mass index, Heberden's nodes, and previous knee injuries. Lau et al.2000[30]showed that the association between knee OA and climbing stairs was significantly elevated with an odds ratio for men OR=4.1,95%CI 2.1-8.2, and for women OR=6.1, 95% CI 3.5-10.8. The differences remained significant when adjusted for body mass index, knee injury, and smoking habits.

Summary

16 studies dealt with the associations between knee OA and heavy lifting[30;35;36;53-65]. All these studies revealed a positive association between knee OA and heavy lifting compared to no/low exposure. Seven of the 16 studies reported a significant outcome with an odds ratio ranging between 1.4-7.3[30;35;36;53;55;57;62].
Ten studies measured the exposure for heavy lifting as low versus high exposure[35;36;53;54;57;59-63], while it was defined as the amount lifted in kilograms[30;55;56;58;64;65] in six studies.
In four studies, the association between working in the construction industry and knee OA have been investigated[35;36;41;67]. All the studies revealed a positive association (statistically significant) with OR ranging from 1.36 to 2.5. In two studies, the association between work as a floor layer and knee OA has been investigated, one study showed an association for OA in the tibio-femoral joint[68] and the other study showed only an association with OA in the patellofemoral joint (workers ≤45 years of age)[70].
Four of the studies[55;56;59;64] included results of a combination of exposure of 'heavy lifting and kneeling or squatting'. For all these studies, the association between 'heavy lifting and kneeling/squatting' for men showed a stronger association with an increase in the odds ratio ranging from 2.2-5.4 compared to exposure to 'heavy lifting' alone. For women, only one study showed a significant association with an odds ratio 4.2[55].
In all four studies on the association between knee OA and climbing stairs, there was a positive association (for men in three studies and for women in one study) with OR range of 1.2-6.1. The association was significant in one study including both males and females[56]), and in two studies (only females)[30;73] and in two studies (only males)[30;55]. The measures of exposure in the studies were: climbing stairs > 30 min/day,

climbing ladders or flights of stairs>30 times/day, and climbing stairs ≥15 flights/day. No dose-response relationship has been investigated.

Discussion

In addition to the restrictions of the included studies, this review may have some limitations. Not all potentially relevant studies could be found by using the internet-based search. Some of the studies were identified from references in other studies. Although a great effort was made to identify the relevant literature, some studies may have been missed, some because different keywords were used in the databases, some because they are not indexed in databases, or indexed in other databases than the databases used for this review, and some because they have been written in languages other than English, German, or the Scandinavian languages e.g. French or Spanish. In the computer-based searches, however, very few references in other languages emerged.

Publication bias, which can have the result that negative studies are less likely to be published than positive studies, may be a risk, but is presumably more likely when studies are not well designed. For this type of study, it is supposed that well-designed studies would be published even if the results were negative, because there are no obvious conflicts of interest.

Good exposure data is much wanted but seldom provided, and some of the major problems in the reviewed studies are related to measurement of the occupational exposure. The heterogeneous nature of the exposure in many occupations, the variation over time, the long duration from first exposure to the development of OA makes it difficult to obtain relevant measure of exposure. Many studies classified the level of exposure by job title, and this exposure-measurement used alone may lead to misclassification. Classification into heavy and light occupation with no further differentiation gives only a little more information. For more detailed information, questionnaires or interviews are used. In those studies with retrospective data, it is obviously difficult for the subjects to remember the level of exposure precisely, especially many years after the event, and misclassification due to memory-deficit (recall bias) can occur. In studies using self-reported questionnaires or interviews, the self-evaluation may in addition lead to information bias, because subjects with hip- or knee-pain have a tendency to over-estimate their physical work load. Only one study used video-recordings to observe the amount of weight lifted[71].

In a large Swedish cohort study, which included 250.000 workers, the risk for hospitalisation for hip and knee OA was higher for workers in occupations with heavy physical work, and in occupations such as farmers and construction workers[36]. Another study by Vingård et al. 1992[35] reported a high frequency of farmers and of construction workers on disability pension because of OA in the hip or knee. A possible explanation for this association between occupations with high physical work-load and hip and knee OA is that people with highly physically-demanding jobs will seek joint replacement or disability pension earlier and more often than people in less demanding occupations, because they are more handicapped because of their OA and not because of a higher prevalence of OA. Self-employed farmers with hip or knee OA may seek joint replacement more rapidly than other workers (referral bias) as the necessity of continuing in physically arduous work could be greater and the options for alternative employment more limited. These factors could be a problem in the studies using hospitalisation, total hip or knee replacement or waiting for one as in the Swedish studies, but the high risk is also reported in population based studies and cross sectional studies using radiological changes as their diagnostic criteria. Also, 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, veno- or angiography)[29;33], there have been a consistent excess risk of hip OA among subjects with work including heavy lifting and among farmers.

The development of OA normally takes many years. Pain-disabled people who work in heavy occupations who cannot meet the requirements for managing their physically heavy job tasks will tend to leave their trade; this results in the ”Healthy worker effect’’. In studies, the healthy worker effect may cause underestimates of risk, if only people who are working are included as subjects. Many of the studies in this field have also included people who are no longer working in their former trade, thus avoiding the healthy worker effect.

Hip osteoarthritis

Epidemiological evidence

Heavy lifting

Eight case-control studies on the association between hip OA and heavy lifting were included in this review[24;25;30-32;34;35;37;38]. Seven studies showed a significant association with an odds ratio range of 2.4-12.4 for men, and two studies showed significantly increased risk for women with an odds ratio range of 2.9-4.1. Four cohort studies dealt with the association between hip OA and heavy lifting[26-28;36]. Three of the studies showed a positive association with an odds ratio range of 1.5-2.2[26;27;36], but it was only significant in two of the studies[27;36]. The case definition was THR[27], JSN <2mm[28], Kellgren & Lawrence OA grade 2-4[26], and hospitalized with the diagnostic code ICD 8 (713.00=hip OA)[36].

Based on the study design, the sizes of the population, and the exposure measurements the studies by Vingård et al. 1991[34] Coggon et al. 1998[24], Croft et al. 1992 [25], and Flugsrud et al. 2002[27] were considered to be of the highest quality.

In the study by Vingård et al. [34] men with highest exposures to heavy lifting (measured as lifted tons) up to the age of 49 years had a significant increased relative risk for THR with an odds ratio 1.84. One of the strengths of this study was that interviews including information on exposure were also made on subjects who had had their first myocardial infarction. The differences between these men and the men from the general population in relation to the self-reported physical work-load were very small and non-significant. The work load were divided into three groups: light, medium, and heavy work loads where those unexposed and the 5% lowest exposed were defined as low exposure and medium and high exposure was divided into two equally large groups. This may lead to a risk that cases with a high exposure may be misclassified as medium exposure, or visa versa, and this may lead to a dilution of the results.
In the study by Coggon et al. 1998,[24] a dose-response relationship was shown between hip OA and lifts of weights at least 10 times/week for at least 10 years for men with an odds ratio OR=2.3(≥10 kg), OR=2.7(≥25 kg), and the odds ratio OR=3.2(≥ 50 kg). No associations between heavy lifting and hip OA was apparent in women. The strengths of this study were the high number of participants, the specified work demands, and the description of the study and the analysis. The participation rate was 55% (including primary exclusion) and of those who were invited to participate only 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 report their past exposure more completely than the controls (recall bias).

In the study by Croft et al. 1992 [25] cases and controls were selected among men who had had an intravenous urogram. For severe cases of hip OA(JSN≤1.5mm), the risk was increased for the men employed >20 years in jobs which required heavy lifting with an OR=2.5. The strength of this study is the use of intravenous urograms to establish the study-population. 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 method of selection of the subjects. The exposure measurement for lifting was defined as lift >25.4 kg and the duration of years with heavy lifting. The frequency of lifting was not described. Many workers may lift 25 kg every day (or every week), and it is a question if this criteria is sufficient to classify workers as subjects with heavy lifting. This may lead to a misclassification of non-cases as cases. The potential misclassification of the exposure is most probably non-differential and may thereby dilute the associations.

In the cohort study by Flugsrud et al. 2002[27] data was used from a cardiovascular screening. The large number of participants, the high participation rate (92%), and the prospective design gave strength to the study. The exposure measurement used in this study was reported as the physical activity during the 12 months preceding screening. There may be a correlation between the 12-months activity in middle-aged people, but this association is not confirmed in the study, and there may be a risk of misclassification. In general people have the jobs with the highest physical demands when they are young and still capable of lifting and carrying, and they tend to change occupation to less heavy work when they grow older. It seems most likely that workers in middle-age with heavy work also have had heavy work when they were younger. The classification of physical activity was performed on the background of reported occupation during a 12 months period in 1977-83. This may lead to a misclassification, most probably a non-differential misclassification, and may thereby dilute the associations.

In the study by Vingård et al. 1991 [36], the relative risk for hospitalisation due to hip OA in high versus low exposure occupations was significantly associated for males and was positively associated for women (but not statistically significant). The strength of this study is the relatively large number of participants and OA-cases. Job title was used for classification of the exposure (job held for at least 10 years). It might be a relatively crude approximation for exposure assessment, and it may lead to misclassification. Non-differential misclassification may occur if low exposure occupations have been classified as high exposure or visa versa and this may lead to a bias towards zero and the risk in some groups may thus be underestimated. Little data was available for each of the participants and the results were only adjusted for age and residence, but not for earlier traumas, body mass index or other relevant confounders.

Jacobsen et al. 2004[28] used data from The Copenhagen City Heart Study, a longitudinal health survey of an adult population in the county of Copenhagen, Denmark. Within a population of more than 4500 subjects 105 men and 167 females subjects with radiographic joint space narrowing ≤2mm were found.
No significant relationship was found in the study between radiographic features (not further defined) and heavy lifting (results not shown). The overall design of the study seems good, but data, results, and statistical analysis were not shown, which makes it difficult to evaluate the study further.

In the study by 1981-1983 by Cvijetic et al. 1999[26] the study population, and the participation rate is not described. The radiographs were only taken of the right hip and they used a description of hip OA (Kellgren & Lawrence Grade 2-4) which may also include subjects without JSN and this may thereby dilute the results. The greatest limitation of this study in relation to heavy lifting is the definition of the exposure groups, where the specification for carrying heavy weights was >5 kg. This limit may be altogether too low, and thereby dilute the associations.

Yoshimura et al. 2000[38] carried out a case-control study in Japan. The design was similar to the design used by Coggon et al.1998[24]. Cases consisted of only 11 men and 103 women and the greatest limitation of this project is the relatively small number of cases. The low frequency may be caused by the low prevalence of hip OA reported in Japan in general. The survey included a much higher frequency of women. Women do not in general have as high physical demands in their jobs as men, and, in this study, it was only few women who reported heavy lifting (>50 kg). The exposure was defined as lifts each week, a relatively low amount of lifting, which may lead to misclassification. In spite of these factors, the results showed a positive association. Lau et al. 2000[30] made a study with similar design including subjects from Hong Kong. The results showed a dose-response relationship of heavy lifting for men, but not for women. As among Japanese, only very few Chinese subjects (and especially male subjects) have had THR, probably because of a lower prevalence of hip OA among Asians. The greatest limitation of this project is therefore the relatively small number of cases, especially of men, included in the study. The low frequency of participants would decrease the possibility of showing differences between cases and controls, but, in spite of this problem, significant differences are shown for both men and women for heavy lifting. The relative strength of this study, compared to the study by Yoshimura[38], is the higher number of controls included.

Vingård et al. 1997[37] made a case-control study that only comprised women with THR (cases) and without hip problems (controls). No association was shown between hip OA and heavy lifting. There is no information in the paper on how many of the women, had work outside the home. Furthermore, traditionally heavy jobs are not common among women in Sweden. This may lead to misclassification, and a possible dilution of the results. In the questionnaire the lifts were divided into weights of (0-5 kg, 6-10 kg, 11-15 kg, 16-20 kg, and >20 kg), the frequency of lifting, and the duration of lifting (in years), but only the number of heavy lifts (not further defined) is reported in the paper. The weight of the individual lifts is not reported in the paper.

In the case-control study by Vingård et al. 1992[35] of a Swedish population receiving disability pensions, the diagnoses registered in this study were collected from physicians' certificates. A diagnosis of hip OA, which could be used to decide whether a person should have a disability pension would presumably include both a clinical and a radiological examination, but this is not described in the paper. If the diagnoses were imperfect, this could lead to misclassification, probably non-differential, which would lead to a bias towards zero and the risk may thus be underestimated. Subjects with heavy physical exposure may have a higher risk of getting disability pensions if the physical work load contributes to or causes the disease. Another explanation could be that subjects in physical demanding occupations have an increased risk of getting symptoms caused by the disease which may lead to disability pension without a causal explanation in relation to the work load. This will lead to an overestimation of the risk.
The exposure has been classified as physically high work load on the hips and not especially related to heavy lifting. The occupations which were classified as having a heavy physical work load on the hips included, for example, farmers, forestry workers, miners, metal workers, carpet layers, fishermen, smiths, plumbers and pipe-fitters, concrete workers, and carpenters, are traditionally occupations including relatively heavy lifting. A potential misclassification of the exposure would most probably be non-differential and may thereby lead to a bias towards zero and the risk may thus be underestimated. A possible confounding factor may be age, for which they did not adjust. But the relative risk has been analysed with and without age stratification, resulting in the same magnitude of the relative risk.

In a case-control study by Roach et al. 1994 [32] the greatest limitations included the high exclusion-rate of the study. The initial study-population consisted of 693 subjects identified from a radiology database of all patients who received a radiograph because of hip complaints or had a total hip replacement. Of these 504 (73%) were selected for a questionnaire, and only 332 (48%) were used in the final analysis. The control group was selected on the basis of IVP films and contained a large proportion of subjects with benign prostatic hypertrophy or cancer. In this study, cancer was treated as a potential confounder, because, in some studies, heavy work has been shown to be protective against cancer. The cases were chosen among subjects who were already receiving treatment, and these cases may seek hospitals or health care more frequently than the general population. The participants were only classified according to whether they had a light or a heavy work. This may improve the accuracy of the work loads and may lead to a misclassification, which most probably is non-differential and may thereby dilute the associations.

Occupations, which involve heavy lifting

The association with hip OA has been studied in relation to certain specific occupations. Farmers and construction workers tend to have job tasks involving heavy lifting, and it has therefore been decided to include studies concerning these occupations in the review.

Nine case-control studies have investigated the association between hip OA and farming[24;25;29;33;35;38;42-44], but the quality of the study design and the results are low in four of them[24;29;33;38] and they will not be further discussed here. Among the five studies of higher quality a positive association (significant in three) was found between hip OA and farming in four of them with an odds ratio range of 2.0-13.8.
Five cohort studies investigated the association between hip OA and farming[36;39-41;131]. One of the studies was of poor quality (no control group, no analyses, case definition JSN<4mm)[39] and it is not discussed further here. The four studies showed a significant increased risk of hip OA among farmers with an odds ratios range of 3.8-10.1.

The most extensive studies on farming in respect of study design, size of the population, the case definition, and the exposure measurement have been the four studies of Croft et al. 1992 [25], Croft et al. 1992[40], Thelin et al. 1997[42] , and Tüchsen et al. 2003[45].

In a case-control study by Croft et al. 1992 [25], cases and controls were selected among men who had had an intravenous urogram. For severe cases of hip OA (JSN≤1.5mm), the risk was increased, but not significantly for farmers employed >10 years. The strength of this study is the use of intravenous urograms; this may avoid a bias which can be caused if cases with symptomatic hip disorders seek medical-treatment more often than other people. The number of severe cases were relatively small (farmers n=19), which may explain the non-significant differences for farmers.

The study by Thelin et al. 1997[42] selected all radiological examinations of the pelvis and the hip joint performed during a 3-year period. The risk of getting hip OA was significantly increased for farmers who have been employed more than 10 years compared to subjects who have worked as farmers <1 year. Radiological findings on previous taken x-rays were used as case definitions in this study. In this way, selection bias may be avoided compared to studies using total hip replacement as the criteria. 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, and there may even be a selection bias in the study, although it is another case definition. The cases and controls were matched by age, a well known confounder. No adjustment have been made for others confounders.

Croft et al. 1992[40] selected men from five rural practitioners at random, and chose the farmers (cases) and office workers (controls) for further x-ray examination. The association between hip OA and work as a farmer was increased for both working as a farmer 1-9 years OR=5.8 and for work ≥10 years as a farmer OR=10.1. The greatest limitations in this study may be the relatively low participation rate and the overrepresentation of symptomatic farmers among the participants (78%) compared to 54% of asymptomatic farmers, 60% of symptomatic, and 57% of asymptomatic office workers. But 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 the controls. Radiographs were selected in different ways, but all radiographs were reviewed, including those for subjects who have had total hip replacement. The results have not been adjusted for earlier hip injuries as exclusion of subjects with rheumatoid arthritis, congenital malformations, ankylosing spondylitis are not described.

The risk of hospitalisation due to hip OA was investigated in a cohort study by Tüchsen et al. 2003[45]. Self-employed farmers had a significant increased SHR (standardized hospitalisation ratio) ranging from 281 to 286 in the four cohorts (time-periods). The methodological strength of this study is that all first hospital admissions due to hip OA in Denmark are included. One of the limitations of the study is that not all people with hip OA seek hospital-treatment for their problems, and there may be a selection bias if farmers seek medical care because of hip pain more often than the general population. Another limitation is the definition of hip OA (use of a diagnostic code) which is not so valid as if radiological joint space narrowing had been used. This may lead to a misclassification of subjects as OA-cases. The misclassification will probably dilute the risk and the SHR would go towards 100. The mean age in studies on hip OA has normally been approximately 60-65 years. This study includes relatively young subjects, age 20-59 years of age (average age not mentioned). It is only for the eldest in the population that the risk of hip OA is expected to be increased. Adjustments have not been made for known risk factors as body mass index, traumas, or sports activities. The study included only the working population, and farmers who had left their earlier occupation in farming because of a hip OA would therefore not be included in this study (healthy worker effect), and this will probably have diluted the calculated risk.

In a case-control study by Thelin, 1990 [43] the association between hip OA and work as a farmer showed a positive association for farmers working 1-10 years as a farmer OR=2.1, 95%CI=1.1-4.3, and working >10 years as a farmer OR=3.2, 95% CI=1.8-5.5. An association was also found between hip OA and work including tractor driving OR=2.2, 95%CI=1.3-3.9, and work with milking OR=2.2, CI=1.3-3.7. There was no adjustment for confounders. Cases were defined as subjects with THR. This may lead to a selection bias if farmers seek surgery more often than the general population. Job-title was used as the exposure definition. It will normally be much easier to remember a job-title and the years working in a specific occupation than to remember the physical activity during the past. There will, therefore, only be a small risk of recall bias in this study. In a case-control study by Thelin et al. 2004[44], farmers with defined JSN<3mm were compared to farmers without hip symptoms. The strength of this study is the high number of farmers who participated in the study. The study was done without a control group of non-farmers, and one can not thereby conclude if there was a higher risk among farmers than non-farmers, but it did investigate whether farmers with specific work-tasks were at higher risk of getting hip OA. For the work task 'tractor driving', which in earlier studies had been shown as a potential risk factor, an increased risk among some farmers could not be confirmed in this study. This may be explained by the fact that most farmers work with tractors and that tractor driving is something of a proxy for farming. In this study, there was no indication of any relationship between 'work as a farmer at a young age' and the development of hip OA. This may also be explained by the fact that it is common for farmers to begin work at an early age.

