proceedings

MDPI

Proceeding Paper

Radiographic Hand Osteoarthritis in Relation to Exposure to Hand-Transmitted Vibration: A Systematic Review and Meta-Analysis †

Tohr Nilsson [1,*], Jens Wahlström [1], Eirik Reierth [2] and Lage Burström [1]

[1] Department of Public Health and Clinical Medicine, Faculty of Medicine, Umeå University, 90187 Umeå, Sweden; jens.wahlstrom@umu.se (J.W.); lage.burstrom@gmail.com (L.B.)
[2] Science and Health Library, University of Tromsø, UiT The Arctic University of Norway, 9037 Tromsø, Norway; eirik.reierth@uit.no
* Correspondence: tohr.nilsson@umu.se; Tel.: +46-(0)-702140955
† Presented at the 15th International Conference on Hand-Arm Vibration, Nancy, France, 6–9 June 2023.

Abstract: This systematic review on radiographic hand osteoarthritis (HOA) covering publications in the databases Medline and Embase for the period 1947 to April 2021, with a final selection of 10 studies, revealed a high prevalence of hand osteoarthritis among both vibration-exposed men and non-exposed. The results show a non-significant, unadjusted risk-increase of about 50% for X-ray-diagnosed hand osteoarthritis for those who work with vibrating machinery compared to referents. The risk estimate does not provide reliable support that working with exposure from vibrating machines increases the risk of radiographic changes in the hands.

Keywords: osteoarthritis; hand osteoarthritis; hand–arm vibration; systematic review; meta-analysis; vibration injury

Citation: Nilsson, T.; Wahlström, J.; Reierth, E.; Burström, L. Radiographic Hand Osteoarthritis in Relation to Exposure to Hand-Transmitted Vibration: A Systematic Review and Meta-Analysis. *Proceedings* **2023**, *86*, 31. https://doi.org/10.3390/proceedings2023086031

Academic Editors: Christophe Noël and Jacques Chatillon

Published: 17 April 2023

1. Introduction

Osteoarthritis is used as a collective term for joint failure that comes from disturbances in the balance between breakdown and new formation of the joint's various tissues (bone, cartilage, etc.). Osteoarthritis has historically been regarded as a disease of wear and tear. However, recent research shows that the disease has a complex background where a number of different causal factors work together to cause the disease. Disturbances in blood circulation, inflammatory and proinflammatory activity, mechanical stress, and trauma, as well as age-related processes, interact over time with hereditary disposition and occupational factors in the breakdown and deposits of bone and cartilage in joint structures. The results on cartilage and bone deposits are accompanied by pain, stiffness, and disability. Uneven bone turnover can cause changes in bone density with accompanying cavities (cysts) that are sometimes fluid-filled (vacuoles) and disturbed bone growth (osteophytes) or increased density (sclerosis), which can be depicted on plain film radiography (X-ray).

Early studies on workers exposed to primarily air-powered, striking machines reported injuries ("Die Presslufterkrankung") with skeletal changes in the form of bone cysts, skeletal changes in the bones of the hand, and joint osteoarthritis. The findings were deemed so unambiguous and extensive that bone loosening (malacia) of the lunate bone (Kienböck's disease) has been accepted since the 1930s as an occupational disease caused by vibration exposure and is included in the ILO's previous list of accepted occupational diseases (no. 505.01).

There is currently no recently updated evidence-based systematic review for the relationship between hand–arm vibration exposure and X-ray-diagnosed arthritis in the finger and wrist where the vibration exposure levels can be compared.

The following systematic review aims to specifically answer the question of whether X-ray-diagnosed hand osteoarthritis (HOA) is related to exposure to hand-transmitted vibrations. Moreover, the aim is to estimate the magnitude of such an association using statistical synthesis (meta-analyses).

2. Materials and Methods

This systematic literature review follows PRISMA's method [1] including a literature search, relevance assessment, assessment of risk of bias, descriptive synthesis of results with qualitative descriptive evidence evaluation (narrative synthesis), as well as limited statistical synthesis (meta-analysis) for hand–arm transmitted vibration exposure and hand osteoarthritis. The case definition of osteoarthritis is defined by radiographic markers for osteoarthritis localized to joints in the finger, metacarpal, and metacarpal bones. In this report, vibration exposure was categorized into the following four doses:

- Dose 1 = Estimate of the total number of years during the working life that involved exposure to vibrations from working with vibrating handheld machines;
- Dose 2 = Estimate of the number of hours per day that involved exposure;
- for vibrations from work with vibrating handheld machines;
- Dose 3 = Assessment of the daily vibration exposure through a combination of the daily exposure time and measured vibration level on the used machines;
- Dose 4 = Assessment of the cumulative total vibration exposure over the entire working life through a combination of daily exposure time, measured vibration level of used machines, and number of years during which the various exposures occurred.

