Review

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Associations of work activities requiring pinch or hand grip or exposure to hand-arm vibration with finger and wrist osteoarthritis: a meta-analysis

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Objective We systematically reviewed the epidemiologic evidence linking finger and wrist osteoarthritis (OA) with work activities requiring pinch or hand grip or exposure to hand-arm vibration (HAV).

Methods PubMed and Embase databases were searched up to June 2013. We selected studies assessing the associations of radiographic diagnosed finger and/or wrist joint OA with work activities involving pinch or hand grip or exposure to HAV. We used specific criteria to evaluate completeness of reporting, potential confounding, and bias. Pooled odds ratios (OR) were computed using random-effects meta-analyses.

Results Of the 19 studies included, 17 were cross-sectional, 1 was a prospective cohort, and 1 a case–control study. The meta-analyses of studies that controlled their estimates for at least age and gender showed the associations of pinch grip work with proximal interphalangeal joint [OR 1.56, 95% confidence interval (95% CI) 1.09–2.23] and the first carpometacarpal joint OA (OR 2.10, 95% CI 1.06–4.17), but not with distal interphalangeal, metacarpalphalangeal, or wrist joints OA. Hand grip work and exposure to HAV were not associated with any finger or wrist OA.

Conclusion Epidemiological studies provide limited evidence that pinch grip may increase the risk of wrist or finger OA, but causal relation cannot be resolved because of cross-sectional designs and inadequate characterization of biomechanical strain to the hand and wrist.

Key terms degenerative joint disease; osteoarthrosis; manual work; meta-analysis; occupational exposure.

Osteoarthritis (OA) is a progressive joint disease characterized by focal erosive lesions, loss of cartilage, and bone hypertrophy underneath the cartilage (1). Radiographic OA changes are joint-space narrowing, osteophytes, subchondral sclerosis, and subchondral cysts (1). Using clinical and radiological criteria, OA of the wrist and fingers (hereafter "hand OA") comprise one third of all joints affected by OA (2, 3). The prevalence of radiographically diagnosed hand OA is about 10% in the age group of 40–49 years, reaching 80% and 90% among men and women >70 years, respectively (4). These numbers most likely overestimate the clinical occurrence of hand OA as many people with radiographic evidence of OA have no symptoms (5). Mannoni et al showed that the prevalence of symptomatic hand OA among subjects >65 years of age is only 15% (6, 7). The cause of pain in OA is still unclear (8, 9). The aetiology of OA is multi-factorial. In addition to age and gender, metabolic, genetic, and biomechanical risk factors have been studied (10–12). Physical activity of moderate intensity has been suggested to protect against the development of hand OA by strengthening muscles and ligaments (13). However, the findings of unusual patterns of joint involvement in hand OA in certain occupations have supported the hypothesis that biomechanical forces may contribute to development of hand OA (14–17). It has been suggested that continuous overload of hand joints resulting from highly monotonous usage may lead to joint impairment, for instance by interference with nutrition of the joint cartilage (18, 19). This probably requires pressure exerted on the cartilage by muscular contraction. Supporting this assertion is the

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observation that arthritis does not develop in paralyzed limbs in spite of immobile positions, and that hands weakened by hemiplegia or peripheral nerve injury do not generate Heberden's nodes (20, 21).

If biomechanical load of the hand joints is indeed contributing to the aetiology of hand OA, it is expected that this disorder is more prevalent in some occupations. Even so, it is still unresolved whether the development of hand OA can be caused by work-related activities, or whether occupational exposures only precipitate the symptoms among subjects with radiographic OA (22). Jensen et al (12) published a review on occupational activities involving gripping in relation to finger OA. However, this narrative review did not perform a systematic evaluation of the evidence level.

The objective of this paper was to review the available evidence on the association of hand OA with work activities involving repeated and/or sustained pinch grip, hand grip, or exposure to hand-arm vibration (HAV). Manual work, when mentioned in this document, refers to any work activity that involves primarily the use of the hands.

Methods

Literature search

We performed a systematic search in PubMed and Embase to identify original papers in English that provide risk estimates of radiologic hand OA in relation to manual work. We used four search strings detailed in a footnote to Supplementary table A (www.sjweh.fi/data_repository.php). After merging to omit duplicates, the combined searches resulted in 1951 hits. Eligible papers were identified according to specified exclusion criteria (Supplementary table A). Studies were included regardless of their design or quality. Finally 19 original studies (20 papers) were qualified for the meta-analysis. A seminal paper addressing the influence of pattern of usage on the structure and function of the hands in female textile workers was not included because appropriate measures of association could not be computed (23).

Outcome definition

The defining criterion for wrist and finger OA was radiographically detected OA regardless of symptoms and clinical signs. Finger OA denotes OA in ≥1 of the following joints: distal interphalangeal (DIP), proximal interphalangeal (PIP), and metacarpophalangeal (MCP). Wrist OA denotes OA in the carpometacarpal (CMC) joints and/or the intracarpal joints. The first CMC joint (thumb-base) was distinguished from OA in other wrist joints.

Exposure definition

We grouped manual work into three categories: (i) pinch grip: activities requiring repetitive and/or sustained grip with the fingers being pressed together at their tips to hold an object – most often pinch grip involves primarily the thumb, the index finger and the middle finger. These activities require, in general, precision pinch, for example writing, sewing, knitting, painting with small brushes and holding dentistry instruments; (ii) hand grip: activities mostly requiring repetitive and/or sustained holding an object pressing all fingers against the palm. In this case the activities require power grip, for example handling heavy tools, cutting with knives and carrying heavy objects. Manual activities requiring jolting of the hands were included in this category; and (iii) HAV: use of handheld tools emitting vibration.

Four studies stated explicitly whether the work activities required repeated and/or sustained pinch or hand grip (18, 24–26). For the remaining studies, the authors (including three specialists in occupational medicine) categorized the type of manual exposure by an assessment of job titles and described work activities. For example, textile work was considered to require mostly pinch grip, while foundry work and mining were activities considered to require mostly hand grip.