In the cohort study by Jensen et al. 1994[41] using the Danish Occupational Hospitalisation Register) the standardized hospitalisation rate (SHR) for farmers was SHR=273. The strength of the study is that it includes a high number of participants. The study have a longitudinal design, which may secure against information bias. The limitation of the study is that the register only includes job-title, which may lead to misclassification. The occupation may be poorly described, and the main job has been registered during 5-year periods, which may result in approximation. This can also lead to misclassifications. Unskilled workers such as the construction workers are a group, which often change occupation whereas farmers normally work within their occupation for many years without changing. The risk for misclassification is therefore probably higher among construction workers than among farmers. The case definition has been made on the basis of a diagnostic codes. A misclassification of the diagnosis will normally dilute any differences, and the risk estimate will tend to go towards zero. The study includes subjects that seek hospitals for treatment. If subjects in heavy work as farmers seek treatment more often than people in sedentary jobs there may be a risk for selection bias. The register only include subjects still at work. If workers such as farmers choose to leave their occupation, they are then not represented in this study (healthy worker effect), or if they change to work with less physical demands because of their hip OA, they would be represented in the new job category. This will probably be a differential misclassification and bias estimates for farmers downwards.

Six studies have investigated the risk of hip OA in construction workers[24;25;33;35;36;41] as a part of the study. In two of the studies, only the number of construction workers were mentioned[24;33]. Two studies showed an increased risk for hospitalisation due to hip OA (Vingård et al 1991[36], Jensen et al. 1994[41]), and in another study by Vingaard et al. 1992[35], the relative risk of receiving disability pension for construction workers was shown to be increased. There may in these studies be a risk for selection bias if subjects from physically heavy work seek hospital-treatment or get disability pension more often than others. Croft et al. 1992[25] showed significantly increased hip OA among construction workers with employment 1-10 years but not for >10 years of employment. The strength of this study is the use of intravenous urograms. A bias which can be caused if cases with symptomatic hip disorders may seek hospital-treatment more often than others may in this way be avoided. The total number of severe cases were relatively small, as was the number of construction workers, and the occupation 'construction worker' was not further defined. This may lead to misclassification if construction workers without heavy lifting are included in this group.

Climbing stairs or ladders

As a part of the study, five studies investigated the relationship between climbing stairs and hip OA[24;25;30;37;38]. Three studies showed a significant increased risk of hip OA. In two studies the risk were increased for women[30;37], and in two studies for men[24;30]. Only one study investigated the risk for climbing ladders and showed a positive but not significant association for climbing >20 years[25]. It is known that people with hip pain experience worse pain when climbing stairs. People in occupations which include work-tasks which include climbing stairs or ladders may seek treatment earlier than other workers because of pain. This could be a problem in the studies which used total hip replacement or waiting for one[24;30;37;38] as case definition. Only one study used radiographic OA as inclusion criteria and the association in this study was not statistically significant[25].

Definition of osteoarthritis

In eight epidemiological studies[25;28;29;39;40;42;44;132]on the relationship between hip OA and physical work load, the diagnostic criterion for OA was joint-space narrowing at radiographs ranging between <1.5 mm and < 4 mm, in one study the Kellgren and Lawrence criteria (grade 2-4 hip OA) was used[26], and total hip replacement or waiting for one have been used as diagnostic criteria[24;27;30;34;38;43] in 6 studies. Four studies used a diagnostic code for hospitalisation or getting a disability pension because of hip OA[35;36;41;45]. The radiographic diagnoses of hip OA only have relevance if it leads to symptoms or disability. In the studies using THR or waiting for surgery it can be expected that the subjects have symptomatic hip OA. There is no stringent definition of the cut-off point for joint-space narrowing as the primary criterion for hip OA. Croft et al.1992[25] evaluated two definitions of joint-space narrowing, 2.5 mm and 1.5 mm, based on the proportion of subjects each classified as abnormal. Only the more stringent cut-off point was clearly associated to other criteria such as pain and other radiographic changes. The more stringent definition was also more strongly associated with risk factors than the less stringent one. In a study by Jacobsen et al.2004[133] no association was found between occupational lifting versus no lifting among asymptomatic people with hip joint-space > 3 mm. Jacobsen et al. 2004 [77]showed an association between self-reported hip pain at a joint space width ≤2 mm.

Patho-physiological mechanisms

The pathogenesis of hip OA in relation to work loads has not been clarified. The forces that act on the hip in the standing position are 1/3 of the body weight. When lifting 12.5 kg the weight increases to 3 times body weight, and climbing stairs increases the load to 5-7 times body weight[34;134].
If mechanical effect is the primary cause of developing OA in the hip, obesity may also increase the risk of OA in the hip by increasing the load on the weight-bearing joints[16]. Alternatively, because obesity and OA are both associated with a genetic predisposition, it has been thought that the two conditions could be linked if the genes that cause obesity also predispose to OA, but this could not be verified in two large twin studies[78;108]. Another theory has been that obesity, by changing the hormone balance, may change the risk for OA. This theory is supported by the fact that obesity also may increase the risk for hand OA.
Another hypothesis for the pathogenesis of hip OA is that subchondral microfractures may induce OA[16]. Microfractures may occur when the joint is in extreme positions or when physical work load exceeds a critical level. Radin et al. 1972, 1975[135-137] describe that microfractures appear in the subchondral bone due to repeated high forces across a joint. The overlying cartilage has to absorb more force, which will cause degeneration of the cartilage. These studies indicate a possible patho-physiological mechanism by a mechanical effect and/or microfractures during repeated physical work load.

Exposure

In four studies on heavy lifting, 9 studies on farming, and 6 studies on construction, job-title was used to indicate the level of exposure.
In 10 studies on the relation with heavy lifting, and 5 on farming exposure information was collected by questionnaire or interviews on more specific physical activities.
In 4 studies[27;34;35;37], medium exposure compared to low exposure showed [27;34;35;37]a positive association with hip OA with OR ranging between 1.1 (females) and 4.1 (males). In five studies[27;34-37], high exposure compared to low exposure showed an OR ranging between 1.5 (females) and 12.4 (males). In the studies, there seemed to be a dose-response relationship with higher risks for the high exposure groups than for the medium exposed groups when both were compared to the low exposure groups.
In five studies, the weight of the lifts were more specified. In two studies the exposure were divided in 'lifts ≥10kg'; lifts ≥25kg or lifts ≥50 kg[24;38]; one study used only lifts ≥25 kg[25]; one study used lifts ≥40 kg[34], in one study were used lifting >1 tons, 1-2 tons, 2-5 tons, and >5-10 tons/per day, and one study used lifts ≥5 kg combined with standing/walking[26]. The four studies showed significantly increased risk for hip OA; in one study for lifting >25 kg > 20 years (only men)[25] , in one study for lifting both >10kg, >25 kg, and >50 kg

10 times/week at least 10 years (only men)[24], in one study there was an increased risk for lifting >10 kg more than 10 times/week, and for lifting >50 kg 1-10 times and more than 10 times/week for men. For women, only lifting >50 kg more than 10 times /week showed significant differences[30]. In two of the studies, there was no significant increase of hip OA[26;133]. On the basis of three of these studies[24;30;38], there seems [24;30;38]to be a dose-relationship with an increase in OR ranging from 1.2-1.9 for lifts ≥10 kg to OR 1.5-2.7 for lifts ≥25 kg and OR 3.2-8.5 for lifts ≥50 kg. The risk increases in relation to the amount lifted (≥10 kg, 25kg or 50 kg), with the frequency of lifting (1-10 times/week versus more than 10 times/week).
Only two studies investigated the importance of the duration of the exposure. Croft et al. 1992 showed a risk for severe JSN OR=1.2 for subjects lifting loads of 25 kg < 20 years compared to OR=2.5 for subjects who have lifted loads 20 years or more. In the study by Coggon et al. 1998 [24], at least 10 years of exposure showed an increased risk of hip OA compared to 0-10 years of exposure for heavy loads of >10 kg, >25 kg, and >50 kg. In the study by Vingård et al. 1991[34], the OR increased for subjects exposed to heavy weights after the age of 30 years (OR 2.74) compared to those exposed before the age of 30 years (OR 1.95). These results were confirmed by the study of Coggon et al. 1998[24], which also showed an increased risk of getting hip OA both for subjects exposed before and after the age of 30 years.

Vingård et al. 1991[34] used accumulated exposure between the ages of 16-50 years. The weight lifted/per day or per week was not described in the paper. A rough estimate of the exposure can be calculated by using a mean of 20 years of work (between 16-50 years of age) and 200 work-days/year. This leads to an average of <5 lifts/day in the low exposure group, 5-10 lifts/day in medium exposure group, and >10 lifts/day in the high exposure group for lifts >40 kg.

The studies are consistent in documenting an increase risk of hip OA among agricultural workers, but the precise mechanism for this association remains a subject of study. Many farmers grow up on the farm, and begin to work during childhood when the hip is not fully developed, and degeneration of the hip may be caused by the long-term heavy physical labour in farming. This theory thus could not be confirmed in a study of Thelin et al. 2004[44], but in this study all participants comprised farmers. The potential risk factors also include regular heavy lifting, prolonged standing and walking over rough ground and exposure to vibration from tractor driving. In a study by Croft at al., 1992[40], 91% of the farmers reported lifting or moving weights of 25 kg or more. This was confirmed in the study by Coggon et al.1998[24], where farmers and construction workers reported working in occupations involving lifting weights of 25 kg or more. These studies support that farmers do heavy lifting.
Heavy lifting has been a risk factor for hip OA in other occupations, such as construction workers, although the risk shown is not so consistent[24;25;33;35;36;41;45]. The reason for not-so-strong associations in studies on construction workers may be the result of inclusion of too few participants, and of misclassification of the work loads; the exposure in these studies have mostly been based on job title. In a study by Wickström et al. 1983[71], concrete reinforcement workers and painters were studied by video-recordings. The concrete reinforcement workers lifted heavy loads 5-20 kg 15 times/hour and loads >20 kg six times/hour. Painters (who are also construction workers) lifted loads 5-20 kg 6 times/hour, but only seldom lifted heavier loads. This study showed that there are great differences between different kinds of construction work in relation to the lifting of burdens both in frequency and in weight. These studies indicate that lifting heavy burdens is normal among farmers and among some of the construction workers.

In all the studies, the exposure information on climbing stairs was collected by questionnaire or interviews with physical activities specified. Only one study included informations on climbing ladders. For climbing stairs, the exposure definition differed from ‘number of stairs climbed during life-time’, to climbing >15 or >30 flights of stairs. The duration of climbing stairs ranged from more than 1 year to more than 10 or 20 years. There was a tendency towards a dose-response relationship in two studies on females with an OR=1.3 (medium vs. low exposure), and OR=2.1 (high vs. low exposure)[37] and an OR= 1.3 (<20 years of climbing stairs) and OR=2.3 (>20 years of climbing stairs).

Other findings

None of the identified studies have investigated the effect of physical work demands in relation to the prognosis of hip OA. Thus, conclusions based on scientific evidence in relation to this aspect cannot be drawn. Felson 1998[17] estimated the potential reduction in the incidence of symptomatic hip OA using different preventive strategies. By eliminating obesity, 26% of hip OA would be prevented in men, and for women, 27% of hip OA would be prevented. Based on the material from Vingård et al [31;34], Olsen et al [31] have [31;34]calculated the etiologic fraction of hip OA to 40% caused by physical work load.

In 7 studies[24;26;27;30;36-38], the association between hip OA and physical work loads have been investigated for women. The association were positive, but only significant in two of the studies in the highest exposure group, with OR ranging from OR 2.1-2.9[27;30]. All the studies revealed more significant results for men than for women. One of the explanations for this may be that many of the studies had too few female participants. In general, women do not have work-tasks with the same degree of physically heavy work-loads in their occupations as men do, and they 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 are equal to men if they have the same exposure.

There have been earlier reviews on the relationship between hip OA and occupational physical demands. Maetzel, 1997[138] concluded that studies suggest that the evidence between work-related exposure, particular farming, and hip OA was consistently positive, but weak. The review was only based on 5 studies. Bøggild et al. 1997[12] concluded that there was an increased risk for hip OA among farmers, and less evidence for an association among construction workers, and for work including heavy physical work-load.
Lievense et al. 2001[14] found moderate evidence for an association between heavy lifting and hip OA. This review was based on 16 studies compared to the five studies included in the review of Maetzel, and, notably, it included new research which had taken place between 1997 and 2001. Walker-Bone et al. 2002[23], in a review on musculoskeletal disorders in farmers, found strong evidence for hip OA among farmers. In November 2003, the Industrial Injuries Advisory Council in Britain concluded that people engaged in employed work for at least 10 years in aggregate as a farmer, farm worker, or farm manager who have been diagnosed with OA of the hip prior to surgery on the hip (painful hip and evidence of OA on X-ray) can be considered to have suffered an industrial injury[15].

Conclusion

In surveys with different study designs based upon these approaches, investigations from several countries have consistently shown an excess risk of hip OA among workers with heavy-lifting for many years. Exposure response associations have also been found in a number of studies, but these relations have not been fully characterized in terms of lifted weights (kg), frequency (number of lifts per day) and duration (years). It cannot be ruled out that information bias with respect to exposure may have occurred in case-control studies where the subjects retrospectively estimate their degree of heavy lifting. Also, selection bias in studies of THR studies or studies based on hospital discharges may have occurred, since subjects with heavy-lifting and hip OA may have more pain and seek medical help at an earlier stage than similar subjects without heavy-lifting. There may also be some misclassification with respect to x-ray diagnoses in some studies due to inadequate criteria or methods, but since 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.
Research investigation in relation to an association between hip OA and work as a farmer also exists from several countries. The studies, which have a wide range of study designs, have consistently shown an excess risk of hip OA among farmers. There is a substantial weight of evidence that the risk of hip OA is at least doubled for farming >10 years. The association has been found to a lesser degree in women.

There are relatively few studies investigating the association between climbing on stairs or ladders and development of hip OA. Although many of the studies show a positive association, these are not statistically significant, and no studies show a dose-response relationship. No studies were found for this review dealing with an association between heavy lifting combined with kneeling/squatting.

Knee osteoarthritis

Epidemiological evidence

Heavy lifting

11 case-control studies[30;35;55-58;60;61;64;65;73] on the association between knee OA and heavy lifting have been included in this review. Seven studies[30;35;55;57;60;61;73] showed a significant association with an odds ratio range of 1.4-7.1 for men, and in four studies[30;55;57;73] significant increased risk was shown for women with an odds ratio range of 1.7-2.9.
Five cohort studies deal with the association between knee OA and heavy lifting[36;53;54;59;63]. Two of the studies showed a significant association with an odds ratio range of 1.9-3.1[36;53].

Based on the study design, the size of the population, and the exposure measurement the studies by Coggon et al. 2000 and Sandmark et al. 2000 were considered as being of the highest quality[55;73].
In the case-control study by Sandmark et al. 2000[73], lifting was associated with significant increased risk of getting a total knee replacement in men (high exposure: OR= 3.0, and medium exposure OR= 2.5) and for women (only high exposure OR=1,7). Men and women in occupations involving heavy physical loads to the knees for at least 10 years had an increased risk of developing knee OA compared to workers unexposed to heavy jobs, with an odds ratio 2.5 for men and OR=2.5 for women. Male construction workers, farmers, and forestry workers all showed significantly high risks of getting knee OA. This very well-described study had the same limitations as all case-control studies, while the exposure assessment is retrospective, which might involve a certain degree of non-differential misclassification, giving a dilution of true risk for highly exposed and an overestimation or underestimation of the risk for medium exposed. In the study, they also used job-titles which may lead to a lower (but also existing) degree of misclassification.
In a case-control study by Coggon et al. 2000[55] the association between knee OA (placed on a waiting list for TKR) and heavy lifting was positive (odds ratio ranged between 1.2 to 1.9) for lifting >10 kg, >25, and >50 kg for men and women, but it was only significant for >10 kg (men and women), and for lifting >25 kg (only women). The association became more pronounced for subjects employed in occupations which involved both heavy lifting and kneeling/squatting with an odds ratio for men OR= 2.9 and for women OR= 4.2. The strengths of the study are the high number of participants, and that information of the occupation activities were collected by interviews (specified in different physical activities) instead of using only job-titles. The information about the occupational activities was collected retrospectively which might be susceptible to recall bias. One of the limitations of the study may be the low participation rate, especially among controls. It is possible that subjects with poorer social background were less willing to participate, but when adjusting for social class only small differences occurred. The case definition was ‘placed on a waiting list for TKR’. Subjects in heavy occupations may seek hospital care more often than subjects without heavy occupation and this may therefore lead to a selection bias. Subjects with knee pain may also recall their physical demands differently than subjects without knee pain and remembering past situations may be a problems for both cases and controls (recall bias).

[53]In a population-base cross-sectional study, (HANES I), Anderson & Felson, 1988[53] showed a positive, but not significant, association between knee OA and heavy physically demanding work , for men aged 55-64 years, OR 1.88 and for women OR 3.13, while no associations were shown in younger age groups (adjusted for race, education level, and body mass index.

The radiographs were taken as non-weight bearing which may lead to an underestimation of knee OA in this study. It is supposed that the underestimation will be the same among subjects with heavy physical work demands as among subjects without. The exposure was measured by current occupation when they join the study. Unskilled workers, especially, may have worked in many occupations with different physical demands, and there may be a risk of misclassification. When coding physical demands by using job-titles, there may also (even though more than 300 job-titles have been used) be a risk of misclassification. Non-differential misclassification may occur if low exposure occupations have been classified as high exposure or visa versa and this may lead to a bias towards zero and a possible risk in some groups may then be underestimated.

In the Framingham Knee Osteoarthritis longitudinal cohort study, Felson et al. 1991[59], the association between knee OA and lifting showed no significant differences either for men or for women. Men in occupations which required knee bending and at least medium physical demands had higher rates of radiological knee OA (grade 2-4) with an OR =2.22, and of severe knee OA≥ grade 3 an OR=1.98. For women, no significant differences were shown. The strength of this study is the longitudinal design, and the fact that the radiographs were taken weight-bearing. In this study, there was no significant relationship shown for women. One of the explanations may be that physical demanding jobs were uncommon among the women. Only 14 women reported heavy lifting (4 knee OA), and 13 women (2 knee OA) reported having knee bending and heavy lifting in their work. Although some of the jobs required knee bending, it was assumed that is was very mild in character and not enough to cause knee OA. 209 men were defined as having medium, heavy, or very heavy work demands; 136 were craftsmen (e.g. carpenter or foremen), 52 were labourers/service workers (e.g. farmers, janitors, maids) and the rest were professional/technical (n=80), manager/administrative (n=82), sales (n=34), clerical (n=39), operative/transport (n=76), and with no single occupation or unemployed (n=70). There may be a high risk of misclassification in this study and a dilution of the results, because it only included a few with really heavy physical work demands. Non-differential misclassification may occur if low exposure occupations have been classified as high exposure or visa versa and this may lead to a bias towards zero, and a possible risk in some of the groups may then be underestimated.