The review process was based on articles found at systematic database-based literature searches. The searches covered Ovid MEDLINE®, including online searching for articles under indexing and non-indexed references, from 1946 until 14 April 2021, as well as the Embase® Classic and Embase® databases, from 1947 until 14 April 2021. Established MESH search terms were used for MEDLINE®, and terms from the search list for Emtree for EMBASE®, as well as free text word search. Additional manual search was carried out on reviews and reference lists of identified articles.

The assessment of risk of bias (lack of reliability) followed a predefined protocol with established criteria for a. diagnostic reliability, b. exposure assessment reliability, and c. methodological reliability and scientific quality of studies, all summed up as a sum value for quality, where high numerical values indicate low risk of bias or high reliability (details are presented in a full-paper, open-access report, in Swedish https://gupea.ub.gu.se/handle/2077/73757 (accessed on 6 October 2022) [2].

All meta-analyses were conducted with the statistical program Comprehensive Meta-analysis. Studies that reported a relative risk (odds ratio) were included in the meta-analyses as well as studies that presented data which made calculation of an unadjusted odds ratio possible.

3. Results

The literature search identified a total of 66 references. After removal of duplicates, 43 references remained. In addition, 48 articles were identified after manual review of reference lists in the overview articles and the original studies. Ten articles fulfilled the pre-established criteria for inclusion (Table 1). Excluded were 20 due to a language other than English, 49 due to lack of information on vibration or outcome, and 9 due to none-original research (reviews).

In the end, 10 articles remained for the narrative synthesis. Of those, eight articles were included in the final meta-analysis (Figure 1).

Table 1. Included studies, reference, and assessed risk of bias according to predefined criteria, summarized for diagnosis, exposure, methodology, and summed up as a total. The articles are sorted in descending order based on summed up risk of bias. A high numerical number of totals implies high reliability or an expected small impact on the result from interfering factors.

Study	Ref.	Diagnosis	Exposure	Methods	Total
Kivekas et al. 1994	[3]	6	3	10	19
Bovenzi et al. 1987	[4]	7	5	4	16
Malchaire et al. 1986	[5]	6	5	4	15
Kumlin et al. 1973	[6]	4	2	2	8
Van den Bossche et al. 1984	[7]	3	3	2	8
Burke et al. 1977	[8]	4	1	2	7
Härkonen et al. 1984	[9]	4	2	5	7
Suzuki et al. 1978	[10]	4	1	2	7
Hellström and Andersen 1972	[11]	3	1	2	6
Laitinen et al. 1974	[12]	2	1	2	5

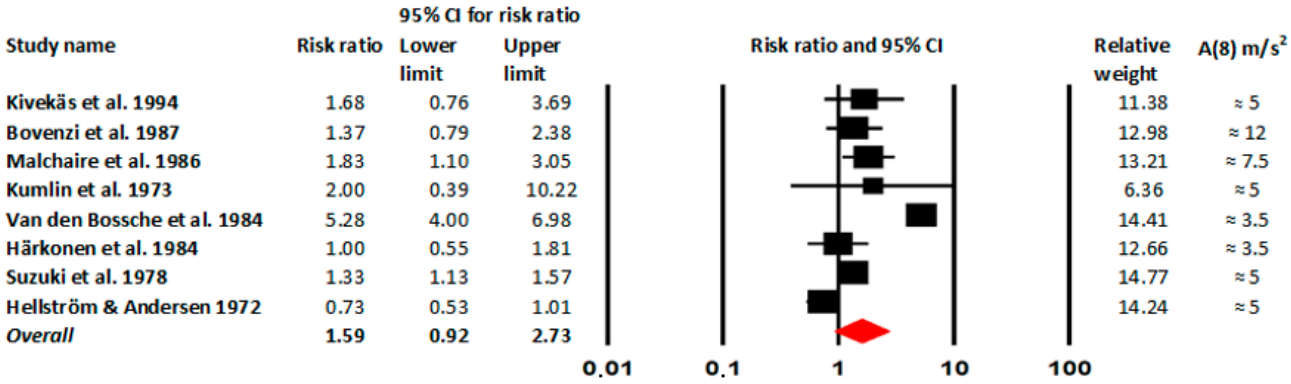

Figure 1. Statistics and "forest plot" with "random-effect" meta-analysis on prevalence ratios of hand osteoarthritis in vibration-exposed and non-vibration-exposed groups. The studies [3–12] are sorted in decreasing order from highest to lowest reliability score according to rated risk of bias (Table 1).

3.1. Prevalence of Hand Osteoarthritis in Relation to Vibration Exposure

The prevalence of hand and wrist osteoarthritis among the studies on vibration-exposed men showed a meta-prevalence mean of 36 (95% CI. 19 to 57), with a prevalence ranging from 11 to 83. The corresponding values for non-vibration-exposed men was 20 (95% CI 10 to 37) and 6 to 62, respectively.

3.2. Meta-Analysis of Groups Exposed versus Not Exposed to Vibration

The final meta-risk expressed as a hazard ratio (RR), not adjusted for the influence of confounders, from the eight studies included in the meta-analysis, for vibration-exposed versus non-vibration-exposed men to develop radiographically diagnosed hand and wrist osteoarthritis, was 1.59 (95% CI 0.92–2.73).

