Journal of Epidemiology and Public Health (2024), 09(01): 25-36
Masters Program in Public Health, Universitas Sebelas Maret

Research
Open Access

Meta-Analysis: Effects of Smoking, Alcohol Consumption, and Low Physical Activity on Osteoporosis in Adults

Muhammad Fahrezi Al Ghifari, Yulia Himawati, Aem Ismail, Bhisma Murti

Master's Program in Public Health, Universitas Sebelas Maret

Received: 5 November 2023; Accepted: 23 December, 2023; Available online: 16 January, 2024

ABSTRACT

Background: Osteoporosis is a systemic skeletal disease characterized by low mineral bone mass and microarchitectural deterioration of bone tissue. This study aims to analyze the effect of smoking, alcohol consumption, and low physical activity on osteoporosis in adults.
Subjects and Method: This was a meta-analysis study using the PICO format. Population: Adults, Intervention: Smoking, Alcohol Consumption, Low Physical Activity, Comparison: No Smoking, No Alcohol Consumption, High Physical Activity, Outcome: Osteoporosis. Articles were searched using online databases such as PubMed, Google Scholar, Science Direct. The search for articles using the keywords "Smoking" OR "Tobacco" AND "Alcohol consumption" OR "Drinking" AND "Physical activity" OR "Exercise" AND "Osteoporosis" OR "Bone mineral density" AND "Cross-sectional". The inclusion criteria for articles used were articles published in 2013-2023. Articles were filtered using PRISMA flow diagrams and analysis was conducted using RevMan 5.4.
Results: The meta-analysis used 15 articles with cross-sectional studies from Ireland, Nepal, Taiwan, South Korea, China, Iran, America, Brazil, India, Congo, and Thailand with a total sample of 111,478 samples. The risk of osteoporosis increased with smoking (aOR= 1.49; CI 95%= 1.04 to 2.16; p= 0.030), alcohol consumption (aOR= 1.04; CI 95%= 0.84 to 1.30; p = 0.690), and low physical activity (aOR= 1.17; CI 95%= 0.92 to 1.48; p= 0.210).
Conclusion: Smoking, alcohol consumption, and low physical activity increase the risk of osteoporosis in adults.

Keywords: smoking, alcohol consumption, physical inactivity, osteoporosis.

Correspondence:
Muhammad Fahrezi Al Ghifari. Master's Program in Public Health, Universitas Sebelas Maret. Jl. Ir. Sutami. 36A, Surakarta 57126, Central Java, Indonesia. Email: Fahrezialghifari@student.uns.-ac.id. Mobile: +6281386225625.

Cite this as:
Ghifari MFA, Himawati Y, Ismail A, Murti B (2023). Meta Analysis: Effects of Smoking, Alcohol Consumption,and Low Physical Activity on Osteoporosis in Adults. J Epidemiol Public Health. 9(1): 25-36. https://doi.org/10.26911/jepublichealth.2024.09.01.03.

BACKGROUND

Osteoporosis defined as a systemic skeletal disease characterized by low mineral bone mass and microarchitectural deterioration of bone tissue. More specifically, osteoporosis is a disease that occurs due to a decrease in the number of trabeculae and trabecular thinning, and loss of connectivity among bones, as well as a decrease in cortical thickness and an increase in its porosity. This leads to increased bone fragility which makes them brittle and susceptible to fractures (Tański et al., 2021). WHO explains

the definition of osteoporosis as low mineral bone density with a T-score of ≤-2.5 SD found in the spine, femoral neck, or in examination of the hip bone (IOF, 2023).

Risk factors for osteoporosis are divided into two, namely modifiable and non-modifiable factors. Non-modifiable factors include age, sex, history of fractures, and poor health conditions. Whereas modifiable factors include vitamin D deficiency, smoking, alcohol consumption, and low physical activity (Tański et al., 2021). Smoking is one of the risk factors for osteoporosis. This is because smoking can cause a decrease in circulating levels of 1,25-dihydroxyvitamin D and parathyroid hormone (Johnston dan Dagar, 2020). The behavior of drinking alcohol is also one of the factors in the occurrence of osteoporosis. Jhonston and Dagar (2020) state that consuming alcohol with levels of >50 g/d has an association with an increased risk of hip fracture. Lack of physical activity is one of the causes of osteoporosis. Eckstrom et al. (2020) state that one form of prevention of osteoporosis is to carry out physical activity.