In a cohort study by Vingård et al. 1991[36], the relative risk for hospitalisation due to knee OA in high versus low exposure occupations for males was a range of RR=1.2-1.4 and for females a range of RR=1.4-1.9. The strength of this study is the high number of participants (including many OA-cases). The exposure was classified from job-titles by experienced persons, but there may be a risk of misclassification. The exposures were classified as high dynamic or static forces on the knee joint and not as occupations with heavy lifting. In a case-control study of Vingård et al. 1992[35], the relative risk to receive disability pension due to knee OA was increased for persons with medium (RR=4.5) and high exposure (RR=14.3) to physical work loads. The strengths and the weakness of these studies have been described in relation to hip OA.

In a longitudinal prospective study, Bagge et al. 1991[54] studied 79-year-old subjects and found no association between subjects with knee OA and earlier employment in jobs with heavy work loads. There are some limitations of the study, which is not well-described. 52% of males and 54% of the females had knee OA grade 2 or more in this sample of 79-year olds. The risk of getting knee OA was high in all subjects, which may lead to a risk of underestimation of a real risk. Only a few men were included in the study, and only 17 have been included in the highest exposure score category (only for subjects who worked for at least 33 years). At the score 3 (in the second lowest category) subjects should have had a heavy physical work load for 10 years, which in other studies is defined as heavy work. The exposure assessment was made retrospectively in 79 year old people (some perhaps with memory problems) and there may be a risk for misclassification (recall bias). All these factors may lead to a risk of underestimation. Only few men were still alive among the 79-year olds. Normally, there is an increased risk to die early in the lower working classes with the heaviest jobs. This may also lead to a risk of underestimation.

Schouten et at, 1992[63] made a 12-year follow-up on a population survey. Cartilage-loss developed between baseline and follow-up was not associated with earlier employment in occupations with medium or heavy

lifting. In this study, only a small number of the participants from the first study were included in the follow-up. One of the explanations was differences in the scorings of the radiographs. In the follow-up, a more restrictive scoring was used compared to the first study. This may lead to a misclassification of cases as not-cases. It also caused a very low number of participants in the study (n=105) and the numbers with and without heavy lifting are not shown. Cartilage-loss developed during the 12-year period may describe the prognosis for the cartilage. The relation between cartilage-loss and JSN has not been described.
It is possible that not all the participants have had an occupation with heavy lifting during the follow-up period, and have left the physical demanding occupations when they had their knee OA at or before baseline (healthy worker effect). These factors will all tend to dilute the associations.

In the study by Cooper et al. 1994[56], the association between knee OA and heavy lifting (lifting weights over 25 kg in an average working day) was positive (not significant) with an OR 1.4. The strengths of this study is the use of weight-bearing radiographs, inclusion of PFJ OA, inclusion of subjects with moderate and severe symptomatic OA, and that information of the occupational activities were collected by interviews instead of using only job-titles. The information about exposure was collected retrospectively which might be susceptible to recall bias. The limitations of the study may also be the small number of male participants among cases (n=30), and furthermore the small number of cases and controls who had been employed in occupations with heavy lifting (10 cases and 12 controls (7%)). Only 13 cases and controls (5%) had had heavy lifting combined with kneeling, squatting, or climbing stairs). These factors could dilute the associations; most probably it may lead to a bias towards zero and risk in some of the groups may then be underestimated.

Elsner et al. 1996[58] showed a positive, but not significant, risk of developing knee OA in relation to heavy lifting >20 kg for men OR= 1.3 and for women OR=1.5. One of the strength of the study was that subjects filled out a diary about their work demands. The study have some limitations. The participation rate was not very high among cases (61%). Probably, subjects with the highest physical demands will fill out the diary more often than cases without physically demanding work tasks. The exposure was collected in a diary with information about the actual work demands and this may lead to a misclassification if they did not have the same job throughout their working-life. The controls were collected during 4 years, and the selection of the cases is not further defined (selection bias). The controls had no radiographs taken, and may therefore also have had undetected knee OA (but without reporting knee pain).

In a case-control study by Sahlström & Montgomery, 1997[61], the results showed an association between knee OA and weight-bearing knee bending (medium plus heavy) with OR 1.9 but the association disappeared (OR=1.1) when adjusting for sitting, overweight, and knee injuries. The strength of this study is that the exposure was assessed in two ways, but the limitations are that the definition of the exposure, where lifting/carrying has been defined as light knee moments, and only lifting objects from one level to another have been defined as medium exposure, and jumping as heavy exposure. This may misclassify some subjects with heavy lifting/carrying as light exposure and a possible risk in the exposure groups may then be under-estimated.

Lau et al. 2000[30] carried out a study in Hong Kong and found the association between knee OA and heavy lifting was significant elevated for lifting weights of ≥10 kg with OR= 5.8 (men) and OR=3.0 (women) and ≥50 kg OR=7.1(men) and OR=2.9 (women) when lifting >10 times/week. The association was weaker for lifting < 10 times/week. The strengths of the study are the high number of participants, and that information of occupational activities was collected by interviews (specified by different physical activities) instead of using only job-titles. The information of the occupational activities was collected retrospectively, which might be susceptible to recall bias. The cases were recruited from subjects seeking hospital-treatment for knee OA, which may lead to a selection bias if subjects in heavy occupations seek hospital care more often than subjects without heavy occupations. Subjects with knee pain may also recall their physical demands differently than subjects without knee pain and remembering past situations may be a problem for both cases an controls (recall bias). In Japan, Yoshimura et al. 2004[65] made a case-control study on women and showed a positive, but not significant, association between knee OA and lifting of ≥25 kg in their main job with an odds ratio 1.91. Some of the limitations of this study are the differences in the participation rate among cases (84%) and controls (59%). Individuals from poorer backgrounds (who tend to have occupations which includes more heavy lifting) may have been less willing to participate as controls. Among cases 50 of 101 had a previous knee injury compared to 14 of 101controls and previous knee injuries were found to be an independent risk factor for knee OA (OR=5.00). This may influence the result when analysing for other risk factors (odds ratios not adjusted for knee injuries). The results on the association between TKR, and heavy lifting may be diluted by the relatively few exposed to heavy lifting. The cases were defined as TKR which might lead to a selection bias if patients with knee pain and heavy physical work load seek hospital care more often than others. The exposure assessment is retrospective and this may lead to recall bias.

In a case-control study by Seidler et al. 2001[64], the association between knee OA and heavy lifting was positive (but not significant) only for daily lifting of >50 kg for men (OR=3.4). The strength of the study is the confirmation that controls had no radiological knee OA, and the exclusion of subjects with meniscal lesions. The limitations of the study is the case definition (OA grade 1-4 according to the criteria by Kellgren & Lawrence) which includes all grades of OA from 1 through 4. Two thirds (66%) of the cases were grade 1 OA and only 10% grade 3-4 OA. This may result in a non-differential misclassification of the cases (which may in reality be not-cases), and this may give a dilution of true risk. The exposure assessment is retrospective, and this may result in recall bias.

Dawson et al. 2002[57] found a positive association between TKR and heavy lifting in women; the result was significant for lifting 24-33 years but not for >33 years. The limitations of this study includes a low participation rate (or high exclusion rate), a low number of cases (n=29), and the retrospective and non-specific exposure assessment, which is defined as lifting two times/week without defining the weight, or the number of lifted burdens (subjects without heavy lifting may be classified as subjects with heavy lifting). Included subjects may be housewives (without high work load or heavy lifting), but this is not described in the paper. Exposure to heavy lifting <24 years was uses as controls and compared to subjects with more years of lifting. All these factors may result in a non-differential misclassification of the cases and may lead to a dilution of true risk. The exposure assessment was retrospective, and this may result in recall bias.

Occupations involving heavy lifting and/or kneeling/squatting

The association between knee OA and occupations involving heavy lifting has been investigated in 11 studies[35;36;41;62;65-71]. Some of the studies have been described in detail in relation to heavy lifting, and only the conclusions about occupations involving heavy lifting and/or kneeling/squatting are repeated.

Four case-control studies on the association between knee OA and occupations involving heavy lifting and kneeling were included in this review[35;38;67;73]. All studies showed a significant association with an odds ratio range of 2.1 and 23.1. Seven cohort studies dealt with the association between knee OA and occupations involving heavy lifting and kneeling[36;41;66;68-71]. Five of the studies showed a significant association with an odds ratio range of 2.1-14.8[36;41;66;68;69]. .

Two studies concerning miners have been included in this review[66;69]. Kellgren and Lawrence, 1952 showed an increased risk for miners compared to manual workers and office workers to get slight and severe knee OA. The strength of this study is that it is well-described (study population, participation rate, exclusion criteria). Radiographs were taken not only of knees (not-weight-bearing) but also of low back and hands, and the study investigated factors other than knee OA. The radiographically investigation included blinded evaluation (and validation) of the radiographs. The exposure was only described by job-title, which may lead to some misclassification, probably most for the manual workers. No statistical analysis or adjustment for confounders has been made. The results has been confirmed by another newer study of the miners by Greinemann 1997[66], who showed an increased risk of both TFJ knee OA and PFJ OA in miners.

In four studies, the association between working in the construction industry (not further defined) and knee OA has been investigated[35;36;41;67]. All the studies revealed a positive association (statistically significant) with OR ranging from 1.36 to 2.5. Holmberg et al. 2004[67] showed only a significant risk for knee OA in men who had worked for 11-30 years as construction workers with OR= 3.7, but no association for fewer years as a construction workers. The job-title used in these studies is less specific than a more precise description of work load, it decreases the risk of recall bias, but increases the risk of non-differential misclassification of subjects without heavy work as subjects with heavy work, especially within the group of construction workers. In two studies, the association between work as a floor layer and knee OA has been investigated; one study showed an association for OA in the tibio-femoral joint[68], and the other study showed only an association with OA in the patellofemoral joint[70]. One of the limitations of the study by Kivimäki et al. 1992 [70]is that only subjects up to the age of 49 years were included. OA normally first develops after the age 45-50 years, and therefore this criteria may lead to the inclusion of very few OA cases; differences may be diluted and the risk estimates may thereby go downwards . A cross-sectional study by Wickström et al. 1983[71] found 2% with JSN in both concrete reinforcement worker and in painters (control group). The strength of this study is that the exposure assessment done by video-taping showing differences between the amount of lifted work loads in the two groups. The limitation is the relatively few subjects in the age group >50 years. Only active workers are included. There may be a risk that workers with knee OA have left occupations with physically heavy work loads (healthy workers effect). These factors may thereby dilute the results, most probably it may lead to a bias towards zero, and the possible risk in the exposure groups may then be under-estimated.

Heavy-lifting and kneeling/squatting

The association between knee OA and kneeling combined with heavy lifting has been investigated in 4 studies on heavy lifting combined with kneeling/squatting[55;56;59;64]. All the studies showed a significant increased risk between knee OA and heavy lifting and kneeling/squatting with OR ranging from 2.2-5.4. One of the studies has used TKR as case definition, and the other three used radiographic knee OA grade 1-4[64]; grade 2-4[59], and symptomatic grade 3-4[56].In a case-control study by Coggon et al. 2000[55], the association between knee OA (placed on a waiting list for TKR) and heavy lifting was positive (odds ratio ranged between 1.2 to 1.9) for lifting. The association became more pronounced for subjects employed in occupations which involved both heavy lifting and kneeling/squatting with an odds ratio for men OR= 2.9 and for women OR= 4.2. This result was confirmed by the study of Cooper et al. 1994[56], with OR=1.4 for lifting and OR=5.4 for combined lifting and kneeling/squatting, and by the study of Felson et al. 1991[59] with OR 0.96 for lifting and OR=2.2 for combined lifting and kneeling/squatting.
No studies have investigated a dose-response relationship in relation to the combination of heavy lifting and kneeling, either in relation to the amount lifted, the frequency of lifting, the duration of lifting-work, or to the aggregate of years with kneeling- and lifting-work activities.

Climbing stairs or ladders

Four studies have investigated the association between knee OA and climbing stairs (four studies) or ladders (one study)[30;56;72;73]. All four studies on the association between knee OA and climbing stairs showed a positive association (for men in three studies and for women in one study with OR range of 1.2-6.1). The association was significant in one study (males and females[56]); in two studies for females[30;73] and for males[30;55]. The measures of exposure in the studies were climbing stairs > 30 min/day, climbing a ladder or flights of stairs>30 times/day, and climbing stairs ≥15 flights/day. No dose-response relationship has been investigated.
It is known that people with knee pain experience worse pain when climbing stairs. People in occupations which include works-tasks which include climbing stairs or ladders may seek treatment earlier than other workers because of pain. This could be a problem in the three studies which used total knee replacement, or waiting for one, as the case definition [30;55;73]. Only one study on the association between knee OA and climbing stairs used radiographic OA as the inclusion criteria; the association in this study was statistically significant with OR 2.7[56].

Definition of osteoarthritis

In seven studies on the association between knee OA and heavy lifting, the criteria established by Kellgren and Lawrence were used[53;54;56;59;60;64;65]. In all studies but one[64], a rating of ≥grade 2 on a 0-4 graded scale has been used as diagnostic criteria for knee OA. Two studies[35;36] used the ICD 8–code or the diagnosis used when a person was being granted a disability pension or being hospitalised. In four studies, total knee replacement or waiting for one was used[30;55;57;73], and rest of the studies used other criteria.
The differences between the classification criteria may explain some of the differences between the odds ratios reported in the studies, and the use of different classification criteria and different cut-off points may lead to diagnostic misclassification. However, there is no reason to believe that the misclassifications will go in a particular direction, and there was no specific pattern of higher risk estimates when using TKR comparing to radiological knee OA or the diagnostic code ICD 8. Only for the study on subjects having a disability pension was the OR higher compared to the rest of the studies[35].
The AP radiograph in standing position with the knee in complete extension has recently been shown to have a low sensitivity for identification of early femoro-tibial OA in serial films, and Vignon describes the superiority of knee radiographs in flexion rather than extension for detection of joint-space narrowing[16].
In another study, a sensitivity of 97% for knee OA was found as long as at least an AP and either skyline or lateral image of the patellofemoral joint was obtained [139]. Using definitions which are too stringent without including early OA or OA in the patellofemoral joint may lead to an underestimation of the risk, but there is no reason to believe that the differences between the studied populations will change the results.
Factors which can differentiate symptomatic OA from asymptomatic radiographic disease are unknown. Even though some subjects with radiological OA may have no symptoms, subjects with more severe radiographic OA have symptoms more often than those with milder radiographic findings. Tibial cartilage volume is weakly associated with symptoms in knee OA. This suggest that, although cartilage is not a major determinant of symptoms in knee OA, it does relate to symptoms[140]. The grade of joint-space narrowing and lateral patellofemoral radiographs has been shown to be inversely associated with patella cartilage volume[141]. MRI can detect cartilage loss earlier than radiographic findings, and it can therefore detect OA at an earlier stage[142].
Studies which have used different classification of the diagnoses all seem to show differences between subjects with and without heavy lifting.

Patho-physiological mechanisms

The pathogenesis of knee OA in relation to work loads has not been clarified. In the standing position, the weight on either knee corresponds to 40% of body weight, during normal walking the pressure on the knees increases to 2-4 times body weight, and to six times during climbing stairs[143-147]. During kneeling, approximately 70% of the body weight rests on a few cm^2 of the tibia and the patella which may lead to damage to cartilage and bone. In a study on knee stress during deep knee flexion, the estimated forces on the tibio-femoral joint were between 4.7 and 5.6 times body weight in the vertical direction and 2.9-3.5 times body weight in the horizontal direction[144]. In a study of twelve healthy subjects, the sagital moment in normal gait was measured as 15 Nm, while the moment for lifting with flexed knee was 50 Nm, and jumping down from a level of 50 cm was measured as 65 Nm. The frontal moment in normal gait was 30 Nm, in flexed knee lifting it was 25 Nm, and it was 60 Nm in jumping down from 50 cm. The results indicate that the moment increases while lifting with flexed knee or when jumping from one level to another[148]. The increase in the extensor force during deep knee flexion will increase the stress on the patella tendon and joint contact forces. At the angle 150 degree of flexion or more, the extensor mechanism will also apply a posteriorly-directed force on the tibia since the patella tendon is tilting posteriorly and this will increase the total force at the knee.
The dose-response-relationship documented in the studies on heavy lifting and climbing stairs supports the hypothesis of a biological gradient. A biomechanical model supports that the load can cause damage to the knee joint because of heavy lifting and climbing stairs.

If the mechanical effect is the primary cause in developing OA in knee, obesity may also increase the risk of OA in the knee by increasing the load on the weight-bearing joints. Alternatively, because obesity and OA are both associated with a genetic predisposition, it has been thought that the two conditions could be linked if the genes that cause obesity also predispose to OA, but this could not be verified in two large twin studies[78;108]. Another theory has been that obesity, by changing the hormone balance, may change the risk for OA. This theory is supported by the fact that obesity also may increase the risk for hand OA.
Another hypothesis for the pathogenesis of knee OA is that subchondral microfractures may induce OA[16]. Microfractures may occur when the joint is in extreme positions or when physical work load exceeds a critical level. Radin et al. 1972, 1975[135-137] describe that microfractures appear in the subchondral bone due to repeated high forces across a joint. The overlying cartilage has to absorb more force, which will cause degeneration of the cartilage. These studies indicate a possible patho-physiological mechanism by a mechanical effect and/or microfractures during repeated physical work load.

Exposure

In 2 studies, medium exposure compared to low exposure showed a positive association with knee OA with OR range of 2.5-4.5[35;73] In five studies high exposure compared to low exposure showed an OR range of 1.4-14.3[35;36;53;60;73]In the studies, there seemed to be a dose-response relationship, with higher risks for the high exposure groups than for the medium exposure groups when both were compared to the low exposure groups. In six studies, the weight of the lifts was more specified. In one study, the exposure was divided into 'lifts ≥10kg', lifts ≥25kg, or lifts ≥50 kg[55]; in one study the work load was divided into lifts ≥10 kg, and ≥50 kg[30]; one study used daily lifts 20-50 kg, and ≥50 kg[64], and two studies used lifts ≥25 kg[56;65], and in one study >20 kg[58]. Two studies showed significant increased risk for knee OA for lifting ≥10 kg more than 10 times/week with OR range of 1.9-5.8 for men and 1.5-3.0 for women[30;55]. In two studies, there was a positive but not significant association for lifting ≥25 kg with OR range of 1.7-1.9[55;65], and for lifting ≥50 kg the association was significant with OR range of 1.7-7.1(males), and not significant with OR 1.2-2.9 (females) in three studies[30;55;64]. In only one study did there seem to be a dose-relationship, with an increase in OR for men ranging from 1.7 for lifts ≥10 kg 1-10 times/week, OR 5.8 for lifts ≥10 kg >10 times/week, OR 3.5 for lifts ≥50 kg 1-10 times/week, and OR 7.1 for lifts ≥50 kg > 10 times/week. The risk was also increased for women. The results suggest a dose-response relationship in relation to the weight and with the frequency of lifting (1-10 times/week versus more than 10 times/week). In four studies, the importance of the duration of the exposure was investigated, and a significant increased risk of getting knee OA was shown when comparing workers in heavy jobs (at least 10 years or at least 25 years) with unexposed [55;57;64;73].