Assessment of studies

In order to provide a transparent evaluation of the epidemiological evidence, we systematically assessed three separate aspects of each eligible study, namely completeness of reporting, bias, and confounding.

Completeness of reporting

To assess completeness of reporting, we applied a modified version of a checklist originally proposed by van der Windt et al (27), which has recently been used in several systematic reviews (28, 29). The aim is to describe whether a paper provides essential information on key study characteristics, such as design, sampling frame and recruitment, participation rates, population characteristics, exposure and outcome ascertainment, and statistical methods. This approach does not result in "quality" scores, which are discouraged in systematic reviews (30). The applied completeness of reporting checklist includes eight criteria detailed in Supplementary table B (www.sjweh.fi/data_repository.php). Each item was assigned a score of "1" if the specified information was provided and "0" if not. Each paper was independently reviewed by at least two of the authors. Disagreements between the reviewers were resolved by discussion. Total scores for completeness of reporting were calculated as sum of scores for each

study by giving equal weight to all items. Completeness of reporting was considered high if a total score of ≥5 was achieved.

Confounding

Gender and age are established strong determinants of hand OA (31, 32). A study was considered subject to potential confounding if gender and age were not taken into account in the study design (balanced distribution across exposure groups) or by statistical analysis. Adjustment for other risk factors such as body mass index, previous hand trauma and manual leisure activities were also recorded. We considered confounding as likely if effects of age and gender were not accounted for.

Bias

We identified three types of bias with obvious relevance for the present review. First, if enrolment of participants into a cross-sectional study is dependent on exposure as well as outcome status, the risk estimates may be distorted. We considered recruitment bias likely if the response rate was <60% unless data indicated that participation was not differential. Second, retrospective recall of exposure may be prone to information bias. Third, blinding towards exposure and clinical outcome status is essential for unbiased reading of radiographs. Bias was considered as likely if one or more of the three types of bias were present.

Meta-analyses

The estimates from studies with reasonable uniform measures of exposure and outcome were considered for meta-analyses. This included six studies addressing the association of finger OA (DIP, PIP, and/or MCP joints) with work activities involving repeated or sustained pinch grip (18, 24–26, 33, 34) and nine studies (ten papers) addressing finger OA and/or wrist OA (intracarpal and/or CMC joints) in relation to work activities involving repeated or sustained hand grip (34–43). The study of Kellgren & Lawrence (34) was included in both exposure groups as they provided the estimates separately for different occupations. Five studies addressed finger and/or wrist OA following occupational exposure to HAV (44–48).

Eight studies reported no appropriate measure of association. We estimated gender- and age specific odds ratio (OR) with 95% confidence intervals (95% CI) for five of these studies (25, 26, 39, 44, 46) and crude OR for three (34, 38, 48). We calculated Woolf confidence intervals for the estimated OR. We used a fixed model to estimate overall OR for combining subgroups of a single study, eg, combining the estimates for different age groups or combining the estimates for men and women. We used a random model to combine the estimates of a single study on different joints or to combine the estimates of different studies.

We assessed heterogeneity by I^2 statistics and publication bias by a funnel plot and the trim and fill method. For the assessment of publication bias, we included an overall estimate of each study (19 studies) in the funnel plot. We used the Egger's test to assess the asymmetry of the funnel plot. All analyses were performed by STATA, version 13.0 (StataCorp, College Station, TX, USA).

Results

Characteristics of the studies

Tables 1–3 present the main characteristics of the studies according to manual work involving pinch grip, hand grip, and HAV, respectively.

Among the 19 studies (20 papers) eligible for this review, a majority (18, 25, 26, 33–43, 45–48) were cross-sectional, followed by a prospective cohort (44) and a case–control study (24). The sample sizes included >1000 participants (26, 35–37, 41), 500–1000 participants (25, 33, 38, 39, 42, 43), 100–500 participants (18, 24, 34, 40, 44–46, 48), and <100 participants (47). The study populations included only men (39, 40, 44–48), only women (18, 24–25, 38), or both men and women (26, 33–37, 41–43). The type of work seems a likely reason for not including both genders in some studies. For example, grinding, chipping, logging, and work in the mining and metal industry and in stone pits are typically male occupations.

The average age of the participants varied from 34–46 years old in studies on exposure to HAV (44–48) to 50–65 years old in studies addressing pinch and hand grip (18, 24–26, 34–38, 41–43).

Measures of exposure and outcome

In 13 studies (18, 25, 26, 33, 34, 38–40, 44–48), exposure assignment was based on job titles and subjective recall of exposure provided by questionnaire or interview in 7 studies (24, 35–37, 41–43). None of the studies on pinch and hand grip eligible for meta-analysis performed measures of hand/finger movements, applied forces, postures, or repetition. Two studies on exposure to HAV (45, 46) measured exposure levels.

Eleven studies (18, 25, 26, 33, 34, 36, 37, 39–41, 44) used the Kellgren & Lawrence system (50) for evaluation of radiographs, and two studies (42, 43) used the atlas of radiographic features by Altman et al (51). Nakamura et al (38) applied a modification of Swanson's

Table 1. Studies on association of manual work requiring repeated and/or sustained pinch grip with hand osteoarthritis (OA) in one case-control (24) and five cross-sectional studies. [CMC=carpometacarpal joint; CMC-1=first carpometacarpal joint; DIP=distal interphalangeal joint; IP=interphalangeal joint; MCP=metacarpophalangeal joint; PIP=proximal interphalangeal joint ; 95% CI=95% confidence interval].