Osteoporosis is a disease that occurs in old age. Osteoporosis mostly attacks people who have entered the age of over 65 years and women over 55 years. Osteoporosis is a disease that must be prevented from occurring in adults because it greatly interferes with an individual productivity (Aibar-Almazán et al., 2022). This study aims to determine the effect of smoking, drinking alcoholic beverages, and low physical activity on the incidence of osteoporosis in adults based on previous articles.

SUBJECTS AND METHOD

1. Study Design

It was a systematic review study and meta-analysis study using primary data obtained from the results of previous studies. Article search was conducted using 3 online databases, namely: Google Scholar, PubMed, and Science Direct. The keywords used in this study were "Smoking" OR "Tobacco" AND "Alcohol" OR "Drinking" AND "Physical Activity" OR "Exercise" AND "Osteoporosis" OR "Bone Mineral Density". The study used 15 Primary study articles that met the inclusion criteria of this study.

2. Steps of Meta-Analysis

1) Create research questions using the PICO format, which involves defining the Population, Intervention, Comparison, and Outcome.
2) Searching for review of main articles from various electronic and non-electronic databases
3) Screening articles with Critical Appraisal assessment of primary research.
4) Performing data extraction and synthesize effect estimates using RevMan 5.4
5) Conducting interpretation and conclusion of study results.

3. Inclusion Criteria

The inclusion criteria included a full article using a cross-sectional study design, the study subjects were adults, the study interventions were smoking, alcohol consumption, and physical activity, and the outcome of the study was osteoporosis.

4. Exclusion Criteria

Non-English articles, articles that were performed only through bivariate analysis, and articles published before 2013.

5. Operational Definition of Variables

Osteoporosis: is systemic skeletal disease characterized by low mineral bone mass and microarchitectural deterioration of bone tissue.

Smoking: is an activity of consuming cigarettes perpetrated by adults.

Alcohol Consumption: is an activity of consuming alcoholic beverages perpetrated by adults

Physical activity: daily activities carried out by adults.

6. Study Instruments

The quality assessment in this study was conducted using critical Appraisal sheet for a cross-sectional study published by Murti in 2023.

7. Data Analysis

The collected articles were subsequently screened using predetermined criteria. It was a meta-analysis study that used secondary data in the form of data from previous primary studies. The collected data were processed using the RevMan 5.4. Data processing results were presented in forest plots and funnel plots.

RESULTS

In Figure 1, The article search in this study was conducted using several online databases such as Google Scholar, PubMed, Science Direct. The article selection process was conducted using PRISMA diagrams. The initial search process obtained 4,326 articles, subsequently, an article selection was carried out so that the final results for eligible articles were 15 articles and could be included in the meta-analysis study. The study was conducted using critical appraisal for cross-sectional studies.