An association has been shown between knee OA and employment as construction workers[24;25;33;35;36;41;45] and forestry workers[29;33;36;43], although the risk shown in these occupations is not so consistent. The reason for not-so-strong associations in studies on construction workers and forestry workers may be the result of inclusion of too few participants, and misclassification of the work loads; the exposure in these studies mostly has been based on job title. In a study by Wickström et al. 1983[71], concrete reinforcement workers and painters were studied by video-recordings. The concrete reinforcement workers lifted heavy loads 5-20 kg 15 times/hour and loads >20 kg six times/hour. Painters (who are also construction workers) lifted loads 5-20 kg 6 times/hour, but only seldom lifted heavier loads. This study showed that there are great differences between different kinds of construction work in relation to loads lifted, both in frequency and in weight. These studies indicate that lifting heavy weights is normal among some of the construction workers.
This was confirmed in the study by Coggon et al.1998[24] where construction workers reported working in occupations involving lifting weights of 25 kg or more.

Other findings

None of the identified studies addressed any possible effect of heavy lifting combined with kneeling/ squatting or climbing stairs on the prognosis of knee OA. In a longitudinal follow-up by Schouten et al. 1992[63], prognostic factors for cartilage loss were shown to be associated with body mass index, Heberden's Nodes, and generalised osteoarthritis. Factors which correlate with worsening of joint-space narrowing of the knees include presence of obesity (BMI>30), a greater number of joints affected by OA, daily consumption of non-steroidal anti-inflammatory drugs, and having undergone a synovial fluid aspiration[149;150]. When osteoarthritis has been demonstrated in radiographs, there is no evidence that the changes will disappear or decrease with time. However, symptomatic knee OA is more often found in subjects in physically-heavy (knee-straining) occupations such as floor layers[68], and their symptoms may be relieved by reducing their physical work–loads, so as to reduce the disability of the subject. Climbing stairs may increase pain in subjects with knee OA. Weight reduction would lower symptomatic knee and hip OA, especially in women more than 50 years. It has been calculated that if all obese were to reduce weight until their BMI was in the recommended range, the proportion of cases that might develop knee OA would be reduced by 57%[111]. Felson 1998[17] estimated the potential reduction in the incidence of symptomatic knee OA, using different preventive strategies. By eliminating obesity, 27-52% of knee OA would be prevented in men. For women, 28-53% of knee OA would be prevented. By eliminating knee injuries, 25% of the knee OA among men, and 14% among women would be prevented. And by eliminating jobs with knee-bending and carrying heavy loads, 15-30% of the knee OA cases would be prevented among men (based on[7;68]).

All the studies on knee OA and heavy lifting revealed more significant results for men than for women. 10 studies have investigated the relationship for women[30;36;53-55;58;59;64;65;73]. Six of these 10 studies have shown a significant positive relationship[30;36;53;55;73] with OR range of 1.7-3.1. Two studies only included women, and the association between heavy lifting and knee OA in these studies was positive, showing OR range of 1.9-7.3[38;57] (statistically significant in only one of the studies).The numbers of women in occupations which had heavy work loads have been few in many of the studies, probably one of the reasons for the non significant results. In general, women do not have work-tasks with the same degree of physically heavy work-loads in their occupations as men do, and they traditionally work in other trades . It is not easy, therefore, to recruit a sufficient quantity of women with high exposure into the studies. Vingård et al. 1991[36] found a relative risk for knee OA (RR) 2.18 (95% CI 1.26-3.00) for cleaners compared to low exposure blue-collar workers, but no significant association for any other trades. Sandmark showed that exposure to physically-demanding work-tasks at home >1 year, such as nursing or taking care of an elderly or handicapped person, was significantly associated with knee OA among women (OR 2.2), and Jensen et al. 1994[41] showed a standardized hospitalisation rate SHR because of knee OA significantly increased for health care workers SHR=245, and for self-employed taxi drivers SHR =460. The most plausible conclusions are that women are at least as susceptible to lifting heavy work loads as men and that the risk of getting knee OA is equal to men if they have the same exposure.

Earlier reviews on the relationship between knee OA and physical demands have been carried out. Jensen et al. 1996[47] concluded that there was high evidence for an association between knee OA and kneeling, and less evidence for an association with physically heavy work. Maetzel, 1997 [138] concluded in a review on knee OA that studies suggest a strong positive relationship between work-related knee-bending exposure and knee OA, but gave no conclusion in relation to heavy lifting. The review was based on 9 studies on knee OA.

Conclusion

There is now a wide range of studies with different study designs that shows a positive association between heavy-lifting and knee OA. The research has been made in several countries and a number of studies have shown a high degree of consistency in their findings. Studies in specific occupations support the results. For the combination of kneeling and heavy lifting, the association seems stronger than for heavy lifting alone, but there are only a few studies, and no studies have investigated a dose-response relationship either in relation to the amount lifted (kg), the frequency of lifting (times/day), the duration of lifting-work (years) or to the aggregate of years with kneeling and lifting-work activities. There are relatively few studies which investigate the association between climbing stairs and development of knee OA. Although many of the studies show a positive association, only some were statistically significant, and no studies showed a dose-response relationship.

Overall evaluation

Evaluation of the degree of evidence of a causal relationship between hip and knee osteoarthritis and heavy-lifting, heavy lifting combined with kneeling/squatting, and climbing stairs or ladders are shown in Table 10. The specific criteria of the different degrees of evidence of causality are described in Appendix I.

Table 10. The degree of evidence of a causal relationship between hip and knee osteoarthritis and heavy lifting, heavy- lifting combined with kneeling/squatting, and climbing stairs*

Risk factor	Hip OA	Knee OA
Heavy lifting	++(+)	++
Heavy lifting and kneeling/squatting	0**	++
Climbing stairs or ladders	0	+

* the evaluation is based on the literature listed in Table 2-9 and appendix I.
** there is no information on this combination of exposure

There is moderate-strong evidence that heavy lifting may cause hip OA. A number of studies indicate an increasing risk of hip OA with an increasing degree of heavy lifting. However, there are not enough data on the combination of frequency (times/day), duration (years) and lifted weights (kg) to characterise fully the exposure-response-relation. With regard to the various indices of heavy lifting, it seems that weights should be at least 10-20 kg and the duration at least 10-20 years to give a clearly increased risk of hip OA. It is not possible to define a corresponding threshold for frequency of lifting.
For farmers the risk of hip OA seems doubled after approximately 10 years of farming.
For the individual case of hip OA the likelihood that occupational lifting has contributed to the OA development increases by degree of ‘heavy lifting’. There is no exact definition of ‘heavy lifting’ except that it includes the combined aspects of weight of lifted burdens, the frequency of lifting and the duration of work with such lifting. If the degree of heavy lifting in relation to hip OA has implications for decision making, e.g. for the decision on recognition as an occupational disease, the term ‘heavy lifting’ must be defined on somewhat arbitrary grounds at the administrative level.

There is insufficient evidence that climbing stairs or ladders causes hip OA, and there is no informations on the relationship 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.

There is moderate evidence that heavy lifting causes knee OA. There is moderate evidence for a causal association between frequent heavy lifting combined with kneeling or squatting. There is limited evidence for an association between knee OA and climbing ladders or stairs.

Tables

Table 1a. Hip osteoarthritis. Number of references by relevant work demands, diagnostic criteria, and exposure assessment used in studies.

Physical demand	*Number of epidemiological studies*	*Diagnostic criteria*	*Assessment of exposure*
Heavy lifting	14	R 5; THR 7; C 2	J 4; P 10
Occupations involving heavy lifting			
Farming	14	R 7; THR 3; C 4	J 9; P 5
Construction work	6	R 2; THR 1; C 3	J 6; P 0
Heavy lifting combined with kneeling/squatting	0	-	-
Climbing stairs or ladders	5	R 1; THR 4; C 0	J 0; P 5

R=radiological investigation; THR=Total hip replacement or waiting for one;; C= use of diagnostic code during hospitalisation
J: Job title or use of the trade code; P: Physical work load collected by questionnaire or interview

Table 1b. Knee osteoarthritis. Number of references by relevant work demands, diagnostic criteria, and exposure assessment used in studies.

Physical demand	*Number of epidemiological studies*	*Diagnostic criteria*	*Assessment of exposure*
Heavy lifting	16	R 10; TKR 4; C 2	J 4; P 12
Occupations involving heavy lifting or heavy lifting combined with kneeling	11	R 7; TKR 1; C 3	J 10; P 1
Heavy lifting combined with kneeling/squatting	4	R 3; TKR 1; C 0	J 0; P 4
Climbing stairs or ladders	4	R 1; TKR 3; C 0	J 0; P 4

R=radiological investigation; THR=Total hip replacement or waiting for one;; C= use of diagnostic code during hospitalisation
J: Job title or use of the trade code; P: Physical work load collected by questionnaire or interview or by video-recording

Table 2. Osteoarthritis of the hip and heavy lifting: details of the studies.

Reference	Study population	Age Years	Partici-pation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/ matched by	Comparisons	Results	Design	Strength Weakness
Typpö, 1985[33]	919 (416 males & 503 females) radiologically examined by veno- or angiography, urography, colography, 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 versus no controls (mental (sic)/white collar workers)	OR= 1.97, CI= 1.14-3.41	Case-control	Participation rate missing No statistical testing. No adjustment for potential confounders. Data for only a part of the study population (n=505)
Jacobsson 1987[29]	85 males waiting for hip replacement 262 males who have had urography OA Cases= 106	70-76	-	Questionnaire Job-title classified as heavy/others	Joint-space <3 mm or waiting for THR	Age, height weight	Heavy labour versus others Heavy lifting versus others	OR= 2.2, CI= 1.34-4.36 OR=2.37, CI=1.32-4.28	Case-control	Participation rate not described. Results only sparsely described. No analyses (or statistical analyses) carried out
Vingaard 1991 Olsen 1994[31;34]	Cases: 233 males with hip replacement controls: 302 randomly selected from general population	50-70	89%	Telephone - interview Occupational history the last 20 years Questionnaire lifting in all occupations	Cases with THR	Age, earlier diseases, sport, BMI	*Lifted tons* Medium versus low exposure Exposure before age 30 Exposure after age 30 High versus low exposure Exposure before age 30 Exposure after age 30 *Number of lifts>40kg* Medium versus low exposure Exposure before age 30 Exposure after age 30 High versus low exposure Exposure before age 30 Exposure after age 30	 RR=1.73, CI=1.06-2.83 RR=1.63, CI=0.98-2.73 RR=1.95, CI=1.23-3.09 RR=2.74, CI=1.70-4.43 RR=1.73, CI=1.06-2.82 RR=1.60, CI=0.81-3.15 RR=2.35, CI=1.47-3.74 RR=3.31, CI=1.97-5.57	Case-control	Inclusion of subjects having their first myocardial infarction. (validation of exposure-informations) Use of THR (selection bias). Work load (light, medium, and heavy) (misclassification) Retrospective exposure information (recall bias)
Vingaard 1991[36]	High exposure: Males:116.581 (914 OA) Females:18.434 (109 OA) Low exposure : Males: 91.057 (320 OA) Females:24.145 (112 OA)	Born 1905-1945	Register based	Occupation Job-title classified by occupational physicians Low/high exposure	Hospitalised in 1981-83 ICD 8 = 713.00 = hip OA	Age, residence	High exposure versus low exposure Males Born 1905-1924 Born 1925-45 Females Born 1905-1924 Born 1925-45	 RR= 2.2, CI=1.6-2.8 RR= 2.0, CI=1.6-2.3 RR=1.6, CI=0.9-3.1 RR=1.1, CI=0.9-1.5	Cohort	High number of participants. Exposure classification=job title. Classification in light, medium, heavy work (misclassification) Case-definition= (hospitalised because of hip OA) (selection bias)
Vingaard 1992[35]	Cases: 140 males disability pension due to hip OA Controls: 298 males from the general population	Born 1915-1934	73%	Interview Occupational history Job-title classified by experienced persons Low/medium/ high exposure	Primary diagnosis made by a physician = hip OA	Age	Medium exposure versus low exposure High exposure versus low exposure	RR= 4.1, CI=2.4-7.1 RR=12.4, CI=6.7-23.0	Case-control	Diagnosis: physicians certificates (misclassi-fication). Subjects in heavy work have an increased risk of getting disability pension? (selection bias) Exposure = high work load on hips, not especially related to heavy lifting (misclassification)

Reference	Study population	Age Years	Partici-pation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/ matched by	Comparisons	Results	Design	Strength Weakness
Croft 1992[25]	Cases 245 males with hip OA Control 294 males without hip OA (examined by urography)	60-75	68%	Blinded interview Occupational history Specified physical activity	Joint-space All ≤ 2.5 mm Severe ≤ 1,5 mm	Age, sport, BMI	Lifting or moving weights >56lbs (>25.4 kg) *All (JSN ≤ 2.5mm)* 1-19 years versus <1 year ≥20 years versus <1 year *Severe (JSN ≤ 1,5 mm* 1-19 years versus <1 year ≥20 years versus <1 year	 OR=0.9, CI=0.6-1.4 OR=1.2, CI=0.7-1.9 OR=1.2, CI=0.5-2.9 OR=2.5, CI=1.1-5.7	Case-control	Use of intravenous urograms (avoiding selection bias) Number of severe cases relatively small. Exposure measurement, lift >25.4 kg , frequency not further ex-plained,. (misclassification)
Roach 1994[32]	Cases: 99 with primary hip OA Controls: 233 examined by intravenous urography (only subjects with no radiographic hip OA) Chosen from a population of 693	aver-age:68	Question naire study 77% Total 48%	Questionnaire Occupational history Classified in light, intermediate and heavy work	Kellgren & Lawrence grade 3-4 (Joint-space <1.5 mm)	Obesity age 40 Sports activities Cancer	Intermediate versus light work Heavy versus light work	OR=1.9, CI= 1.0-3.8 OR=2.4, CI=1.3-4.3	Case-control	High exclusion rate Retrospective exposure measurement (recall bias) Exposure divided in light or heavy work (misclassification,)
Vingaard 1997[37]	Cases: 273 females THR between 1984-1988 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, no of children, hormone therapy.	Heavy lifts Medium exposure versus light High exposure versus light	 RR= 1.1, CI=0.7-1.7 RR= 1.5, CI= 0.9-2.5	Case-control	Retrospective exposure data (non-differential misclassification). Only number of heavy lifts (not further defined) reported.
Coggon 1998[24]	Cases: waiting for surgery in three English districts (2-year period) (210 males 401 females) 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	BMI, hip injury, Heberden's nodes Matched by age and gender	Males Lift ≥10 kg 10 times/week at least 10 years versus no lifting Lift ≥25 kg 10 times/week at least 10 years versus no lifting Lift ≥50 kg 10 times/week at least 10 years versus no lifting Females	 OR= 2.3, CI=1.2-4.2 OR= 2.7, CI=1.4-5.1 OR= 3.2, CI=1.6-6.5 no significant differences	Case-control	Participation rate relatively low (84% of cases, 58% of controls) Cases from a waiting list for THR (selection bias). Retrospective exposure measurement (recall bias). Few women in high exposure group
Cvitetic 1999[26]	590 (292 males 298 females) random sample from Zagreb city records 1981-83	>45 mean: 63	? 678 of invited agreed to partici-pate Exclusion leaved 87%	Questionnaire Occupation divided in 4 categories: Most sedentary Most standing None sitting High physical strain	Clinical hip OA Radiological examination right hip Kellgren & Lawrence grade 2-4	-	*>80% standing versus >80% sitting* Males Females *>80% standing/walking, light work versus >80% sitting* Males Females *>80% standing/walking, often heavy lifting >5 kg versus >80% sitting* Males Females	 OR= 1.5, CI=0.6-3.21 OR= 1.45, CI=0.49-3.58 OR= 1.16, CI=0.58-2.3 OR= 1.19, CI=0.65-2.32 OR= 1.15, CI= 0.52-2.52 OR= 1.34, CI=0.52-3.04	Cross sectio-nal	Participation rate not described. Results not controlled for confounders. Heavy lifting defined as lifts >5 kg (misclassification).
Yoshimura	Cases: (103 females 11	>45	91%	Questionnaire	Waiting for	Age,	*First job*		Case-	Few participants, especially

Reference	Study population	Age Years	Partici-pation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/ matched by	Comparisons	Results	Design	Strength Weakness
2000[38]	males);; waiting for hip replacement in 2 districts in Japan Controls: 114 from the local population	mean: 64		Occupation since leaving school; physical activity in their first and main job	hip replacement	gender, residence matched	Lift of ≥10 kg versus no lift Lift of ≥25 kg versus no lift Lift of ≥50 kg versus no lift *Main job* Lift of ≥10 kg versus no lift Lift of ≥25 kg versus no lift Lift of ≥50 kg versus no lift	OR= 1.2, (CI=0.6-2.4) OR= 3.5, (CI=1.3-9.7) OR= - OR= 1.2, CI=0.6-2.1 OR= 1.5, CI=0.7-3.0 OR= 4.1, CI= 1.1-15.2	control	few males. Few women reported heavy lifting (>50 kg). Cases definition = THR (selection bias) Retrospective exposure data (recall bias)
Lau, 2000[30]	Cases: 30 males, 108 females hospitalised in Hong Kong with hip OA Controls: age and gender matched from general practice in the same region (90 males, 324 females) Cumulative number of patients with OA 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* 1-10 times/week versus no lift Males Females >10 times/week versus no lift Males Females *Lift of 50 kg* 1-10 times/week versus no lift Males Females >10 times/week versus no lift Males Females	 OR= 1.9, CI=0.6-6.6 OR= 0.7, CI= 0.4-1.5 OR= 5.3, CI= 1.8-15.8 OR= 0.7, CI= 0.4-1.5 OR= 8.5, CI=1.6-45.3 OR= 2.9, CI= 0.9-4.6 OR= 9.6, CI= 2.2-42.2 OR= 2.9, CI= 1.5-5.6	Case-control	Only very few Chinese subjects with THR, especially in men. Case definition (THR) (selection bias) Retrospective exposure data (recall bias)
Flugsrud 2002[27]	278 males 391 females who have had a THR in 1989-98 (the Norwegian Arthroplastry Register) total: 24884 males, 24874 females from the Cardiovascular Screening Register in the counties of Finmark (1981-83), Average follow-up length 9 years	Born 1925-42 mean: 55	92%	Questionnaire (graduated physical activity 'during the last year' in sedentary; walking; walking and lifting; heavy manual labour;	THR	Age, height, civil, smoking	*Males:* Moderate versus sedentary work Intermediate versus sedentary work Intensive versus sedentary work *Females* Moderate versus sedentary work Intermediate versus sedentary work Intensive versus sedentary work	 RR= 1.5, CI=1.0-2.2 RR= 1.7, CI= 1.1-2.4 RR= 2.1, CI=1.5-3.0 RR= 1.1, CI= 0.8-1.6 RR= 1.4, CI= 0.9-2.0 RR= 2.1, CI= 1.3-3.3	Cohort	Large number of participants, high participation rate (92%), prospective design Case definition THR (selection bias) Exposure measurement 'physical activity during the 12 months preceding screening'. Measured in 1981-83 (non-differential misclassification).
Jacobsen 2004[28]	4,151 subjects from a longitudinal health survey (1533 males , 2618 females) (Copenhagen City Heart Study) Hip OA cases : 105 males and 167 females 41% of the initial cohort selected for radiography	23-93 males mean: 63 fe-males mean: 65	-	Questionnaire Physical activity since leaving school Most seated Standing/ walking, no lifting Lifting 1tons Lifting 1-2 tons Lifting 2-5 tons Lifting>5 tons	Radiographs (standing) Case definition: JSN ≤2mm	Age BMI	1) Most seated 2) Standing/walking, no lifting 3) Lifting 1 tons 4) Lifting 1-2 tons 5) Lifting 2-5 tons 6) Lifting>5 tons	No significant relationships between type and duration of occupations (sedentary or involving repeated daily lifting OR 0.7-1.0	Cohort	Data and results not shown statistical analysis not shown..