Study	Population	Radiographic classification	Exposure contrast	Joint	Odds ratio (OR)	95% CI	Adjustment for other covariates	Reporting[a]	Bias[b]	Confounding[c]
Fontana, 2007, France (24)	Cases: female patients surgically treated for 1-CMC OA (N=61). Mean age: 64 years. Controls: female orthopaedic patients (N=120) admitted because of injuries or traumas secondary to motor vehicle collision or fall with no history or feature of CMC OA. Mean age: 60 years	Not defined (CMC-1 surgery)	Occupations presumed being a risk factor for CMC-1 OA (secretaries, tailors, dressmakers, and hatters; sewers, embroiderers, and related workers; and domestic helpers and cleaners) compared with other occupations	CMC-1	3.78	1.20–11.9	Matched by ethnicity and 5-year age. Adjusted for age, smoking status, obesity, CMC OA family history, hysterectomy history, parity, and occasional jobs	6/8	Yes	No
Solovieva 2006, Finland (18)	Female dentists (N=291). Age: 45–63 years Mean duration of dental practice: 26 years	Modified Kellgren & Lawrence (less emphasis on osteophytes)	Dentists who have spent most of their work time on restorative treatment and endodontics vs. dentists who have performed variable work tasks	Any finger joint Dig 1-3 Dig 4-5	1.59 2.22 1.53	0.86–2.93 1.04–4.91 0.83–2.82	Number of years in clinical job, daily use of computer (hrs), leisure time physical activity (hrs), daily activities requiring use of hand (hrs), and smoking	8/8	Yes	No
Solovieva, 2005, Finland (25)	Female dentists (N=295) and teachers (N=248). Age: 45–63 years	Modified Kellgren & Lawrence (less emphasis on osteophytes)	Dentists versus teachers	Any finger OA DIP PIP MCP MCP-1	0.72 0.70 1.44 0.51 0.67	0.50–1.03 0.49–1.00 0.65–3.16 0.18–1.44 0.18–2.53	Age OR for MCP and MCP-1 were unadjusted	8/8	Yes	No
Lehto 1990, Finland (26)	Dentists (N=134) and population sample (N=940). Age 33-69 years Clinical dental practice of ≥10 years	Kellgren & lawrence ≥grade 2	Pinch grip in dentistry versus varied hand use among a random sample of general population.	Wrist/finger OA Men Women Both	 2.34 0.82 1.24	 1.08–5.07 0.44-1.52 0.76-2.01	Age and gender	7/8	Yes	No
Lawrence 1961, UK (33)	Cotton workers (N=345) and population sample (N=345). Age ≥45 years	Kellgren & Lawrence grade 2–4	Weavers, spinners and tenters (machine tenders) versus random sample of general population	Men DIP PIP MCP CMC-1 Wrist Any joint Women DIP PIP MCP CMC-1 Wrist Any joint Both Any joint	 1.90 2.41 1.10 2.48 0.40 1.48 1.35 1.37 0.81 1.44 1.53 1.28 1.31	 1.10–3.30 1.11–5.21 0.52–2.29 1.23–4.99 0.15–1.08 0.85–2.57 0.93–1.96 0.86–2.18 0.46–1.44 0.90–2.30 0.61–3.81 1.03–1.60 1.06–1.60	Matched by age and sex	7/8	No	No
Kellgren 1958, UK (34)	Population sample (N=380). Age: 55–64 years	Kellgren & Lawrence grade 2–4	Textile workers versus others (miscellaneous group of different occupations)	Men DIP PIP MCP CMC-1 Wrist Any joint Women DIP PIP MCP CMC-1 Wrist Any joint Both Any joint	 2.37 3.55 2.39 4.60 1.32 2.85 1.11 1.74 0.60 1.50 1.60 1.21 1.82	 0.84–6.67 1.09–11.58 0.77–7.46 1.60–13.2 0.25–6.96 1.69–4.80 0.42–2.96 0.65–4.65 0.19–1.84 0.55–4.11 0.16–16.15 0.74–1.99 1.27–2.61	Unadjusted	6/8	Yes	Yes

[a] Number of study characteristics with complete information.

[b] Bias is likely because of differential recruitment, retrospective recall of exposure and/or reading of radiographs without blinding of exposure status.

[c] Confounding is likely because effects of age and/or gender were not accounted for.

Table 2. Association of repeated and/or sustained hand grip with hand osteoarthritis (OA) in ten cross-sectional studies. [CMC=carpometacarpal joint; CMC-1=first carpometacarpal joint; DIP=distal interphalangeal joint; IP=interphalangeal joint; MCP=metacarpophalangeal joint; PIP=proximal interphalangeal joint; 95% CI=95% confidence interval].