4. Discussion

This systematic review of English-language publications on hand osteoarthritis in relation to exposure to hand–arm transmitted vibrations cover the period 1947 to April 2021. The final synthesis includes 10 studies from 1972 to 1994 and is limited to only radiographic diagnosed osteoarthrosis in the hand/wrist. Radiographic manifestations of HOA occurred frequently among both those exposed to vibration and those not exposed to vibration.

An abnormal X-ray finding does not automatically imply clinical disease, nor does it have to be accompanied by symptoms or problems. Radiographs can show imaging abnormalities without clinical significance, but even insignificant X-ray changes can result in

clinically serious disability. X-ray-defined osteoarthritis is more common in the population than symptomatic arthrosis and can thus lead to a dilution of risk.

The lack of high-quality studies and the lack of studies with quantified vibration dose preclude analysis of osteoarthritis in relation to different dose levels or taking a position on a possible dose–response relationship.

The crude results from the statistical synthesis (meta-analysis), regardless of the varying reliability of the studies, show a non-significant, unadjusted risk-increase of about 50% for X-ray-diagnosed hand osteoarthritis for those who work with vibrating machinery compared to referents.

5. Conclusions

Our findings do not provide reliable support that work with exposure from vibrating machines increases the risk of radiographic hand osteoarthritis. Forthcoming studies should in addition to radiographic findings entail information on symptomatic osteoarthritis.

Author Contributions: Conceptualization, T.N., J.W., E.R. and L.B.; methodology, T.N., J.W., E.R. and L.B.; literature search, E.R.; formal analysis, T.N., J.W., E.R. and L.B. writing—review and editing, T.N., J.W., E.R. and L.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Swedish AFA Insurance (Dnr: part of project 090326).

Data Availability Statement: Additional information is presented in reference [2].

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, G.; The Prisma Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med.* **2009**, *6*. [CrossRef] [PubMed]
2. Nilsson, T.; Wahlström, J.; Reierth, E.; Burström, L. Röntgendiagnosticerad handartros i relation till exponering för handöverförda vibrationer En systematisk litteraturöversikt med meta-analys. *Arb. Hälsa Vetensk. Skr.* **2022**, *56*, 1–53.
3. Kivekas, J.; Riihimaki, H.; Husman, K.; Hanninen, K.; Harkonen, H.; Kuusela, T.; Pekkarinen, M.; Tola, S.; Zitting, A.J. Seven-year follow-up of white-finger symptoms and radiographic wrist findings in lumberjacks and referents. *Scand J. Work Environ. Health* **1994**, *20*, 101–106. [CrossRef] [PubMed]
4. Bovenzi, M.; Fiorito, A.; Volpe, C. Bone and joint disorders in the upper extremities of chipping and grinding operators. *Int. Arch. Occup. Environ. Health* **1987**, *59*, 189–198. [CrossRef] [PubMed]
5. Malchaire, J.; Maldague, B.; Huberlant, J.M.; Croquet, F. Bone and joint changes in the wrists and elbows and their association with hand and arm vibration exposure. *Ann. Occup. Hyg.* **1986**, *30*, 461–468. [CrossRef] [PubMed]
6. Kumlin, T.; Wiikeri, M.; Sumari, P. Radiological changes in carpal and metacarpal bones and phalanges caused by chain saw vibration. *Br. J. Ind. Med.* **1973**, *30*, 71–73. [CrossRef] [PubMed]
7. Van den Bossche, J.; Lahaye, D. X ray anomalies occurring in workers exposed to vibration caused by light tools. *Br. J. Ind. Med.* **1984**, *41*, 137–141. [CrossRef] [PubMed]
8. Burke, M.J.; Fear, E.C.; Wright, V. Bone and joint changes in pneumatic drillers. *Ann. Rheum. Dis.* **1977**, *36*, 276–279. [CrossRef] [PubMed]
9. Härkönen, H.; Riihimäki, H.; Tola, S.; Mattsson, T.; Pekkarinen, M.; Zitting, A.; Husman, K. Symptoms of vibration syndrome and radiographic findings in the wrists of lumberjacks. *Br. J. Ind. Med.* **1984**, *41*, 133–136. [CrossRef] [PubMed]
10. Suzuki, K.; Takahashi, S.; Nakagawa, T. Radiological studies of the wrist joint among chain saw operating lumberjacks in Japan. *Acta Orthop. Scand.* **1978**, *49*, 464–468. [CrossRef] [PubMed]
11. Hellström, B.; Andersen, K.L. Vibration injuries in Norwegian forest workers. *Br. J. Ind. Med.* **1972**, *29*, 255–263. [CrossRef] [PubMed]
12. Laitinen, J.; Puranen, J.; Vuorinen, P. Vibration syndrome in lumbermen (working with chain saws). *J. Occup. Med.* **1974**, *16*, 552–556. [PubMed]