Table 3. Hip osteoarthritis and occupations, which involve heavy lifting, farming: details of the studies

Reference	Study population	Age Years	Partici-pation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/ matched by:	Comparisons	Results	Design	Strength Weakness
Typpö, 1985[33]	Cases: 224 with hip OA (90 farmers) Controls: 255 without hip OA (70 farmers, gender unknown) within a population of 919 (416 males & 503 females) radiological examined by veno- or angiography, urography, colography, cystography, hips and abdomen.	16-86 mean: 57	-	Questionnaire Present occupation/ job-title)	Retrospective radiological hip OA (mild, moderate, severe)	-	Farmers versus office workers Mild/moderate hip OA Severe hip OA	 OR=1.8, CI= 0.97-3.34 OR=1.98, CI=1.01-3.87	Case-control	Participation rate missing No statistical testing. No adjustment for potential confounders Only data for a part of the study population (n=505
Jacobsson 1987[29]	85 males waiting for hip replacement 262 males who have had urography OA Cases= 106	70-76	-	Questionnaire 'working as a farmer'	Joint-space <3 mm or waiting for THR	Age, height weight	Farm work versus others THR JSN	 OR=1.84,CI=1.12-3.02 OR=2.9, CI=1.2-7.37	Case-control	Participation rate not described Results only sparsely described. No analyses (or statistically analyses)
Thelin 1990[43]	Cases: 98 males who have had THR at two hospitals in Sweden Controls: 201 random sample of Swedish males	55-70 average 65	91%	Questionnaire Occupational history from age 15	THR	Age, injuries, tobacco, hospital	1-10 years farming versus <1 year >10 years farming versus <1 year Drove tractor regularly versus not Milking regularly versus not	OR=2.1, CI=1.1-4.3 OR=3.2, CI=1.8-5.5 OR=2.2, CI=1.3-3.9 OR=2.2, CI=1.3-3.7	Case-control	High participation rate. Relatively few cases. Case definition = THR. (selection bias). Exposure definition=Job-title (recall bias). No adjustment for confounders.
Vingård 1991[36]	Male farmers:: 35,981 (479 OA) Female farmers: 1739 (12 OA) Used as control-group: Low exposure: Male: 91,057 (320 OA) Female: 24,145 (112 OA) Same occupation in 1960 and 1970.	Born 1905-1945	Register based	Physical demands classified by two experienced occupational health physicians	Hospitalised in 1981-83 ICD 8c= 713.00 (hip OA)	Age, county	Farmers versus workers with low exposure to physical work demands Males Females,	 OR= 3,78, CI=2,91-4,4 OR=1.47, CI=0.86-2.85	Cohort	High number of participants. Use of job title as exposure classification + classification in light, medium, heavy) (misclassification) Case-definition= hospitalised because of hip OA)(selection bias)
Croft 1992[25]	Cases 245 (males) with hip OA (farmers: 52 OA –all degree; 19 severe) Control 294 without hip OA (farmers: 65) (examined by urography)	60-75	68%	Blinded interview Occupational history Job-title classified by experienced persons	Joint-space All ≤ 2.5 mm Severe ≤ 1,5 mm	Age, sport, BMI	All OA-cases(<2.5 mm) Severe cases (<1.5 mm) 1-9 years farming versus <1 year ≥10 years of farming versus <1year	OR= 0,9, CI= 0,6-1,4 OR= 1.6, CI= 0.8-3.1 OR= 1.0, CI= 0.3-3.1 OR= 2.0, CI= 0.9-4.4	Case-control	Use of intravenous urograms (avoid selection bias) Number of severe cases relatively small (n=68). Exposure measurement, lift >25.4 kg , frequency not further explained,. (misclassification)
Croft	Cases: 167 male	60-76	60%	Questionnaire	Radiological	Age,	Farmers at least 1 year vs. controls	OR= 8.2, CI=2.3-28.5	Cross-	Relatively low participation

Reference	Study population	Age Years	Partici-pation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/ matched by:	Comparisons	Results	Design	Strength Weakness
1992[40]	farmers (28 OA) Controls: 71 (83) sedentary workers (20 OA) from general practice of 1231 males			Interview Years as farmer at least 1 year	hip OA Joint-space <1.5 mm or hip replacement	height, weight, Heber-den's nodes	1-9 years farming vs. <1 year ≥10 years of farming vs. <1year	OR = 5.8, CI= 1.1-31.5 OR=10.1, CI= 2.2-45.9	sectio-nal	rate Overrepresentation of symptomatic farmers among the participants (78%) compared to 54% of asymptomatic farmers, 60% of asymptomatic, and 57% of asymptomatic office workers. No adjustment for hip injuries. No exclusion criteria described.
Vingaard 1992[35]	Cases: 140 males disability pension due to hip OA (17 farmers) Controls: 298 males from the general population	Born 1915-1934	73%	Interview Occupational history Job-title classified by experienced persons	Primary diagnosis made by a physician = hip OA	Age	Farmers and forest workers versus others	RR=13.8 , CI= 4.0-48.1	Case-control	Diagnosis from physicians certificates (misclassification) Subjects in physical demanding occupations may have an increased risk of getting disability pension (selection bias) Exposure = high work load on hips, not especially related to heavy lifting (misclassification)
Axmacher 1993[39]	565 male farmers (45 OA-cases) 1250 general population (10 OA cases) (chosen among 16250 active farmers in the population in Malmö county)	40-64	83%	Questionnaire Working as a farmer	Retrospective review colon radiography + urography Not-weight bearing joint-space <4 mm)	Age, gender	Farmers versus urban controls Males, Females	 OR= 12.0, CI= 6.7 -21.4 OR= 2.3, CI= 0.33-12.27	Cohort	No control group included - results compared to an earlier population study. No statistical analysis Not- weight-bearing radiographs (non-differential misclassification). Case-definition: JSN <4mm. (misclassification)
Jensen 1994[41]	Male farmers: total 63,990, hip OA 1131 Total:1,251,590 males 9674 hip OA males & females	20-59 in1981	- register-based	Occupation Job-title in 1981	Hospitalised 1981-1990 ICD-8 = 713.00 = hip OA	age	Farmers versus other occupations	SHR=273, CI=258-7290	Cohort	High number of participants. Longitudinal design (avoid information bias). Job-title (misclassification). Main job registered in 5-year periods, (misclassification). Case definition=diagnostic code.´(misclassification + selection bias).
Coggon 1998[24]	Cases: waiting for hip replacement in three English districts in a 2-year period (210 males 401 females) (19 farmers) Controls: 611 (210 males, 401 females) random sample from	45-91 mean: 70	68%	Interview Occupation held for >1 year from school age Specified physical activity	Cases waiting for surgery	-	Farmers versus others	OR=2.5, CI=1.10-5,70	Case-control	Numbers of farmers (cases and controls) mentioned. No analysis made. Case definition: waiting list for THR (selection bias). Participation rate relatively low (84% of cases, 58% of controls) Retrospective exposure

Reference	Study population	Age Years	Partici-pation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/ matched by:	Comparisons	Results	Design	Strength Weakness
	general practice in the same area (8 farmers)									measurement (recall bias). No adjustment for confounders
Thelin 1997[42]	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, residence matched	Farmer: 1-10 years farming versus <1 year 11-20 years farming versus <1 year 21-30 years farming versus <1 year >30 years farming versus <1 year Farm- worker: 1-10 years farming versus <1 year 11-20 years farming versus <1 year 21-30 years farming versus <1 year >30 years farming versus <1 year In agriculture Y/N Drive tractor Y/N Milk full-time Y/N	 OR= 1.58, CI= 0.59-4.23 OR= 2.81, CI= 1.31-6.03 OR= 7.35, CI= 2.87-18.8 OR= 3.82, CI= 2.41-6.06 OR= 1.88, CI= 1.23-2.86 OR= 2.53, CI= 1.36-4,72 OR= 4.41, CI= 1.31-14.8 OR= 6.43, CI= 1.83-22.5 OR= 2.70, CI= 1.94-3.77 OR= 2.05, CI= 1.45-2.88 OR= 2.98, CI= 2.07-4.28	Case-control	Case definition: radiological findings in previous taken x-rays (avoid some selection bias), but farmers with heavy physical demands may seek hospital (and have X-ray taken) more often (selection bias) No adjustment for confounders..
Yoshimura 2000[38]	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	Age, gender, residence matched	Farmers or fishermen versus non farmers or fishermen	OR=1.14, CI=0.57-2.33	Case-control	Few participants, especially few males (including farmers). Cases definition = THR (selection bias) Retrospective exposure data (recall bias)
Tüchsen 2003[45]	All actively working males in Denmark In 1981, 1986, 1991 and 1994 Self-employed farmers: 1981-85 : 63,990 (458 OA) 1986-90 52,907 (433 OA) 1991-93 42,825 (213 OA) 1994-99 34,068 (355 OA)	20-59	register-based	Occupation classified by occupation (job-title) 1980, 1985, 1990, 1993	Hospitalised with hip OA (ICD 8 =713.00 or ICD10=M16 1981-85 1986-90 1991-93 1994-99		Farmers versus others Farm worker versus others	Farmer 1981-85, SHR=281, CI= 259-304 1986-90, SHR=283, CI= 269-298 1991-93, SHR=285, CI= 268-302 1994-99, SHR=286, CI= 262-313 Farm-worker 1981-85, SHR=114, CI= 89-147 1986-90, SHR=138, CI= 118-161 1991-93, SHR=160, CI= 140-183 1994-99, SHR=189, CI= 158-227	Cohort	All hospital admissions due to hip OA included. Case-definition= diagnostic code (misclassification) (selection bias). Relatively young subjects (20-59 years). No adjustment for age, body mass index, traumas, or sports activities. Follow-up after 3-5 years (healthy worker effect)
Thelin 2004[44]	Cases: 369 farmers (321 males 68 females) with hip OA Controls: 389 farmers without hip pain From a Norwegian farmers' cooperative (30,000 persons.)	40-71	86%	Interview Work tasks as a farmer	Retrospective and new radiological hip OA < 3mm	Age , sex, residential matched	Working >5 h /day in livestock housing Milking >40 cows daily Working at large farms >100 ha	OR= 13.3, CI= 1.2-145 OR= 4.5, CI= 1.9-11.0 OR= 0.14, CI= 0.05-0.4	Case-control	High number of farmer participants. No control group of non-farmers Cannot conclude if there are a higher risk among farmers than non-farmers, Can investigate if there are risks within specific work-tasks .

Table 4. **Hip osteoarthritis and occupations, which involve heavy lifting, construction work: details of the studies**

Reference	Study population	Age Years	Partici-pation rate	Exposure measured by:	Diagnostic criteria	Adjusted for: Matched by:	Comparisons	Results	Design	Strength Weakness
Typpö, 1985[33]	Cases: 224 with hip OA (22 construction workers) Controls: 255 without hip OA (14 construction workers) within a population of 919 (416 males & 503 females)	16-86 mean: 57	-	Questionnaire Present occupation: Job-title	Retrospective radiological hip OA mild, moderate, severe	-	Construction workers versus others	OR= 1.54, CI=0.8-2.98	Case-control	Participation rate missing No statistical testing. No adjustment for potential confounders Only data for a part of the study population (n=505)
Vingård 1991[36]	Male construction workers:: 38,095 (223 OA) Used as control-group: Low exposure: Males: 91,057 (320 OA) Same occupation in 1960 and 1970.	Born 1905-1945	Register based	Job-title	Hospitalised in 1981-83 ICD 8c= 713.00 (hip OA)	Age, county	Construction workers versus low exposure	RR= 1.66, CI= 1.32-1.87	Cohort	High number of participants. Use of job title as exposure classification + classification in light, medium, heavy) (misclassification) Case-definition= hospitalised because of hip OA (selection bias)
Vingaard 1992[35]	Cases: 140 males disability pension due to hip OA (27 construction workers) Controls: 298 males from the general population	Born 1915-1934	73%	Interview Occupational history Job-title	Primary diagnosis made by a physician = hip OA	Age	Construction workers versus controls	RR= 7.0, CI=3.5-14.3	Case-control	Diagnosis from physicians' certificates (misclassification) Subjects in physical demanding occupations may have an increased risk of getting disability pension (selection bias) Exposure = high work load on hips, not especially related to heavy lifting (misclassification)
Croft 1992[25]	Cases 245 with hip OA (construction workers: all degree 35 ; severe 9) Control 294 without hip OA (construction workers 37) (examined by urography)	60-75	68%	Blinded interview Occupational history Job-title and duration	Joint-space All ≤ 2.5 mm Severe ≤ 1,5 mm	Age, sport, BMI	Severe cases (<1.5 mm) 1-9 years employment versus. <1 year ≥10 years employment versus. <1year	OR= 1.5 CI= 0.7-3.4 OR= 3.3, CI= 1.2-9.2 OR= 0.5, CI= 0.1-2.3	Case-control	Use of intravenous urograms (avoiding selection bias) Number of severe cases relatively small (n=68). Exposure measurement, lift >25.4 kg , frequency not further explained (misclassification)
Jensen 1994[41]	Male construction workers: total 3281, hip OA 30 Total:1,251,590 males 9674 hip OA males & females	20-59 in 1981	Register based	Occupation Job-title 1981	Hospitalised 1981-1990 ICD-8 = 713.00 = hip OA	age	Construction workers versus others	SHR:151, CI=102-216	Case-control	High number of participants. Longitudinal design (avoid information bias). Only job-title included (misclassification). Main job registered in 5-year periods, (misclassification). Case definition = diagnostic code (misclassification + selection bias).
Coggon 1998[24]	Cases: waiting for hip replacement in three English districts in a 2-year period (210 males 401 females) (23 construction workers) Controls: 611 (210 males, 401 females) random sample from general practice in the same area (13 construction workers)	45-91 mean: 70	68%	Interview Occupation held for >1 year from school age Job-title	Cases waiting for surgery	-	Construction workers	OR:1.5 (0.8-2.8)	Case-control	Numbers of construction workers(cases and controls) mentioned. No analysis made. Case definition: waiting list for THR (selection bias). Participation rate relatively low (84% of cases, 58% of controls) Retrospective exposure measurement (recall bias). No adjustment for confounders

Table 5. Osteoarthritis of the hip and climbing stairs or ladders: details of the studies.

Reference	Study population	Age Years	Partici pation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/ matched by:	Comparisons	Results	Design	Strength Weakness
Croft 1992[25]	Cases 245 with hip OA Control 294 without hip OA (males)	60-75	68%	Blinded interview Occupational history Specified physical activity	JSN ≤ 2.5 mm (all) ≤ 1,5 mm (severe) examined by uro-graphy	Age, sport, BMI	Climbing ladders 1-19 years ≥20 years versus climbing <1 year Climbing stairs>30 flights ≥1 year versus climbing< 1 year	Severe cases (<1.5 mm) OR= 0.8, CI= 0.3-1.8 OR= 1.6, CI= 0.7-3.8 OR= 1.2, CI= 0.6-2.5	Case-control	Use of intravenous urograms (avoid selection bias) Number of severe cases relatively small (n=68).Exposure measurement, lift >25.4 kg , frequency not further explained,. (misclassification)
Vingaard 1997[37]	Cases: 273 females THR between 1984-1988 in 4 areas of Sweden Controls: 273 females random sample from same areas	50-70	90%	Interview Number of stairs during the age 16-50 years.	THR	Age, BMI, sports activity, no of children, hormone therapy.	Climbing stairs Medium exposure versus low exposure High exposure versus low exposure	RR= 1.3, CI=0.8-2.0 RR= 2.1, CI= 1.2-3.6	Case-control	Retrospective exposure data (non-differential misclassification). Number of stairs during age 16-50 years classified in low and high (non-differential misclassification).
Coggon 1998[24]	Cases: waiting for hip replacement in three English districts in a 2-year period (210 males 401 females) Controls: 611 (210 males, 401 females) random sample from general practice in the same area	45-91 mean:70	68%	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 <10 years versus 0 years 10-19 years versus 0 years ≥20 years versus 0 years <10 years versus 0 years 10-19 years versus 0 years ≥20 years versus 0 years	Males OR= 1.3, CI=0.7-2.5 OR= 2.3, CI=1.1-4.9 OR= 1.8, CI=0.9-3.4 Females, OR= 1.4, CI=0.8-2.2 OR= 1.3, CI=0.4-4.0 OR= 2.3, CI=0.8-6.3	Case-control	Cases from a waiting list for THR (selection bias. Participation rate relatively low (84% of cases, 58% of controls) Retrospective exposure measurement (recall bias). Few women in high exposure group
Yoshimura 2000[38]	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 in first and main job	Waiting for surgery	Age, gender, residence matched	Climbing stairs ≥ 30 flights versus no climbing First job Main job	 OR= 0.9, CI=0.4-2.0 OR= 1.1, CI=0.5-2.1	Case-control	Few participants, especially few males. Few women reported heavy lifting (>50 kg). Cases definition = THR (selection bias) Retrospective exposure data (recall bias)
Lau, 2000[30]	Cases: 30 males, 108 females hospitalised in Hong Kong with hip OA Controls: age and gender matched from general practice in the same region Cumulative number of patients with OA over a 3-year period.	-	-	Interview 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	Climbing stairs≥15 flights/day versus no climbing stairs Males Females	 OR= 8.7, CI=1.8-42.7 OR= 2.5, CI= 1.0-5.9	Case-control	Missing age and participation rate Only very few Chinese subjects with THR, especially in men. Case definition (THR) (selection bias) Retrospective exposure data (recall bias)

Table 6. Osteoarthritis of the knee and heavy lifting: details of the studies.