Study	Population	Radiographic classification	Exposure contrast	Joint	Odds ratio	95% CI	Adjustment for other covariates	Reporting[a]	Bias[b]	Confounding[c]
Bernard 2010, USA (41)	Population sample (N=3548). Mean age men: 63 years women: 61 years	Kellgren & Lawrence grade 2–4	Jolting of the hands and legs versus. working sitting most of the time (occupations not specified)	DIP 3, PIP 2 and/or CMC-1			Age and body mass index	6/8	Yes	No
				Men	0.93	0.57–1.51				
				Women	1.82	1.19–2.76				
				Both	1.37	0.99–1.88				
Rossignol 2005, France, (35)	Primary care patients (N=1615 men and 1219 women) Mean age 62 years	Not specified	Repetitive hand movements and working at machine pace versus care seekers with knee or hip OA	OA in ≥1 hand joint (joints not specified)			Unadjusted	4/8	Yes	Yes
				Men	1.5	0.9–2.5				
				Women	3.6	2.4–5.7				
				Both	2.50	1.80–3.48				
Haara 2003 and 2004, Finland (36-37)	Population sample (1560 men and 2035 women) Age 53–72 years	Kellgren & Lawrence grade 2–4	Exposure to lifting/carrying heavy objects, awkward hand postures, whole body or HAV, or repeated movements of the hands, and work at machine pace (occupations not specified) versus exposure to none of these factors.	CMC-1	0.85	0.71–1.03	Age, educational level, body mass index, and smoking	6/8	Yes	No
				OA in ≥1 finger joint (joints not specified)						
				Men	1.28	1.05–1. 57				
				Women	1.34	1.10–1.63				
				Both	1.06	0.69–1.62				
Kessler 2003, Germany (42)	Patients scheduled for hip or knee replacement (N=243 men and 396 women). Age: 53–72 years	Altman atlas for joint space narrowing	Heavy physical exertion at work versus moderate, slight or none (occupations not specified)	≥2 IP	1.1	0.7–1.6	Age, sex, body mass index, hypertension, diabetes, and knee OA	6/8	Yes	No
				CMC-1	0.7	0.5–1.1				
				Any joint	0.87	0.56–1.36				
Jones 2002, Australia (43)	Rheumatologic patients (174 men, 348 women). Mean age men: 53 years women: 57 years	Altman atlas for joint space narrowing	Work with high impact of mechanical stress to hand joints (occupations not specified) versus others	DIP	1.29	0.69–2.43	Age, sex, age-sex interaction, body mass index, and family status	5/8	Yes	No
				CMC	0.73	0.40–1.33				
				Any joint	0.96	0.55–1.68				
Nakamura 1993, Japan (38)	Female cooks (N=482) and municipal employees (N=298). Age 40–59 years	Swanson grade 1–5	Cooks with >150 meals/day versus municipal employees, and cooks with >30 meals/day versus municipal employees	DIP			Unadjusted	4/8	Yes	Yes
				Cooks, >150 meals/day	7.57	3.13–18.31				
				Cooks, >30 meals/day	3.03	1.13-8.09				
				Both groups combined	5.03	2.61-9.71				
Lawrence 1966, UK (39)	Male foundry workers (N=299) and population sample (N=298). Age ≥35 years	Kellgren & Lawrence grade 2–4	Foundry workers who had worked for ≥10 years and a random sample of general population from same area	DIP	0.61	0.40–0.93	Age	7/8	No	No
				PIP	1.57	0.79–3.12				
				MCP	0.89	0.54–1.47				
				Wrist	0.72	0.41–1.28				
				Any joint	0.84	0.58–1.20				
Kellgren 1958, UK (34)	Population sample (173 men). Age: 55–64 years	Kellgren & Lawrence grade 2–4	Male miners versus others (miscellaneous group of different occupations)	DIP	1.52	0.80–2.91	Unadjusted	6/8	Yes	Yes
				PIP	1.66	0.69–4.00				
				MCP	1.77	0.82–3.83				
				CMC-1	1.23	0.52–2.89				
				Wrist	1.28	0.44–3.73				
				Any joint	1.51	1.05–2.16				
Kellgren 1952, UK (40)	Male miners (N=84), manual workers (N=45) and office workers (N=42). Age: 40 –50 years	Kellgren & Lawrence grade 2–4	Miners and blacksmiths, machinists, carpenters, painters and other blue-collar workers, respectively, versus office workers (clerks and administrative staff)	OA in any hand joint (joints not specified)			Unadjusted	5/8	No	Yes
				Miners	8.20	1.04–64.66				
				Manual workers	5.12	0.57–45.82				
				Both groups	6.57	1.46–29.56				

[a] Number of study characteristics with complete information.
[b] Bias is likely because of differential recruitment, retrospective recall of exposure and/or reading of radiographs without blinding of exposure status.
[c] Confounding is likely because effects of age and/or gender were not accounted for.

Table 3. Studies on association of exposure to hand-arm vibration (HAV) and hand osteoarthritis (OA). [SD=standard deviation; 95% CI=95% confidence interval].

Study	Population	Radiograph classification system	Exposure contrast	Joint	Odds ratio	95% CI	Adjustment for other covariates	Reporting [a]	Bias[b]	Confounding[c]
Kivekäs 1994, Finland (44)	Male lumberjacks (N=178) and controls, peat workers (N=118). Mean age: lumberjacks 41 years, controls 39 years	Kellgren & Lawrence grade 2-4	Lumberjacks (mean duration of exposure to HAV 19.7 years (range 8–35 years)) versus peat workers /tractor driving and maintenance	Hand and wrist (joints not specified)	1.60	0.65–3.89	Age	6/8	No	No
Bovenzi 1987, Italy (45)	Male foundry workers at one company, HAV exposed (N=67) and HAV unexposed (N=46) Mean age: 39 years	Not specified	Chipping and grinding operators versus mechanics and maintenance workers	Wrist	5.30	1.13–24.73	Unadjusted. Two groups had similar mean age and SD	5/8	No	No
Malchaire 1986, Belgium (46)	Male workers in stone pits (quarrying and slitting granite blocks, N=82) and manual workers (N=75). Mean age 34 years	Ad hoc scheme grade	Quarry workers (mean duration of HAV exposure 14.6 years around 1 hour per day) versus manual workers	Wrist	1.18	0.46–3.00	Matched by age	3//8	Yes	No
Kumlin 1973, Finland (47)	Male lumberjacks (N=35) and random controls from the radiological archives (N=35). Mean age 43 years	Not specified	Lumberjacks (duration of HAV exposure ranged from 7–20 years around 5–9 hours per day) versus reference	Hand and wrist (joints not specified)	1.55	0.24–9.88	Matched by age	3/8	Yes	No
Hellstrom 1972, Norway (48)	Male lumberjacks (N=150) and forest workers who never used chain saw (N=57). Mean age 46 years	Not specified	Lumberjacks using chain saw (mean duration of exposure to HAV: 9 years) versus forest workers not using chain saw	Hand and wrist (joints not specified)	0.74	0.46–1.18	Unadjusted	3/8	No	Yes

[a] Number of study characteristics with complete information.
[b] Bias is likely because of differential recruitment, retrospective recall of exposure and/or reading of radiographs without blinding of exposure status.
[c] Confounding is likely because effects of age and/or gender were not accounted for.

grading of OA (52), and Malchaire et al (46) described their own classification methods. The classification criteria for radiographic OA were not mentioned in five studies (24, 35, 45, 47, 48). The radiologists were blinded in the analyses of the radiographs in more than half of the studies (18, 25, 26, 33, 36, 37, 39–42, 44, 45). Intra- and/or inter-observer agreement on the radiological classifications was analyzed in five studies (25, 26, 37, 43, 46).

Completeness of reporting, confounding and bias

Completeness of reporting was considered high in 15 studies (18, 25, 30, 32-34, 36, 37, 39–45) where information on ≥5 of 8 study characteristics was provided (Supplementary table B). Insufficient information on response rates, population characteristics, and ascertainment of exposure and outcome were most common.

Risk estimates were adjusted for effects of gender by design or analyses in all studies, but six studies did not provide age-stratified data (34, 35, 38, 40, 45, 48).

Bias of risk estimates due to differential recruitment, retrospective recall of exposure and/or reading of radiographs without blinding to exposure status was considered likely in all except six studies (33, 39, 40, 44, 45, 48), see tables 1–3 and Supplementary table 2.

Pinch grip

Pinch grip work was associated with PIP (OR 1.68, 95% CI 1.22–2.31, I^2=0%) and CMC-1 joints OA (OR 2.04, 95% CI 1.40–2.97, I^2=11.7%), but not with DIP, MCP or wrist joints OA (figure 1). The pooled OR for any hand joint OA was 1.35 (95% CI 0.98–1.86, I^2=71.3%).

Hand grip

Hand grip work was associated with any hand joint OA (pooled OR 1.51, 95% CI 1.05–2.15, I^2=82.6%), but not with PIP, DIP, MCP-1, or CMC-1 joints OA (figure 2).

Hand-arm vibration

Of five studies on the association of exposure to HAV with hand OA among male workers, two studies

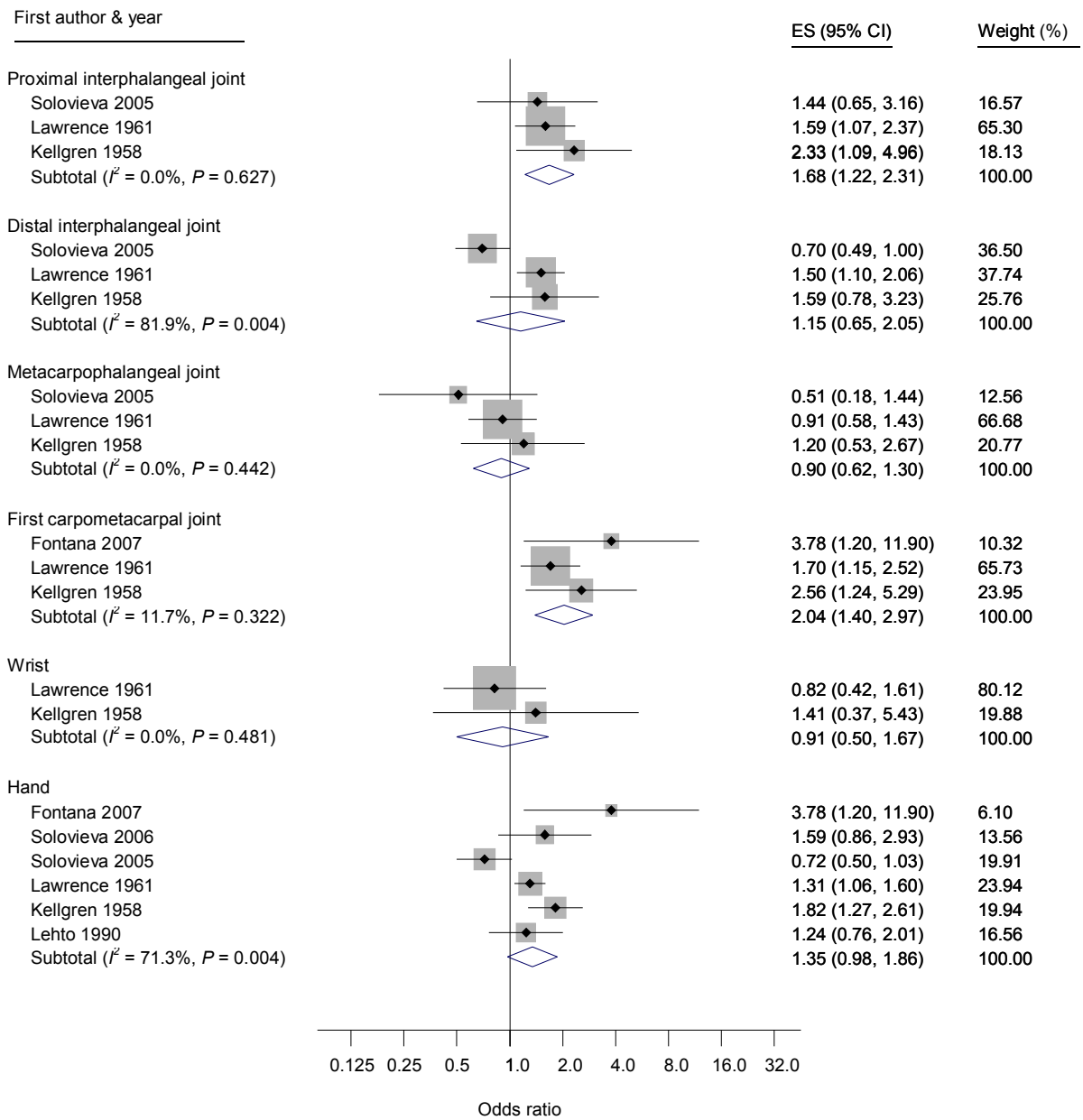

Figure 1. A random-effects meta-analysis on the association between work tasks involving pinch grip and finger or wrist osteoarthritis.

addressed wrist OA (45, 46) and three examined any hand joint OA (44, 47, 48). A meta-analysis of five studies (figure 3) revealed no association between exposure to HAV and hand OA (pooled OR 1.29, 95% CI 0.71–2.35).

Gender-specific results

Pinch grip work was associated with any hand OA among men (OR 2.14, 95% CI 1.41–3.25, I^2=31.6%) but not women (OR 1.16) (figure 4). On the other hand, hand grip work was associated with any hand OA among women (OR 2.46, 95% CI 1.36–4.46, I^2=89.2%) but not men (OR 1.24).

Publication bias

The pooled OR of 19 studies on the associations of pinch or hand grip or exposure to HAV with hand OA was 1.39 (95% CI 1.11–1.75). The funnel plot of 19 studies was symmetrical (figure 5). P-value for Eager's test was 0.37. The trim and fill method imputed only two missing studies. The pooled OR adjusted for funnel plot asymmetry was 1.32 (95% CI 1.05–1.66).