Reference	Study population	Age Years	Parti-cipation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/ matched By:	Comparisons	Results	Design	Strength weakness
Anderson 1988[53]	5193 (2428 males 2765 females) From a population study (N-HANES) 315 with radiological OA (105 males 210 females)	35-74	75%	Questionnaire graded in relation to heavy work by experienced occupational professionals	Kellgren & Lawrence grade 2-4 TFJ Single AP, non-weight-bearing of both knees	Race, BMI education	Low versus moderate or moderate versus high *45-54 years* Males Females *55-64 years* Males Females	 OR=1.05, CI=0.45-2.4 OR=1.09, CI=0.31-3.5 OR=1.88, CI= 0.88-4.0 OR=3.13, CI=1.04-9.4	Cross-sectional	Case-definition: Non-weight bearing x-rays (under-estimation of knee OA) Exposure measured by current occupation . (misclassification). Use of job-titles there may (misclassification)
Kohatsu 1990[60]	Cases: 46 with total knee replacement Controls: 46 random sample from a large community sample	>55	35%	Questionnaire Occupational history classified in light, moderate, and heavy work	Kellgren & Lawrence grade 3-4 OA	-	Moderate to very heavy work versus light work Age 20-29 years Age 30-39 years Age 40-49 years	 OR= 2.3, CI=0.9-6.1 OR= 3.4, CI=0.9-10.8 OR= 3.0, CI=0.9-11.4	Case-control	Few participants (cases and controls) Low participation rate. Exclusion criteria not described. Case definition: TKR (risk for selection bias) Data presentation inadequate. No adjustment for confounders.
Felson 1991[59]	Cases: 176 males 279 females with knee OA Controls: 569 males 807 females from the Framingham Heart Study	mean:73	96%	Interview Physical demands scored by trained coders	Knee OA, grade 2-4 TFJ, Weight-bearing radiographs	Age BMI Smoking History of knee injury education	Lifting medium, heavy or very heavy demands versus no lifting/no knee bending Severe radiographic knee OA Males, Females	 OR=0.96, CI=0.49-1.87 OR=2.53, CI=0.82-7.85	Cohort	Longitudinal design, Case-definition: weight-bearing radiographs Exposure classified by job-title (misclassification) Physical demanding jobs were uncommon in women Few subjects with heavy physical work.
Vingård 1991[36]	High exposure: 116,581 males (321 OA) 18,434 females (66 OA) Low exposure: 91,057 males (200 OA) 24,145 females (48 OA)	Born 1905-1945	Register based	Occupation scored by experienced occupational physicians	Hospitalised in 1981-83 ICD 8c= 713.01 = knee OA ICD10= M17	Age, residence	High exposure vs. low exposure Males Born 1905-1924 Born 1925-45 Females Born 1905-1924 Born 1925-45	 RR= 1.2, CI= 0.9-1.5 RR=1.4, CI=1.1-1.9 RR=1.4, CI=0.6-3.2 RR=1.9, CI=1.3-2.9	Cohort	High number of participants. Exposure classification: job title; classified in light, medium, heavy (misclassification) Case-definition= hospitalised because of knee OA (selection bias)
Bagge 1991[54]	136 men, 207 women from two sub-samples of 79-year-olds in a population study from Göteborg	79	-	Interviews Classified in no, light, moderate, and heavy Categorised in an arbitrary score	Weight-bearing radiographs, Kellgren & Lawrence grade≥2	-	Males Score0-1 Score 2-3 Score 4-9 Score 10-16 Females Score0-1 Score 2-3 Score 4-9 Score 10-16	 68% 39% 58% 47% 48% 56% 69% 67%	Cohort	Results not well-described, No analysis (or adjustment for confounders. Prevalence of knee OA high and independent of earlier work load, (underestimation). Few men; (n=17) with high exposure.

Reference	**Study population**	**Age Years**	**Parti-cipation rate**	**Exposure measured by:**	**Diagnostic criteria**	**Adjusted for/ matched By:**	**Comparisons**	**Results**	**Design**	**Strength** weakness
Vingård 1992[35]	Cases: 181 males disability pension due to knee OA Controls: 298 from the general Swedish population	Born 1915-1934	-	Interview Occupational history Job-title classified by experienced persons	Primary diagnosis knee OA made by a physician	Age	Medium exposure versus low exposure High exposure versus low exposure	RR= 4.5, CI=2.6-7.6 RR=14.3, CI=8.1-25.4	Case-control	Diagnosis from physicians certificates (misclassification) Subjects in physical demanding occupations may have an increased risk of getting disability pension (selection bias) Exposure = high work load on knees, not especially related to heavy lifting (misclassification)
Schouten 1992[63]	105 subjects from the general population Follow-up 12 years	≥45	only 25% from baseline used in analyses	Questionnaire Occupational history number of years employed, heavy lifting	Cartilage loss Weight bearing AP	Age, BMI, gender	Lifting heavy objects versus no lifting Medium High	 OR=1.0, CI= 0.3-3.02 OR=0.65, CI=0.19-2.3	Cohort	Few participant from first study included in the follow-up. More restrictive scoring of radiographs compared to the first study (misclassification). Exposure: Low frequency of participants with heavy lifting. Case definition: cartilage loss (developed during the 12 year period). Participants with heavy lifting may have left the physical demanding occupations (healthy worker effect).
Cooper 1994[56]	Cases: 109 (30 males, 79 females grade 3-4 OA Controls: 218 age and gender matched (without knee pain) from a large general practice	55-90 mean:73	-	Questionnaire Details of the main job entailed eight specific physical activities, including, heavy lifting	Symptomatic knee OA Kellgren & Lawrence grade 3-4 TFJ+/-PFJ Weight-bearing AP	BMI, Heberden s nodes	Lifting weights >25 kg in an average working day	OR= 1.4, CI=0.5-3.7	Case-control	Weight-bearing radiographs, inclusion of PFJ OA, Inclusion of subjects with moderate and severe symptomatic OA, Exposure: retrospectively by interviews (recall bias). Small number of male participants among cases (n=30), small number of cases and controls with heavy lifting (10 cases and 12 controls (7%), (under-estimation).
Elsner 1996[58]	Cases: 115 males, 86 females with knee OA from an orthopaedic clinic Controls: 95 males 87 females from general practice in the same area	<45 (43%) >55 (57%)	61% among cases	Physical demands reported in a diary book	All degrees of radiological knee OA	Age	Lifting weights >20 kg Y/N	Males OR=1.3, CI=0.73-2.35 Females OR=1.5, CI=0.56-4.18	Case-control	Case definition: all degree of OA (misclassification) Exposure: lifting weights (no frequency, no duration) (misclassification) retrospective (recall bias). Low participation rate among cases (61%). Controls

Reference	Study population	Age Years	Parti-cipation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/ matched By:	Comparisons	Results	Design	Strength weakness
										collected during 4 years; selection of the controls not defined (selection bias). Results not adjusted for earlier traumas, sports activities , body mass index or smoking.
Sahlström, 1997[61]	Cases: 266 with knee OA Controls: 463 age- and gender- matched (gender not described)	47-96 mean:72	71%	Questionnaire Light, medium, heavy Classified by industrial hygienists	At least grade 1 Ahlbäck (≤3mm) Weight-bearing	Sitting Overweight Knee injury	Weight-bearing knee bending and lifting/carrying (unadjusted) versus light knee moment Adjusted for confounders (not defined)	OR=1.9, CI=1.4-2.7 OR=1.1, CI=0.7-1.8	Case-control	Case definition: weight bearing radiographs Exposure: assessed in two ways, Definition of medium heavy lifting: lifts of objects from one level to another; heavy: combined jump and lifting (risk of misclassification).
Coggon, 2000[55]	Cases: 518 (205 males 313 females) waiting for knee replacement Controls: 518 (205 males 313 females) from the same community From three English districts in a two-year period	47-93 mean:73	55%	Interview Occupation held for >1 year from school age Specified physical activity	Cases waiting for surgery	BMI Heber-den's nodes Previous knee injuries Matched by gender and age	Lift ≥10 kg 10 times a week at least 10 years versus no lifting Lift ≥25 kg 10 times a week at least 10 years versus no lifting Lift ≥50 kg often at least 10 years versus no lifting	Males, OR= 1.9, CI= 1.0—3.3 Females, OR= 1.5, CI=1.0-2.3 Males, OR =1.7, CI= 0.9—3.0 Females, OR= 1.7, CI=1.0-2.8 Males, OR= 1.7, CI= 0.9—3.2 Females, OR= 1.2, CI=0.6-2.4	Case-control	High number of participants, interviews with specification of different physical activities, collected retrospectively (recall bias). Low participation rate especially among controls. Case definition: placed on a waiting list for TKR(selection bias).
Lau 2000[30]	Cases: 166 males, 492 females hospitalised in Hong Kong with knee OA over a three months period Controls: 166 age and gender matched from general practice in the same region	-	-	Interview Physical activity in job in which they had work for the longest period before symptom	28% had TKR, 15% waiting for TKR, 57% Grade 3-4 OA	Matched by gender and age	Lift of 10 kg 1-10 times a week versus no lift Lift of 10 kg >10 times a week versus no lift Lift of 50 kg 1-10 times a week versus no lift Lift of 50 kg >10 times a week versus no lift	Males, OR= 1.7, CI=0.9-3.2 Females, OR= 1.5, CI=1.0-2.2 Males, OR= 5.8, CI= 3.1-10.8 Females, OR= 3.0, CI= 2.2-4.1 Males, OR= 3.5, CI=1.4-8.8 Females, OR= 0.9, CI= 0.5-1.7 Males, OR= 7.1 CI= 3.1-16.2 Females, OR= 2.9, CI= 1.9-4.5	Case-control	High number of participants, Exposure: collected by interviews, specified in different physical activities, collected retrospectively (recall bias). Cases definition: subjects seeking hospitals for knee OA (selection bias). Controls with knee complaints excluded.
Sandmark 2000[73]	Cases: 325 males, 300 females with TKR Controls: 264 males, 284 females From 14 counties in Sweden between 1991-1995	55-70	80%	Interviews questionnaire Occupational history Specified physical activity including lifts at work in kilo	TKR between 1991-1993	BMI, smoking, sports activity, Age-matched	Lifts at work versus no lifts Medium High Medium High Males: ≥10 years in heavy jobs versus unexposed	Males OR= 2.5, CI=1.5-4.4 OR= 3.0, CI=1.6-5.5 Females OR=1.2, CI= 0.7-1.9 OR=1.7, CI= 1.0-2.9 OR=2.5, CI=1.7-3.6	Case-control	Case definition: TKR (risk of selection bias) Exposure assessment retrospective (recall bias). Use of job-titles (misclassification) .

Reference	Study population	Age Years	Parti-cipation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/ matched By:	Comparisons	Results	Design	Strength weakness
							Females: ≥10 years in heavy jobs versus unexposed	OR=2.5, CI=1.6-3.9		
Seidler 2001[64]	Cases: 195 (105 males 90 females) with knee OA Controls :325 (105 males 90 females) from an orthopaedic clinic 108 from general practice in Frankfurt/Main Controls without OA	Cases mean: 53 Controls Mean: 35	64%	Questionnaire Specified physical demands, lifted kg /day and duration	TFJ Grade 1-4 PFJ excluded	Age, BMI, sports activities,	Males Lifting daily 20-50 kg 1-10 years versus no lifting >10 years versus no lifting Lifting daily >50 kg 1-10 years versus no lifting >10 years versus no lifting Females	 OR=0.5, CI=0.1-1.4 OR=1.2, CI=0.4-3.0 OR=1.0, CI=0.2-3.9 OR=3.4, CI=0.7-17.2 ns (few participants)	Case-control	Controls without radiological knee OA, subjects with meniscal lesions excluded. Case definition: OA grade 1-4 (66%) of cases had grade 1 OA, only 10% grade 3-4 OA (misclassification). The exposure assessment: retrospective (recall bias).
Dawson 2002[57]	Cases 29 females placed on waiting list for TKR during past 12 months Controls:82 females age-matched from general practice	50-70	45%	Interviewed Occupational risk factors in job	Waiting for TKR	Age general practitio-ner	Lifting >25 years versus lifting<25 years Lifting >33 years versus lifting<25 years	OR=7.31, CI=2.01-26.7 OR=3.58, CI=0.89-14.4	Case control	Participation rate low/ high exclusion rate, Low number of cases (n=29), Exposure assessment retrospective (recall bias) Exposure defined as lifting two times/week (weight, frequency not defined) (misclassification). Housewives included but not defined. Duration of exposure divided in three categories ; lowest category= exposure <24 years (misclassification).
Yoshimura 2004[65]	Cases: 101 females with knee OA from 6 hospitals in three cities of Japan Controls: 101 females, random sample from the local population	≥45	84% cases 59% controls	Questionnaire Specific physical demands	Radiological grade 3-4 knee OA	Age matched Adjusted for 'potential risk factors'	Lifting weights >25kg vs. no lifting on an average day First job Main job	 OR=1.0, CI=0.50-2.00 OR=1.91, CI=0.92-3.96	Case-control	Differences in participation rate among cases and controls. 50% of cases had a previous knee injury compared to controls (14%). Relatively few exposed to heavy lifting. Cases defined as TKR (selection bias). Exposure assessment: retrospective (recall bias).

Table 7. Knee osteoarthritis and occupations, which involve heavy lifting and eventually kneeling/squatting: details of the studies.

Reference	Study population	Age years	Parti-cipation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/matched by	Comparisons	Results	Design	Strength Weakness
Kellgren 1952[69]	84 miners, 45 manual workers, 42 office workers age 40-50 years	40-50	73%	Occupation	Radiological grade 2-4 TFJ AP and lateral view of the right knee	-	Miners versus office workers Miners versus manual workers Manual workers versus office workers	OR= 2.77, CI=1.2-6.3 OR=3.03, CI=1.36-6.79 OR=0.91, CI=0.34-2.48	Cross-sectio-nal	Description of study population, participation rate, inclusion, and exclusion criteria. Not-weight-bearing radiographs taken (knee, low back, hands) Blinded evaluation of the radiographs. Exposure: job-title (misclassification).
Wickström 1983[71]	252 reinforcement workers, 231 painters	20-64	85%	Job-title Video-recordings	Radiological grade 1-4, and ≥3	Age	Reinforcement workers versus painters All Severe	OR=1.1, CI=0.72-1.74 OR=1.1, CI=0.31-4.33	Cross-sectio-nal	Exposure assessment done by video-taping. Relative few subjects in the age group >50 years. Only active workers included (healthy workers effect).
Vingård 1991[36]	Male construction workers:: 38,095 (114 OA) Low exposure: Male: 91,057 (200 OA) Same occupation in 1960 and 1970.	Born 1905-1945	register based	Physical de-mands clas-sified by two experienced occupational health physicians	Hospitalised in 1981-83 ICD 8= 713.01 =knee OA ICD10=M17	Age, county	Construction workers versus low exposure	RR=1.36, CI=1.13-1.79	Cohort	High number of participants. Exposure classification: job title + light, medium, heavy (misclassification) Case-definition= hospitalised because of knee OA (selection bias)
Vingård 1992[35]	Cases: 181 males disability pension due to knee OA (34 construction workers; 13 painters & carpet layers) Controls: 298 from the general Swedish population	Born 1915-1934	-	Interview Occupational history	Primary diagnosis knee OA made by a physician	Age	Construction workers versus never exposed to any of 20 most exposed occupations Painters and carpet layers versus never exposed to any of 20 most exposed occupations	RR= 5.1, CI=2.6-10.6 RR=23.1, CI=3.0-178.3	Case-control	Diagnosis from physicians certificates (misclassification) Exposure = high work load on knees, not especially related to heavy lifting (misclassification) Subjects in physical demanding occupations may have an increased risk of getting disability pension (selection bias)
Kivimäki 1992[70]	168 floor layers 146 painters(controls)	25-45	72%	Job-title Video recording for kneeling activities	TFJ + PFJ Osteophytes and JSN Weight bearing radiographs	Age, occupation, smoking, BMI, knee injury	Floor layers versus painters TFJ Knee osteophytes PFJ (caudal) PFJ (cranial)	OR=0.87 ,CI=0.17-4.36 OR=1.96, CI=1.25-3.06 OR=2.85, CI=1.85-4.4 OR=1.3, CI=0.98-1.94	Cross-sectio-nal	Exposure assessment: only for kneeling working activities. Only subjects up to the age of 49 years included.
Jensen 1994[41]	10,223 construction workers (35 OA) 13,447 carpenters (40 OA) total: 2,664,192 males and females (7588 OA) All active working persons in Denmark	20-59 in 1981		Occupation 1981	Hospitalised 1981-1990 ICD-8 713.01=knee OA ICD10=M17	age	Construction workers vs. other Carpenters vs. other	Males SHR=144, CI=101-201 SHR=159, CI=117-217	Cohort	High number of participants. Longitudinal design (avoid information bias). Job-title (misclassification). Main job has been registered in 5-year periods, (misclassification). Case definition = diagnostic code.´(misclassification + selection bias).

Reference	Study population	Age years	Parti-cipation rate	Exposure measured by:	Diagnostic criteria	Adjusted for/matched by	Comparisons	Results	Design	Strength Weakness
Greinemann 1997[66]	Cases: 500 miners working at least 25 years underground' Controls: 500 without knee demanding work	50	-	Occupation	Radiological and clinical examination Radiological investigation in two planes	-	Miners versus non-miners TFJ OA PFJ OA	 OR= 14.8, CI=7.3-30.1 OR= 3.83, CI=2.21-6.66	Cross-sectio-nal	High number of participants (miners and non-miners). Description of the study design, the inclusion and exclusion criteria , the participation rate, case definition, and statistical analysis are all missing.
Jensen 2000[68]	50 floor layers, 50 carpenters, 49 controls without knee demands selected from respon-ders in a questionnaire study of workers in Copenhagen area	26-72	78% in question naire study	Job-title Video recordings for kneeling	Kellgren & Lawrence grade 2-4 TFJ Not-weight bearing	-	Floor layers Carpenters Graphic designers Symptomatic knee OA >50 years of age Floor layers Carpenters Graphic designers	14% 8% 6% 64% 22% 6%	Cross-sectio-nal	Few participants in the radiological study (underestimation). Selection of participants for the radiological study: stratified sample - only restrictive statistical analysis. Radiographs non-weight-bearing (non-differential misclassification). Exposure to kneeling (not lifting) recorded.
Sandmark 2000[73]	Cases: 325 males, 300 females with TKR Controls: 264 males, 284 females From 14 counties in Sweden between 1991-1995	55-70	80%	Interviews questionnaire Occupational history 'lifts in kilo'	TKR between 1991-1993	BMI, smoking, sports activity, Age-matched	*Males:* Construction workers versus unexposed Farmers versus unexposed Forestry workers versus unexposed *Females:* Farmers versus unexposed	 OR=3.1, CI=1.5-6.4 OR=3.2, CI=2.0-5.2 OR=2.1, CI=1.0-4.6 OR=2.4, CI=1.4-4.1	Case-control	Case definition: TKR (risk of selection bias) Exposure assessment retrospective (recall bias). Use of job-titles (misclassification) .
Yoshimura 2004[65]	Cases: 101 females with knee OA from 6 hospitals in three cities of Japan Controls: 101 females, random sample from the local population	≥45	84% cases 59% controls	Questionnaire Physical demands Job-title	Radiological grade 3-4 knee OA	Knee injury, AR excluded	Construction workers among cases and controls	First job, OR=2.62, CI= 1.37-5.03 Main job, OR=1.30, CI= 0.69-2.46	Case-control	Differences in participation rate among cases and controls. 50% of cases had a previous knee injury compared to controls (14%). Relatively few exposed to heavy lifting. Cases defined as TKR (selection bias).Exposure assessment: retrospective (recall bias).
Holmberg 2004[67]	Cases: 778 with knee OA (338 males 440 females) Controls: 695 (293 males 402 females) From three counties of Sweden 57 construction workers (only males)	Mean: 63	89%	Questionnaire occupation since the age of 15 years	Retrospective X-Ray 1999-2000 TFJ OA	Heredity, overweight, smoking, civil status, self employment, knee injury, meniscus injury, sports	Construction workers 1-10 years versus others 11-30 years versus others >30 years versus others Farmers 1-10 years versus others 11-30 years versus others >30 years versus others 1-10 years versus others 11-30 years versus others >30 years versus others	Males OR=1.5, CI=0.4-4.5 OR=2.5, CI=1.0-6.0 OR=1.6, CI=0.6-4.6 Males OR=1.3, CI=0.6-2.1 OR=0.8 CI=0.3-2.1 OR=1.7, CI=0.7-4.0 Females OR=0.8, CI=0.4-1.9 OR=2.1, CI=1.0-4.5 OR=2.0, CI=0.7-5.5	Case-control	High frequency of participants. Cases identified via x-ray departments Exposure: retrospective (recall bias) job-title (non-differential misclassification).

Table 8. Osteoarthritis of the knee, kneeling and heavy lifting: details of the studies.