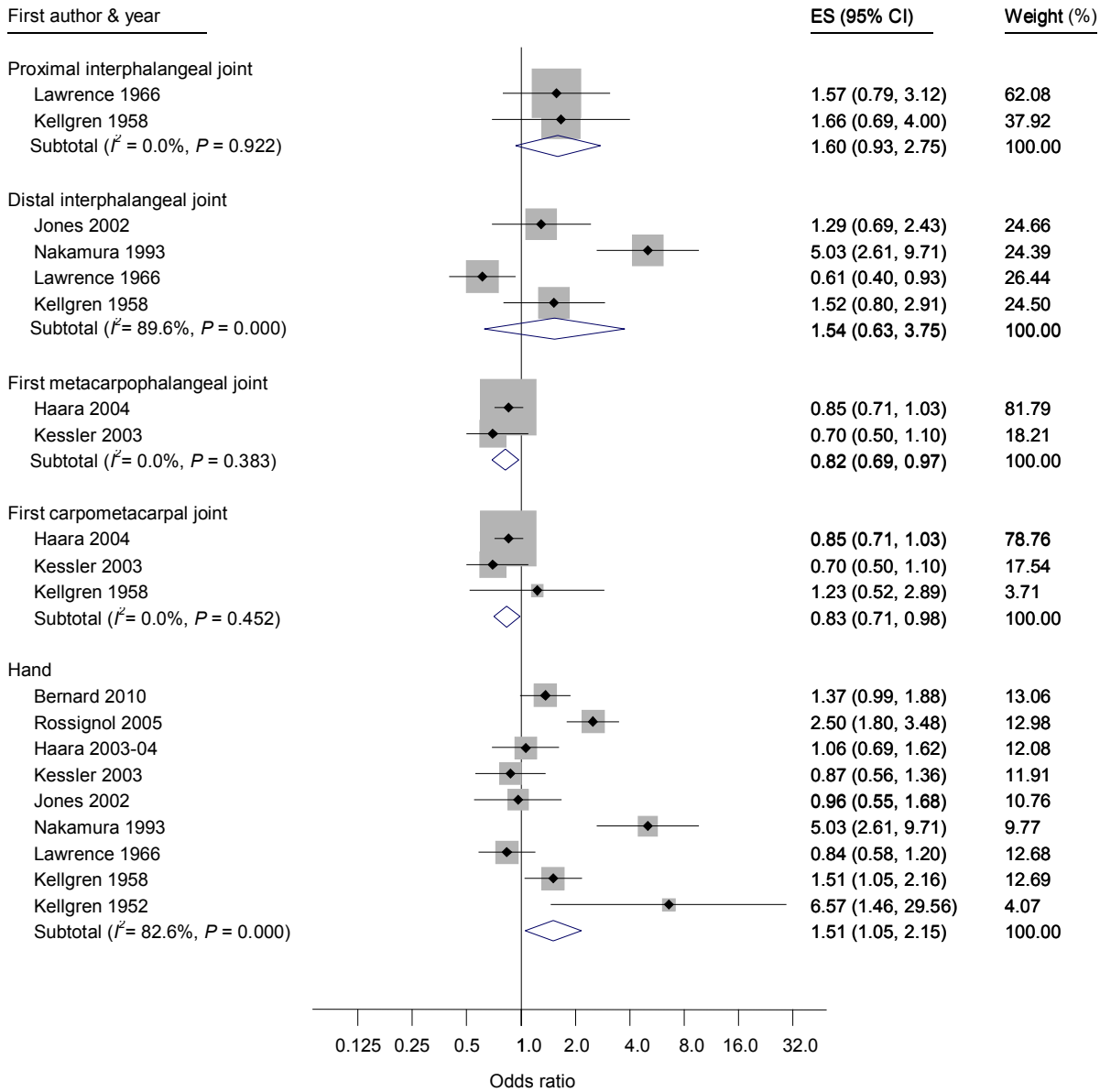

Figure 2. A random-effects meta-analysis on the association between work tasks involving hand grip and finger or wrist osteoarthritis.

Sensitivity analysis

We excluded the studies from the meta-analyses that did not control their estimates for age. For pinch grip, the pooled OR of PIP OA was 1.56 (95% CI 1.09–2.23, I^2=0%), 2.10 for CMC-1 (95% CI 1.06–4.17, I^2=39.8%), and 1.25 for any hand OA (95% CI 0.87–1.80, I^2=69.2%). The pooled OR of hand OA for pinch grip was 1.73 (95% CI 1.10–2.71, I^2=0%) among men. For hand grip, the pooled OR of any hand OA among both genders combined was 1.03 (95% CI 0.84–1.26, I^2=17.4%). It was 1.47 (1.12–1.94, I^2=40.1%) among women.

Discussion

Through a systematic search, we identified 19 studies (20 papers) assessing the association between hand OA and manual work, which we classified into work mostly characterized by pinch or hand grip or use of handheld vibrating tools. Pinch grip work was associated with PIP and MCP-1 joints OA, but not with DIP, MCP, or wrist joints. Hand grip work and exposure to HAV were not associated with finger or wrist OA. In the gender-specific analyses, pinch grip work was associated with

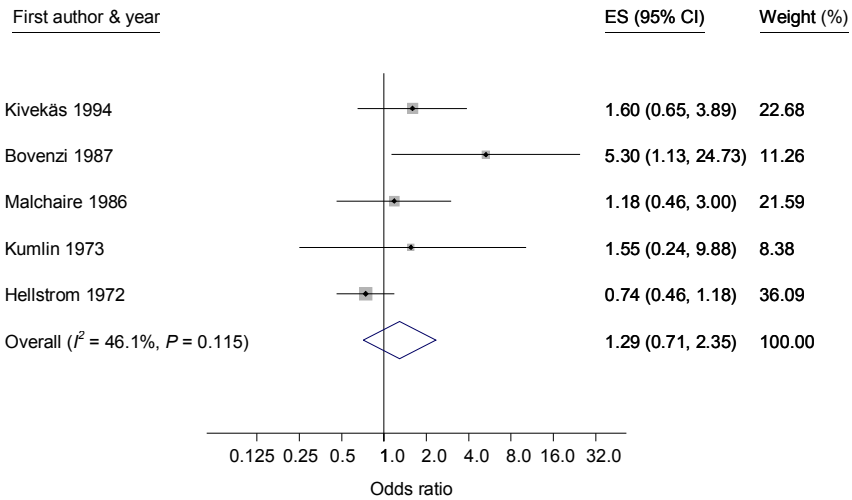

Figure 3. A random-effects meta-analysis on the association between exposure to hand-arm vibration and any hand joint osteoarthritis.

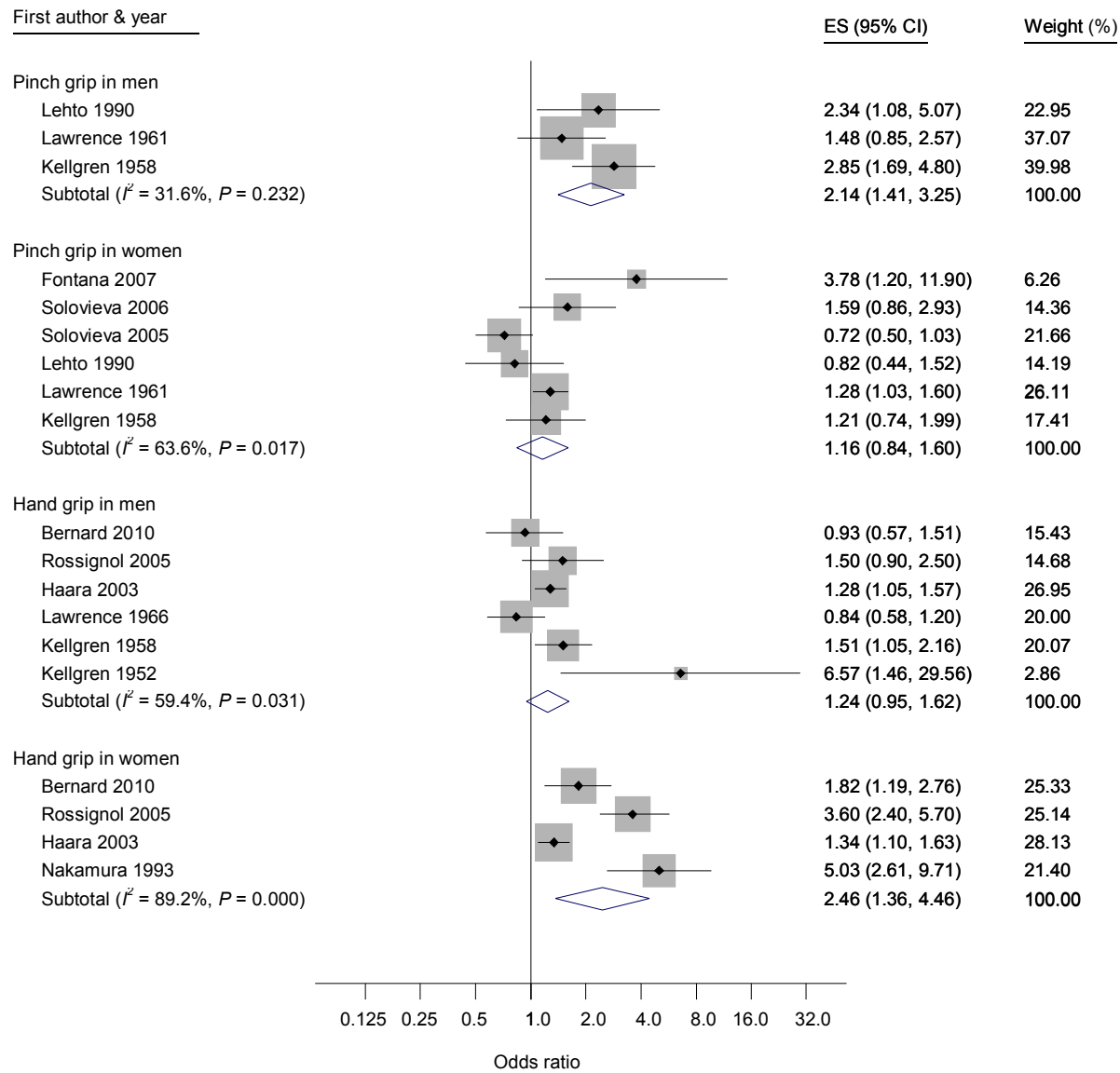

Figure 4. A gender-specific random-effects meta-analysis on the associations of work tasks involving pinch or hand grip with any hand joint osteoarthritis.

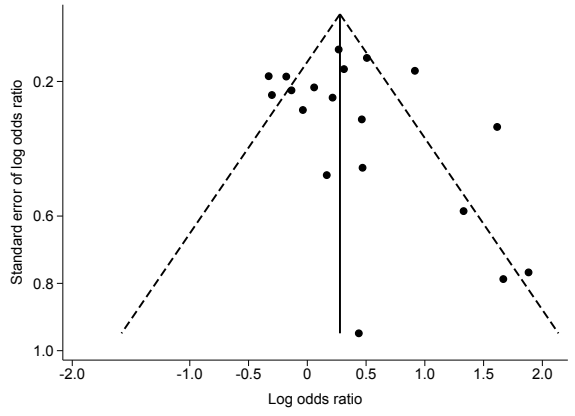

Figure 5. A funnel plot of 19 studies on the associations of exposure to work tasks involving pinch grip or hand grip or hand-arm vibration with any hand joint osteoarthritis

any hand OA among men while hand grip was associated with any hand OA among women.

Quality assessment

A major limitation of this review was the cross-sectional design of the majority of included studies, which precludes causal inference. The only prospective cohort study was based on a small sample with few years of follow-up and confounding control restricted to gender and age (44). Fontana et al's case–control study (24) presented confounding control for several factors but the study sample was quite small.