Reference	Study population	Age Years	Parti-cipation rate	Exposure measured by:	Diagnostic criteria	Adjusted for: Matched by:	Comparisons	Results	Design	Strength Weakness
Felson 1991[59]	569 males 807 females from the Framingham Heart Study 176 males, 279 females with knee OA	mean:73	96%	Interview Physical demands scored by trained coders	Knee OA, grade 2-4 TFJ, Weight-bearing radiographs	Age BMI Smoking History of knee injury education	Kneeling and lifting medium, heavy or very heavy demands versus no lifting/no knee bending Males Females	OR=2.2, CI=1.38-3.6 OR=0.36, CI=0.09-1.4	Cohort	Longitudinal design, Case-definition: weight-bearing radiographs Exposure classified by job-title (misclassification) Physical demanding jobs were uncommon in women Few subjects with heavy physical work.
Cooper 1994[56]	Cases: 109 (30 males, 79 females grade 3-4 OA Controls: 218 age and gender matched (without knee pain) from a large general practice	55-90 mean:73	-	Questionnaire Occupational history	Symptomatic knee OA Kellgren & Lawrence grade 3-4 TFJ+/-PFJ Weight-bearing AP	BMI, Heberdens nodes	Both heavy lifting and kneeling/ squatting or climbing stairs versus no heavy lifting, kneeling/squatting or climbing stairs	OR=5.4, CI=1.4-21.0	Case-control	Weight-bearing radiographs, inclusion of PFJ OA, Inclusion of subjects with moderate and severe symptomatic OA, Exposure: retrospective (recall bias), interviews. Small number of male participants among cases (n=30). Only 13 cases and controls (5%) have had combined heavy lifting and kneeling, squatting, or climbing stairs.
Coggon, 2000[55]	Cases: 518 (205 males 313 females) waiting for knee replacement Controls: 518 (205 males 313 females) from the same community From three English districts in a two-year period	47-93 mean:73	55%	Interview Occupation held for >1 year from school age	Cases waiting for surgery	BMI Heberden's nodes Previous knee injuries Matched by gender and age	Both kneeling or squatting and heavy lifting versus no kneeling or squatting or heavy lifting	Males OR= 2.9, CI=1.3-6.6 Females OR= 4.2, CI=1.5-12.1	Case-control	High number of participants, interviews with specification of different physical activities, collected retrospectively (recall bias). Low participation rate especially among controls. Case definition: placed on a waiting list for TKR(selection bias).
Seidler 2001[64]	Cases: 195 (105 males 90 females) with knee OA Controls :325 (105 males 90 females) from an orthopaedic clinic 108 from general practice in Frankfurt/Main Controls without OA	Cases mean:53 Controls mean:35	64%	Questionnaire Physical demands	TFJ grade 1-4 Grade 1-4 PFJ excluded	Age, BMI, sports activities,	Lifting>50 kg and/or daily kneeling >10 years versus no kneeling/no lifting	Males OR=2.7, CI=1.0-7.1 Females OR=0.3, CI=0.03-4.1	Case-control	Controls without radiological knee OA, subjects with meniscal lesions excluded. Case definition: OA grade 1-4 (66%) of cases had grade 1 OA, only 10% grade 3-4 OA (non-differential misclassification of the cases). The exposure assessment: retrospective (recall bias).

Table 9. Knee OA and climbing stairs: details of the studies.

Reference	**Study population**	**Age Years**	**Partici-pation rate**	**Exposure measured by:**	**Diagnostic criteria**	**Adjusted for: Matched by:**	**Comparisons**	**Results**	**Design**	**Strength** Weakness
Cooper 1994[56]	Cases: 109 (30 males, 79 females grade 3-4 OA Controls: 218 age and gender matched (without knee pain) from a large general practice	55-90 mean:73	?	Questionnaire Occupational history	Symptomatic knee OA Kellgren & Lawrence grade 3-4 TFJ+/-PFJ Weight-bearing AP	BMI, Heberdens nodes	Climbing stairs>30 flight of stairs/day versus no climbing stairs	OR= 2.7, CI=1.2-6.1	Case-control	Weight-bearing radiographs, inclusion of PFJ OA, Subjects with moderate and severe symptomatic OA, Exposure: retrospectively (recall bias), by interviews . Small number of male participants among cases (n=30), small number of cases and controls which have been employed in occupations with climbing stairs (19 cases and 20 controls (12%)).
Sandmark 2000[73]	Cases: 325 males, 300 females with TKR Controls: 264 males, 284 females From 14 counties in Sweden between 1991-1995	55-70	80%	Interviews questionnaire Occupational history (lifts at work in kilo)	TKR between 1991-1993	BMI, smoking, sports activity, Age-matched	Climbing stairs Medium High Medium High	Males OR= 1.2, CI=0,8-1,9 OR= 1.2, CI=0.7-2.1 Females OR= 1.7, CI=1.1-2.5 OR= 1.4, CI=0.8-2.3	Case-control	Case definition: TKR (risk of selection bias) Exposure assessment retrospective (recall bias). Use of job-titles (misclassification) .
Coggon, 2000[55]	Cases: 518 (205 males 313 females) waiting for knee replacement Controls: 518 (205 males 313 females) from the same community From three English districts in a two-year period	47-93 mean:73	55%	Interview Occupation held for >1 year from school age	Cases waiting for surgery	BMI Heberden's nodes Previous knee injuries Matched by gender and age	Climbing a ladder or flight of stairs >30 times/day versus no climbing	Males, OR= 2.3, CI= 1.3—4.0 Females OR= 0.7, CI=0.3-1.6	Case-control	High number of participants, interviews with specification of different physical activities, collected retrospectively (recall bias). Low participation rate especially among controls. Case definition: placed on a waiting list for TKR(selection bias).
Lau 2000[30]	Cases: 166 males, 492 females hospitalised in Hong Kong with knee OA over a three months period Controls: 166 age and gender matched from general practice in the same region	-	-	Interview Job in which they had work for the longest period before symptom	28% had TKR, 15% waiting for TKR, the rest Grade 3-4 OA	Matched by gender and age	Climbing stairs ≥ 15 flights/day	Males, OR= 4.1, CI=2.1-8.2 Females, OR= 6.1, CI= 3.5-10.8	Case-control	High number of participants, Exposure: collected by interviews, specified in different physical activities, collected retrospectively (recall bias). Cases definition: subjects seeking hospitals for knee OA (selection bias). Controls with knee complaints excluded.

Abbreviations

BMI	Body mass index (weight/height^2)
ICD10	WHO's International Classification of Diseases (tenth edition)
ICD8	WHO's International Classification of Diseases (eighth edition)
J	Job-title
JSN	Joint-space narrowing
OA	Osteoarthritis
OR	Odds ratio;
P	Physical work load
PFJ	Patello-femoral joint
R	Radiological investigation
RR	Relative risk
SHR	Standardised hospitalisation ratio
TFJ	Tibio-femoral joint
THR	Total hip replacement
TKR	Total knee replacement

Appendix I.

Scientific Committee of the Danish Society of Occupational and Environmental Medicine.

Degree of evidence of a causal association

The following categories are used.

+++	strong evidence of a causal association
++	moderate evidence
+	limited evidence
0	insufficient evidence of a causal association
-	sufficient evidence of no causal association

Description of categories:

Strong evidence (+++):

A causal relationship is very likely between an exposure to a specific risk factor and a specific outcome.

A positive relationship has been observed between exposure to the risk factor and the outcome in several studies in which chance, bias, and confounding could be ruled out with reasonable confidence.

Moderate evidence (++):

Some convincing epidemiological evidence exists for a causal relationship between an exposure to a specific risk factor and a specific outcome.

A positive relationship has been observed between exposure to the risk factor and the outcome in several studies in which chance, bias, and confounding are not the likely explanation.

Limited evidence (+):

Some convincing epidemiological evidence exists for a causal relationship between an exposure to a specific risk factor and a specific outcome.

A positive relationship has been observed between exposure to the risk factor and the outcome, but it is not unlikely that this relationship could be explained by chance, bias, or confounding.

Insufficient evidence of a causal association (0)

The available studies are of insufficient quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of a causal association.

Evidence suggesting lack of a causal association (-)

Several studies of sufficient quality, consistency and statistical power indicate that the specific risk factor is not causally related to the specific outcome.

Reference List

(1) Kellgren J, Lawrence J. Osteoarthrosis and disk degeneration in an urban population. Annals of the Rheumatic Diseases 1958; 17:388-397.

(2) Lawrence J, Bremner J, Bier F. Osteo-arthrosis. Prevalence in the population and relationship between symptoms and X-ray changes. Ann Rheum Dis 1966; 25:1-24.

(3) Lawrence RC, Hochberg M, Kelsey JL, McDuffie FC, Medsger TA, Felts WR et al. Estimates of the prevalence of selected arthritic and musculoskeletal diseases in the United States. The Journal of Rheumatology 1989; 16:427-441.

(4) Felson DT, Lawrence RC, Hirsch R, Helmick CG, Jordan JM, Kington RS et al. Osteoarthritis: New insights (Part I: The disease and its risk factors). Ann Intern Med 2000; 133(8):635-646.

(5) Lawrence RC, Helmick CG, Arnett Frank C, Deyo Richard A, Felson DT, Giannini Edward H et al. Estimates of the prevalence of arthritis and selected musculoskeletal disorders in the United States. Arthritis & Rheumatism 1998; 41(5):778-799.

(6) Cooper C, Inskip H, Croft P, Campell L, Smith G, McLaren M et al. Individual risk factors for hip osteoarthritis: Obesity, hip injury, and physical activity. American Journal of Epidemiology 1998; 147(6):516-522.

(7) Oliveria SA, Felson DT, Reed JI, Cirillo PA, Walker A. Incidence of symptomatic hand, hip, and knee osteoarthritis among patients in a health maintenance organization. Arthritis & Rheumatism 1995; 38(8):1134-1141.

(8) Felson DT. Epidemiology of hip and knee osteoarthritis. Epidemiologic Reviews 1988; 10:1-28.

(9) Lawrence J, Seno M. The geography of osteoarthrosis. In: Nuki G, editor. The Aetiopathogenesis of Osteoarthrosis. Edinburgh: Pitman Medical Publishing Co.Ltd., Po Box 7, Tunbridge Wells, Kent, TN1 1xH, England; 1980. 155-183.

(10) Hannan MT, Felson DT, Pincus T. Analysis of the discordance between radiographic changes and knee pain in osteoarthritis of the knee. J Rheumatol 2000; 27:1513-1517.

(11) Felson DT. An update on the pathogenesis and epidemiology of osteoarthritis. Radiol Clin North Am 2004; 42:1-9.

(12) Bøggild H, Johansen JP. Arbejdsmiljø og slidgigt i hoften. En oversigt over epidemiologiske undersøgelser af sammenhængen mellem arbejdsmiljø og coxarthrosis. [Working environment and osteoarthrosis of the hip]. Ugeskrift Læger 1997; 159(28):4370-4376.

(13) Lau E, Symmons DP, Croft P. The epidemiology of hip osteoarthritis and rheumatoid arthritis in the Orient. Clinical Orthopaedics and related Research 1996; 323:81-90.

(14) Lievense A, Bierma-Zeinstra S, Verhagen A, Koes B. Influence of Work on the Development of Osteoarthritis of the Hip: A Systematic Review. J Reumatol 2001; 28:2520-2528.

(15) Taylor AJ Newman, Brown I, Cockcroft A, Lawson IJ, Ifill G, Platt MA et al. Osteoarthritis of the hip. Department for Work and Pensions 2003;3-19.

(16) Brandt KD, Felson DT, Hochberg MC, Radin EL, Moskowitz RW, Zhang W et al. Update of proceedings of the 2002 international workshop on osteoarthritis outcomes. The Journal of Rheumatology 2005; 32(6):1132-1159.

(17) Felson DT, Zhang Y. An update on the epidemiology of knee and hip osteoarthritis with a view to prevention. Arthritis & Rheumatism 1998; 41(8):1343-1355.

(18) Maetzel A, Mäkelä M, Hawker G, Bombardier C. Osteoarthritis of the hip and knee and mechanical occupational exposure - A systematic overview of the evidence. The Journal of Rheumatology 1997; 24:1599-1607.

(19) Moskowitz RW. Primary osteoarthritis: Epidemiology, clinical aspects, and general management. The American Journal of Medicine 1987; 83(suppl. 5 A):5-10.

(20) Vingård E, Alfredsson L, Hogstedt C, Goldie I. Increased risk of arthrosis of the knee and hip among workers with heavy weight on the legs. Läketidningen 1990; 87(51-52):4413-4416.

(21) Vingård E, Alfredsson L, Hogstedt C, Goldie J. Ökad risk för artsros i knän og höfter för abetare i yrken med hög belastning på benen. Läketidningen 1990; 87:51-52.

(22) Zetterberg C, Hansson T. Artros i Höft och Knä [Arthrosis of the hip and knee]. Läketidningen 1995; 92(Nr. 22):2307-2310.

(23) Walker-Bone K, Palmer K. Musculoskeletal disorders in farmers and farm workers. Occup Med 2002; 52(No. 8):441-450.

(24) Coggon D, Kellingray S, Inskip H, Croft P, Campell L, Cooper C. Osteoarthritis of the hip and occupational lifting. American Journal of Epidemiology 1998; 147(no. 6):523-528.

(25) Croft P, Cooper C, Wickham C, Coggon D. Osteoarthritis of the hip and occupational activity. Scand J Work Environ Health 1992; 18(1):59-63.

(26) Cvijetic S, Dekanic-ozegovic D, Campell L, Cooper C, Potocki K. Occupational physical demands and hip osteoarthritis. arh hig rada toksikol 1999; 50(no 4):371-379.

(27) Flugsrud GB, Nordsletten L, Espehaug B, Havelin LI, Meyer HE. Risk factors for total hip replacement due to primary osteoarthritis. Arthritis & Rheumatism 2002; 46(No.3):675-682.

(28) Jacobsen S, Sonne-Holm S, Søballe K, Gebuhr P, Lund B. The distribution and inter-relationships of radiologic features of osteoarthritis of the hip. a survey of 4,151 subjects of the Copenhagen city Heart Study: the Osteoarthritis Substudy. Osteoarthritis and Cartilage 2004; 12:704-710.

(29) Jacobsson B, Dalén N, Tjörnstrand B. Coxarthrosis and labour. International Orthopaedics 1987; 11:311-313.

(30) Lau E, Cooper C, Lam D, Chan V, Tsang K, Sham A. Factors associated with osteoarthritis of the hip and knee in Hong Kong Chinese: Obesity, joint injury, and occupational activities. American Journal of Epidemiology 2000; 152(9):855-862.

(31) Olsen O, Vingård E, Köster M, Alfredsson L. Etiologic fractions for physical work load, sports and overweight in the occurrence of coxarthrosis. Scand J Work Environ Health 1994; 20(3):184-188.

(32) Roach KE, Persky V, Miles T, Budiman-Mak E. Biomechanical aspects of occupation and osteoarthritis of the hip: A case-control study. The Journal of Rheumatology 1994; 21:2334-2340.

(33) Typpö T. Osteoarthritis of the hip - radiologic findings and etiology. Annales chirurgiae et gynaecologiae 1985; 74(suppl. 201):5-38.

(34) Vingård E, Hogstedt C, Fellenius E, Goldie J, Köster M, Alfredsson L. Coxarthrosis and physical work load. Scand J Work Environ Health 1991; 17:104-109.

(35) Vingård E, Alfredsson L, Fellenius E, Hogstedt C. Disability pensions due to musculo-skeletal disorders among men in heavy occupations. Scand J Soc Med 1992; 20:31-36.

(36) Vingård E, Alfredsson L, Goldie J, Hogstedt C. Occupation and osteoarthrosis of the hip and knee: A register-based cohort study. International Journal of epidemiology 1991; 20:1025-1031.

(37) Vingård E, Alfredsson L, Malchau H. Osteoarthrosis of the hip in women and its relation to physical load at work and in the home. Annals of the Rheumatic Diseases 1997; 56:293-298.

(38) Yoshimura N, Sasaki S, Iwasaki K, Danjoh S, Kinoshita H, Yasuda T et al. Occupational lifting is associated with hip osteoarthritis: A Japanese case-control study. J Rheumatol 2000; 27:434-440.

(39) Axmacher B, Lindberg H. Coxarthrosis in farmers. Clinical Orthopaedics and related Research 1993;(287):82-86.

(40) Croft P, Coggon D, Cruddas M, Cooper C. Osteoarthritis of the hip: an occupational disease in farmers. BMJ 1992; 304:1269-1272.

(41) Jensen MV, Tüchsen F, Bach E. Erhvervsindlæggelsesregistret [Registration of occupation and hospitalization]. Arbejdsmiljøfondet, Denmark 1994;1-160.

(42) Thelin A, Jansson B, Jacobsson B, Ström H. Coxarthrosis and farm work: A case-referent study. American Journal of Industrial Medicine 1997; 32:497-501.

(43) Thelin A. Hip joint arthrosis: An occupational disorder among farmers. American Journal of Industrial Medicine 1990; 18:339-343.

(44) Thelin A, Vingård E, Holmberg S. Osteoarthritis of the hip joint and farm work. American Journal of Industrial Medicine 2004; 45:202-209.

(45) Tüchsen F, Hannerz H, Jensen M, Krause N. Socioeconomic status, occupation, and risk of hospitalisation due to coxarthrosis in Denmark 1981-99. Ann Rheum Dis 2003; 62:1100-1105.

(46) Vingård E. Risken för män i fysiskt tunga yrken att förtidspensioneras på grund af sjukdommar i rörelsesapparatet.[Risk for men with physical heavy work load to get a disability pension based on musculoskeletal disorders]. Arbets Miljö Institutet; 1991.

(47) Jensen L, Eenberg W. Occupation as a risk factor for knee disorders. Scand J Work Environ Health 1996; 22:165-175.

(48) Vingård E. Osteoarthrosis of the knee and physical load from occupation. Annals of the Rheumatic Diseases 1996; 55(No 9):677-679.

(49) Westrich G.H., Haas S.B., Bono JV. Occupational knee injuries. Orthop Clin North Am 1996; 27(4):805-814.

(50) Hunter D, March L, Sambrook P. Knee osteoarthritis: the influence of environmental factors. Clinical and Experimental Rheumatology 2002; 20:93-100.

(51) Schrøder HM, Pedersen NW, Pedersen C, Kjærsgaard-Andersen P, Hindsø K. Knænær osteotomi og primær knæalloplastik (DOS referenceprogram). [Knee osteotomy and primary alloplastics (Danish Ortopaedic Society Reference Programme)]. Ugeskrift Læger 2005; 167(18):1974.

(52) Moskowitz RW. Primary Osteoarthritis:Epidemiology, clinical Aspects, and General Managment. The American Journal of Medicine 1987; 83(Suppl 5A):5-10.

(53) Anderson JJ, Felson DT. Factors associated with osteoarthritis of the knee in the first national health and nutrition examination survey (Hanes 1). American Journal of Epidemiology 1988; 128(No.1.):179-189.

(54) Bagge E, Bjelle A, Eden S, Svanborg A. Factors associated with radiographic osteoarthritis:. Results from a population study 70-year-old people in Göteborg. J Rheumatol 1991; 18:1218-1222.

(55) Coggon D, Croft P, Kellingray S, Barrett D, McLaren M, Cooper C. Occupational physical activities and osteoarthritis of the knee. Arthritis & Rheumatism 2000; 43(7):1443-1449.

(56) Cooper C, McAlindon T, Coggon D, Egger P, Dieppe P. Occupational activity and osteoarthritis of the knee. Ann Rheum Dis 1994; 53:90-93.

(57) Dawson J, Juszczak E, Thorogood M, Marks S-A, Dodd C, Fitzpatrick R. An investigation of risk factors for symptomatic osteoarthritis of the knee in women using a life course approach. J Epidemiol Community Health 2003; 57:823-830.

(58) Elsner G, Nienhaus A, Beck W. Kniegelenksarthrose und arbeitsbedingte Faktoren (Knee joint arthroses and work-related factors). Soz Präventivmed 1996; 41:98-106.

(59) Felson DT, Hannan MT, Naimark A, Berkeley J, Gordon G, Wilson PW et al. Occupational physical demands, knee bending, and knee osteoarthritis: Results from the Framingham Study. The Journal of Rheumatology 1991; 18:1587-1592.

(60) Kohatsu ND, Schurman DJ. Risk factors for the development of osteoarthrosis of the knee. Clinical Orthopaedics and related Research 1990;(261):242-246.

(61) Sahlström A, Montgomery F. Risk analysis of occupational factors influencing the development of arthrosis of the knee. European Journal of Epidemiology 1997; 13:675-679.

(62) Sandmark H, Hogstedt C, Lewold S, Vingård E. Osteoarthrosis of the knee in men and women in association with overweight, smoking and hormone therapy. Annals of the Rheumatic Diseases 1999; 58(151):155.

(63) Schouten JSAG, Van den Ouweland FA, Valkenburg HA. A 12 year follow up study in the general population on prognostic factors of cartilage loss in osteoarthritis of the knee. Annals of the Rheumatic Diseases 1992; 51(8):932-937.

(64) Seidler A, Horung J, Heiskel H, Börner M, Elsner G. Gonarthrose als Berufskrankheit (Osteoarthrosis of the knee as an occupational disease?). Zbl Arbeitsmed 2001; 51:106-117.

(65) Yoshimura N, Nishioka S, Kinoshita H, Hori N, Nishioka T, Ryujin M et al. Risk factors for knee osteoarthritis in Japanese women: heavy weight, previous joint injuries, and occupational activities. The Journal of Rheumatology 2004; 31:157-162.

(66) Greinemann H. Die Kniegelenkartrose des Bergmannes - eine Berufskrankheit. Unfallchirurgie 1997; 23(Nr.1):10-17.

(67) Holmberg S, Thelin A, Thelin N. Is there an increased risk of knee osteoarthritis among farmers? A population-based case-control study. Int Arch Occup Environ Health 2004; 77:345-350.

(68) Jensen L, Mikkelsen S, Loft I, Eenberg W, Bergmann I, Løgager V. Radiographic knee osteoarthritis in floorlayers and carpenters. Scand J Work Environ Health 2000; 26(3):257-262.

(69) Kellgren J, Lawrence J. Rheumatism in miners. Part II: X-Ray study. British Journal of Industrial Medicine 1952; 9:197-207.

(70) Kivimäki J, Riihimäki H, Hänninen K. Knee disorders in carpet and floor layers and painters. Scand J Work Environ Health 1992; 18:310-316.

(71) Wickström G, Hänninen K, Mattsson T, Niskanen T, Riihimäki H, Waris P et al. Knee degeneration in concrete reinforcement workers. British Journal of Industrial Medicine 1983; 1983(40):216-219.

(72) Coggon D, Croft P, Kellingray S, Barrett D, McLaren M. Occupational physical activities and osteoarthritis of the knee. Arthritis & Rheumatism 2000; 43:1443-1449.

(73) Sandmark H, Hogsted C, Vingård E. Primary osteoarthrosis of the knee in men and women as a result of lifelong physical load from work. Scand J Work Environ Health 2000; 26(1):20-25.

(74) Kellgren J, Lawrence J. The epidemiology of chronic rheumatism. Volume II. Atlas of standard radiographs of arthritis. Philadelphia: F.A.Davis Company. Blackwell Scientific Publications (1963); 1963.

(75) Croft P, Cooper C, Wickham C, Coggon D. Defining osteoarthritis of the hip for epidemiological studies. American Journal of Epidemiology 1990; 132(3):514-522.

(76) Reijman M, Hazes J, Pols H, Bernsen RMD, Koes BW, Bierma-Zeinstra S. Validity and reliability of three definitions of hip osteoarthritis:cross sectional and longitudinal approach. Ann Rheum Dis 2004; 63:1427-1433.

(77) Jacobsen S, Sonne-Holm S, Søballe K, Gebuhr P, Lund B. The relationship of hip joint space to self reported hip pain. a Survey of 4,151 subjects of the Copenhagen City Heart Study: the Osteoarthritis Substudy. Osteoarthritis and Cartilage 2004; 12:692-697.

(78) Page WF, Hoaglund FT, Steinbach LS, Heath AC. Primary osteoarthritis of the hip in monozygotic and dizygotic male twins. Twin Research 2003; 6(number 2):147-151.

(79) Croft P, Lewis M, Jones CW, Coggon D, Cooper C. Health status in patients awaiting hip replacement for osteoarthritis. Rheumatology 2002; 41:1001-1007.

(80) Lievense A, Bierma-Seinstra S, Verhagen A, Verhaar J, Koes BW. Influence of hip dysplasia on the development of osteoarthritis of the hip. Ann Rheum Dis 2004; 63:621-626.

(81) Yoshimura N, Campbell L, Hashimoto T, Kinoshita H, Okayasu T, Wilman C et al. Acetabular dysplasia and hip osteoarthritis in Britain and Japan. British Journal of Rheumatology 1998; 37:1193-1197.

(82) Tepper S, Hochberg MC. Factors associated with hip osteoarthritis: Data from the First National Health and Nutritional Examination Survey (NHANES-I). Amercan Journal of Epidemiology 1993; 137(10):1081-1088.

(83) Lievense A, Bierma-Seinstra S, Verhagen A, van Baar M, Verhaar J, Koes BW. Influence of obesity on the development of osteoarthritis of the hip: a systematic review. Rheumatology 2002; 41:1155-1162.

(84) Heliovaara M, Makela M, Impivaara O, Knekt P, Aromaa A, Sievers K. Association of overweight, trauma and workload with coxarthrosis. A health survey of 7.217 persons. Acta orthop scand 1993; 64(5):513-518.

(85) Vingård E, Alfredsson L, Malchau H. Lifestyle factors and hip arthrosis. A case referent study of body mass index, smoking and hormone therapy in 503 Swedish women. Acta orthop scand 1997; 68(3):216-220.

(86) Lequesne M, Azorin M, Lamotte J. Posttraumatic osteoarthritis of the hip. Criteria for imputation to fractures, dislocations, or contusion. Rev Rhum 1993; 60(11):814-821.

(87) Konradsen L, Hansen EMB, Søndergaard L. Long distance running and osteoarthrosis. The American Journal of Sports Medicine 1990; 18(4):379-381.

(88) Kujala U, Kettunen J, Paananen H, Aalto T, Battié M, Impivaara O et al. Knee osteoarthritis in former runners, soccer players, weight lifters, and shooters. Arthritis & Rheumatism 2000; 38:539-546.

(89) Kujala U, Kaprio J, Sarna S. Osteoarthritis of weight bearing joints of lower limbs in former élite male athletes. BMJ 1994; 308:231-234.

(90) Lane NE, Michel B, Bjorkengren A, Oehlert J, Shi H, Bloch DA et al. The risk of osteoarthritis with running and aging: A 5-year longitudinal study. The Journal of Rheumatology 1993; 20(3):461-468.

(91) Marti B, Knobloch M, Tschopp A, Jucker A, Howald H. Is excessive running predictive of degenerative hip disease? Controlled study of former elite athletes. British Medical Journal 1989; 299:91-93.

(92) Sohn RS, Micheli LJ. The effect of running on the pathogenesis of osteoarthritis of the hips and knees. Clinical Orthopaedics and related Research 1985; 198:106-109.

(93) Vingård E, Alfredsson L, Goldie I, Hogstedt C. Sports and osteoarthrosis of the hip. The American Journal of Sports Medicine 1993; 21(2):195-200.

(94) Lievense A, Bierma-Seinstra S, Verhagen A, Bernsen R, Verhaar J, Koes BW. Influence of sporting activities on the development of osteoarthritis of the hip: A systematic review. Arthritis & Rheumatism 2003; 49(2):228-236.

(95) Klünder KB, Rud Bjarne, Hansen J. Osteoarthritis of the hip and knee joint in retired football players. Acta orthop scand 1980; 51:925-927.

(96) Vingård E, Alfredsson L, Malchau H. Osteoarthrosis of the hip in woman and its relationship to physical load from sports activities. The American Journal of Sports Medicine 1998; 26(no. 1):78-82.

(97) Lindberg H, Ross H, Gärdsell P. Prevalence of coxarthrosis in former soccer players. Acta orthop scand 1993; 64(2):165-167.

(98) Hannan MT, Felson DT, Anderson JJ, Naimark A, Kannel WB. Estrogen use and radiographic osteoarthritis of the knee in women. Arthritis & Rheumatism 1990; 33(4):525-532.

(99) Nevitt M, Felson DT. Sex hormones and the risk of osteoarthritis in women: an epidemiological evidence. 55[No 9], 673-676. 2000. Annals of Rheumatic Diseases.

(100) Samanta A, Jones A, Regan M, Wilson S, Doherty M. Is osteoarthritis in women affected by hormonal changes or smoking? British Journal of Rheumatology 1993; 32:366-370.

(101) Spector T, Nandra D, Hart D, Doyle D. Is hormone replacement therapy protective for hand and knee osteoarthritis in women The Chingford study. Ann Rheum Dis 1997; 56:432-434.

(102) Wolfe F, Altman R, Hochberg M, Lane NE, Laggan M, Sharp J. Post menopausal oestrogen therapy is associated with improved radiographic scores in OA & RA. The Florida Chapter of the Arthritis Foundation 2000.

(103) Oliveria SA, Felson DT, Klein RA, Reed JI, Walker AM. Estrogen replacement therapy and the development of osteoarthritis. Epidemiology 1996; 7(4):415-419.

(104) McAlindon T, Snow S, Copper C, Dieppe P. Radiographic patterns of osteoarthritis of the knee joint in the community: the importance of the patellofemoral joint. Annals of the Rheumatic Diseases 1992; 51:844-849.

(105) Altman R, Asch E, Bloch D, Bole G, Borenstein D, Brandt K et al. Development of criteria for the classification and reporting of osteoarthritis. Classification of osteoarthritis of the knee. Arhtritis and Rheumatism 1986; 29(No.8):1039-1049.

(106) Ahlbäck S. Osteoarthrosis of the knee. A radiographic investigation. Acta Radiol Diagn 1968;(Suppl 277):7-72.

(107) Felson DT, Naimark A, Anderson J, Kazis L, Castelli W, Meenan R. The prevalence of knee osteoarthritis in the elderly. The Framingham Osteoarthritis Study. Arthritis & Rheumatism 1987; 30(8):914-918.

(108) Neame R, Muir K, Doherty M, Doherty S. Genetic risk of knee osteoarthritis: a sibling study. Ann Rheum Dis 2004; 63:1022-1027.

(109) Felson DT, Zhang Y, Hannan MT, Naimark A, Weissman BN, Aliabadi P et al. Risk factors for incident radiographic knee osteoarthritis in the elderly. Arthritis & Rheumatism 1997; 40(4):728-733.

(110) Manninen P, Riihimäki H, Heliövaara M, Mäkelä P. Overweight, gender and knee osteoarthritis. International Journal og Obesity 1996; 20:595-597.

(111) Coggon D, Reading I, Croft P, McLaren M, Barrett D, Cooper C. Knee osteoarthritis and obesity. International Journal of Obesity 2001; 25:622-627.

(112) Felson DT. Does excess weight cause osteoarthritis and, if so, why? Annals of Rheumatic Diseases 2000; 55(No 9):668-670.

(113) Roos H, Laurén M, Adalberth T, Ross EM, Jonsson K, Lohmander LS. Knee osteoarthritis after meniscectomy. Arthritis & Rheumatism 1998; 41(No. 4):687-693.

(114) Berthiaume M-J, Raynauld J-P, Martel-Pelletier J, Labonté F, Beaudoin G, Bloch D et al. Meniscal tear and extrusion are strongly associated with progression of symptomatic knee osteoarthritis as assessed by quantitative magnetic resonance imaging. Ann Rheum Dis 2005; 64:556-563.

(115) Cicuttini F, Forbes A, Yuanyuan W, Rush G, Stuckey SL. Rate of knee cartilage loss after partial meniscectomy. The Journal of Rheumatology 2002; 29:1954-1956.

(116) Englund M, Lohmander LS. Risk factors for symptomatic osteoarthritis fifteen to twenty-two years after meniscectomy. Arthritis & Rheumatism 2004; 50(9):2811-2819.

(117) Roos H, Lindberg H, Gärdsell P, Lohmander L, Wingstrand H. The prevalence of gonarthrosis and its relation to meniscectomy in former soccer players. The American Journal of Sports Medicine 1994; 22(2):219-222.

(118) von Porat A, Roos H, Roos E. High prevalence of osteoarthritis 14 years after an anterior cruciate ligament tear in male soccer players: a study of radiographic and patient relevant outcomes. Ann Rheum Dis 2004; 63:269-273.

(119) Fairbank T. Knee joint changes after meniscectomy. The Journal of Bone and Joint Surgery 1948; 30:664-670.

(120) Jackson J. Degenerative changes in the knee after meniscectomy. British Medical Journal 1968; 2(2):525-527.

(121) Sommerlath Karola, Gillquist J. The long-term course of various meniscal treatments in anterior cruciate ligament deficient knees. Clinical Orthopaedics and related Research 1992; 283:207-214.

(122) Enderlein G, Kasch J. Modellierung von Dosis-Wirkungsbeziehungen für expositionsabhängige Veränderungen am Bewegungsapparat. Z gesamte Hyg 1989; 35(4 heft):215-218.

(123) Kasch J, Enderlein G. Kniegelenksschäden im Schiffbau. Beitr Orthop Traumatol 1986; 33(10):487-494.

(124) Zhang Y, Glynn RJ, Felson DT. Musculoskeletal disease research. Should we analyze the joint or the person. J Reumatol 1996; 23:1130-1134.

(125) Lane NE, Bloch DA, Wood PD, Fries JF. Aging, long-distance running, and the development of musculoskeletal disability. The American Journal of Medicine 1987; 82:772-780.

(126) Kujala UM, Kettunen J, Paananen H, Aalto T, Battié MC, Impivaara O et al. Knee osteoarthritis in former runners, soccer players, weight lifters, and shooters. Arthritis & Rheumatism 1995; 38(4):539-546.

(127) Larsen E, Jensen P, Jensen P. Long-term outcome of knee and ankle injuries in elite football. Scand J Med Sci Sports 1999; 9:285-289.

(128) Shepard G, Banks A, Ryan W. Ex-professional association footballers have an increased prevalence of osteoarthritis of the hip compared with age matched controls despite not having sustained notable hip injuries. Br J Sports Med 2003; 37:80-81.

(129) Sandmark H, Hogstedt C, Lewold S, Vingård E. Osteoarthrosis of the knee in men and women in association with overweight, smoking, and hormone therapy. Ann Rheum Dis 1999; 58:151-155.

(130) Felson DT, Anderson JJ, Naimark A, Hannan MT, Kannel WB, Meenan R. Does smoking protect against osteoarthritis. Arthritis & Rheumatism 1989; 32(no.2):166-172.

(131) Tüchsen F, Hannerz H, Burr H, Lund T, Krause N. Risk factors predicting hip pain in a 5-year prospective cohort study. Scand J Work Environ Health 2003; 29(1):35-39.

(132) Cooper C, Campbell L, Byng P, Croft PR, Coggon D. Occupational activity and the risk of hip osteoarthritis. Annals of Rheumatic Diseases 1996; 55(No 9):680-682.

(133) Jacobsen S, Sonne-Holm S, Søballe K, Gebuhr P, Lund B. Factors influencing hip joint space in asymptomatic subjects a survey of 4151 subjects of the Copenhagen city heart study: The osteoarthritis Substudy. Osteoarthritis and Cartilage 2004; 12:698-703.

(134) Németh G, Ekholm J. A biomechanical analysis of hip compression loading during lifting. Ergonomics 1985; 28(2):429-440.

(135) Radin EL. Mechanical aspects of osteoarthrosis. Bulletin on the Rheumatic Diseases 1975; 26(7):862-865.

(136) Radin EL, Parker HG, Pugh JW, Steinberg RS, Paul IL, Rose RM. Response of joints to impact loading III. J Biomechanics 1973; 6:51-57.

(137) Radin EL, Paul IL, Rose RM. Role of mechanical factors in pathogenesis of primary osteoarthritis. The Lancet 1972;(march,4.):519-522.

(138) Maetzel A, Mäkelä M, Hawker G, Bombardier C. Osteoarthritis of the hip and knee and mechanical occupational exposure A systematic overview of the evidence. J Rheumatol 1997; 24:1599-1607.

(139) Chaisson C, Gale D, Kazis L, Skinner K, Felson D. Detecting radiographic knee osteoarthritis: what combination of views is optimal? Rheumatology 2000; 39:1218-1221.

(140) Wluka A, Wolfe R, Stuckey S, Cicuttini FM. How does tibial cartilage volume relate to symptoms in subjects with knee osteoarthritis? Ann Rheum Dis 2004; 63:264-268.

(141) Cicuttini F, Wang Y, Forbes A, Wluka A, Glisson M. Comparison between patella cartilage volume and radiological assessment of the patellofemoral joint. Clinical and Experimental Rheumatology 2003; 21:321-326.

(142) Biswal S, Hastie T, Andriacchi TP, Bergman GA, Dillingham MF, Lang P. Risk factors for progressive cartilage loss in the knee: A longitudinal magnetic resonance imaging study in forty-three patients. Arthritis & Rheumatism 2002; 46(11):2884-2892.

(143) Andriacchi TP, Andersson BJ, Fermier RW, Stern D, Galante JO. A study of lower-limb mechanics during stair-climbing. The Journal of Bone and Joint Surgery 1980; 62-A(NO.5):749-757.

(144) Dahlkvist.N.J., Mayo P, Seedhom BB. Forces during squatting and rising form a deep squat. M P E 1982; 11(2):69-77.

(145) Morrison J. Bioengineering analysis of force actions transmitted by the knee joint. Bio-medical Engineering 1968;(.):164-170.

(146) Morrison J. Function of the knee joint in various activities. Bio-medical Engineering 1969;573-581.

(147) Morrison J. The mechanics of the knee joint in relation to normal walking. J Biomechanics 1969; 3:51-61.

(148) Sahlström A, Lanshammar H, Adalberth G. Knee joint moments in work-related situations. Ergonomics 1995; 38(7):1352-1359.

(149) Hochberg M. Prognosis of osteoarthritis. Annals of the Rheumatic Diseases 1996; 55(No 9):685-688.

(150) Cooper C, Snow S, McAlindon TE, Kellingray S, Stuart B, Coggon D et al. Risk factors for the incidence and progression of radiographic knee osteoarthritis. Arthritis & Rheumatism 2000; 43(5):995-1000.