Crude exposure characterization was another important limitation of the included studies. The biomechanical strain on finger and wrist joints was not quantified in any of the studies and the reliability of the expert classification of jobs into those mostly requiring pinch and hand grip, respectively, is uncertain. Exposure–response could seldom be evaluated and studies varied in grouping of finger and wrist joints. However, two studies on HAV exposure did present objective exposure assessments.

Preferential drop-out of diseased workers among the exposed is a potential limitation in cross-sectional studies that will result in bias towards the null. Only two studies took this bias into account by including workers on sick leave in the study population (33, 39). Even in these studies, healthy worker selection may attenuate observed associations because workers with hand OA may have left the job before the study was initiated. On the other hand, recruitment bias may inflate risk estimates in studies where people are enrolled following visits to the general practitioner or surgeon (24, 35, 42). Workers with manual work tasks may have more difficulties in carrying out their work than non-manual workers with the same degree of hand OA. Similarly, pronounced exposure misclassification, such as control groups composed of manual workers, is expected to underestimate the risk of a potential association between manual work activities and hand OA. However, retrospective and self-reported collection of exposure data may overestimate the risk estimate. It is not possible to evaluate the overall influence of these opposing types of bias.

Only a few studies considered relevant confounders such as previous hand trauma, manual leisure activities requiring repetitive/sustained pinch or hand grip and handedness.

Outcome assessment

The use of radiological findings as the main diagnostic criterion for hand OA is not equivalent to disease occurrence because radiological signs of OA often are subclinical (5). We chose to use radiological rather than clinical criteria because they are more well-defined for hand OA and because the aim of this review is to examine occupational risk factors for the development of OA – not to evaluate the clinical burden of the disease. Besides, the radiographic definition of hand OA is currently the most widely used in epidemiological studies (53).

Exposure assessment

In most of the studies, exposures were crudely assessed by self-reporting. Moreover the criteria for defining manual work varied widely. Some applied the term to occupations generally known as manual – such as dentists, cooks, cotton workers, and carpenters (18, 25, 26, 34, 38, 40) – while others used various score classifications to evaluate whether a job should be categorized as manual or not (36, 37, 42, 43). Furthermore, the indirect determination of biomechanical exposures – categorization into pinch or hand grip – based upon information on job and work tasks must always be considered with caution.

Pathophysiological mechanisms

Theoretically, biomechanical factors producing joint overload may trigger development of OA (15, 16, 54). Several biomechanical studies support this assertion. An et al (55) demonstrated that the compressive force across the articular surface is much higher in the PIP and MCP joints than DIP joints during grasp (hand grip), briefcase grip, holding a glass, or opening a jar. In grasp, compression forces have been shown to rise dramatically from the IP joint of the thumb to the first MCP to the first CMC joint (56).

Chaisson et al (57) analyzed in a longitudinal study the effect of maximal hand grip strength on the incidence or new occurrence of hand OA. They found that men with high maximal hand grip strength had an increased risk of OA in the PIP and MPC joints and

thumb base. Among women, they found an increased risk of developing OA in the MCP joints and a modest increase in risk for OA in the thumb base. The absence of a relationship between maximal hand grip strength and the development of OA in the DIP joint is not surprising since maximal forces at this site are attained during pinch rather than hand grip (58). A potential concern regarding this study is that grip strength is a mediating variable in the relationship between use pattern and incident OA, particularly since occupational and physical activities were crudely assessed. This confirms the importance of objective and detailed biomechanical assessment of occupational activities in this scenario. Cvijetic et al's longitudinal study (59) is another example: they found that grip strength was related to hand OA among men but not women. It should be noted that 90% of the men were farmers, while 63% of the women were housewives. Once again, the question is whether this difference was attributable to occupational activity.

Findings of specific clinical patterns of involvement of hand OA that correlate to specific biomechanical workloads, as shown by several studies in this review (18, 24–26, 36, 38, 42, 43), seem informative. The study of Hadler et al (23) was a pioneer study using this approach. They identified two main patterns of manual activities among textile workers. Burling and spinning required precision pinch grip with the first three fingers in the dominant hand, while winding were performed with both hands requiring wrist motion and sustained hand grip. They found that burlers and spinners presented more OA changes in the second and third fingers of the dominant hand when compared to winders, while winders were the only group with bilateral impairment of range of motion on the wrist.

Six studies reported different risk estimates for men and women although formal tests for interaction by gender were not performed in any of these studies (33–35, 37, 41, 43). It is known that hormonal and metabolic factors play a role in the development of hand OA (10, 11). However, occupational exposures could also contribute to these gender-dependent differences. It has been suggested that women prefer to perform jobs requiring precision pinch grip and, therefore, are more exposed to overload of the distal finger joints (23). On the other hand, it is not elucidated whether men and women are exposed to different workloads within the same occupation. For example, a stronger pinch grip among male compared to female dentists might explain the higher prevalence of hand OA among male dentists (26).

It is of interest whether symmetrical hand OA has a different patophysiology and, thus, different risk factors than OA presenting specific patterns of involvement of the hand mostly used at work. One might argue that hand OA can be the first manifestation of polyarthritis. However polyarthritis is always symmetrical (1). So even though the symptoms may be precipitated by use of the dominant hand at work, radiological signs of OA are expected to be symmetrical. The studies focusing on this aspect found actually different clinical and radiological signs of OA between the dominant and non-dominant hand (18, 23, 25).

Regarding exposure to HAV, it is still unclear whether hand OA is specifically related to the vibration transmitted to the hand or the strong dynamic and static joint loading – often in extreme positions of the joint – and repetitive movements typical for tool manipulation in heavy manual activities (60). On the other hand, vibration from hand-held tools per se may induce additional joint load due to the increased need for joint stabilization and hand grip force (61, 62). These questions remain to be answered.

Concluding remarks

Current meta-analysis provides limited support to the hypothesis that work activities requiring repeated and / or sustained pinch grip contribute to the occurrence of finger or wrist OA. Major limitations of the included studies were poor characterization of biomechanical strain to the hand and wrist and lack of prospective cohort studies. Regarding the association of occupational exposure to hand grip or HAV with finger or wrist OA, the current evidence is insufficient as a result of inconsistent findings.

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