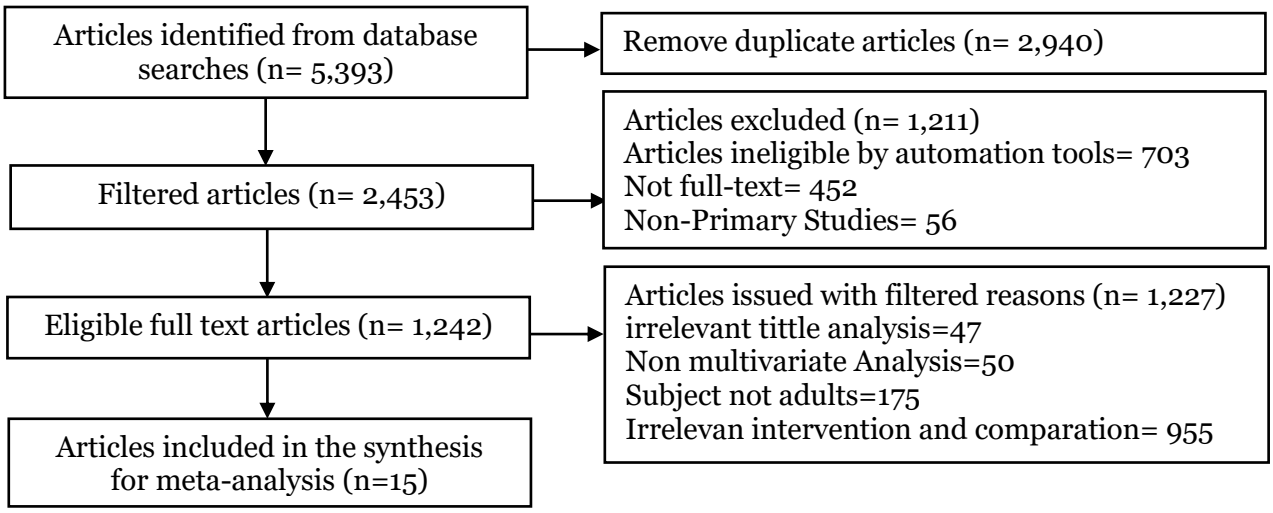

Figure 1. PRISMA flowchart

Figure 2. Map of the distribution of articles included in the meta-analysis

Figure 2 explains the distribution map of the articles. The study obtained 10 articles from Asia, 1 article from Africa, 1 article from Europe, and 2 articles from America. The article distribution map is useful for identifying the distribution of articles' publication locations to see the level of heterogeneity in the sample studied.

Table 1. The Critical Appraisal of Articles with a Cross-Sectional Study

Authors (Year)	Criteria													total
	1a	1b	1c	1d	2a	2b	3a	3b	4	5	6a	6b	7	
Burke et al. (2021)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Chaudary et al. (2019)	2	2	2	1	2	2	2	2	2	2	2	2	2	25
Yang et al. (2021)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Choi et al. (2013)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Zheng et al. (2023)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Lee et al. (2023)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Zhang et al. (2020)	2	2	2	2	1	2	2	2	2	2	2	2	2	25
Abdolalipor et al. (2021)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Huang et al. (2022)	2	2	2	1	1	2	2	2	2	2	2	2	2	24
Felix-Beltran et al. (2021)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Ahmed and Muneera (2023)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Min et al. (2020)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Ladan et al. (2023)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Mavinga et al. (2022)	2	2	2	2	1	2	2	2	2	2	2	2	2	25
Wongsuttilert et al. (2015)	2	2	2	2	2	2	2	2	2	2	2	2	2	26

Description of question criteria:

1a. Is the population in the primary study the same as the population in the PICO meta-analysis?

1b. Is the operational definition of the intervention, i.e. exposed status in the primary study the same as the definition intended in the meta-analysis?

1c. Is the comparison, i.e. unexposed status used by the primary study the same as the definition intended in the meta-analysis?

1d. Are the outcome variables studied in the primary study the same as the definitions intended in the meta-analysis?

2a. In analytical cross-sectional studies, did researchers randomly select samples from the population (random sampling)?

2b. Alternatively, if in an analytically cross-sectional study, the sample was not randomly selected, did researchers select the sample based on outcome status or based on intervention status?

3a. Were both exposure and outcome variables measured with the same instruments in all primary studies?

3b. If variables were measured on a categorical scale, were the cutoffs or categories used the same across primary studies?

4. If the sample was not randomly selected, had the researcher made efforts to prevent bias in choosing the study subject? For example, selecting subjects based on outcome status was not affected by exposure status (intervention), or in selecting subjects based on exposure status (intervention) was not affected by outcome status.

5. Whether the primary study researcher has made efforts to control for the influence of confusion (e.g., performing a multivariate analysis to control for the influence of several confounding factors)

6a. Did the researchers analyze the data in this primary study with multivariate

analysis models (e.g., multiple linear regression analysis, multiple logistic regression analysis)

6b. Whether the primary study reports effect size or the association of the results of the multivariate analysis (e.g., adjusted OR, adjusted regression coefficient)

7. Is there no possibility of a conflict of interest with the research sponsor, which causes bias in concluding research results?

Description of Scoring:

Yes=2; Hesitate=1; No=0

Table 2. Description of the cross-sectional studies of smoking, alcohol consumption, physical activity, and osteoporosis in adults (N= 111,478)

Author (Years)	Country	Sample	P	I	C	O
Burke et al. (2021)	Ireland	244	Men of 50 years old and older	Mobility	Difficult mobility	Osteoporosis
Chaudary et al. (2019)	Nepal	169	People aged 50 and above	Smoking, alcohol consumption	No smoking, no alcohol consumption	Bone mineral density
Yang et al. (2021)	Taiwan	3,819	People aged <40 year	Tobacco, alcohol, regular exercise	No tobacco, no-alcohol, no regular exercise	Osteoporosis
Choi et al. (2013)	South Korea	556	Cancer survivor ≥60 years old	Smoking, alcohol, 1st tertile exercise	No-smoking, no alcohol, 3rd tertile exercise	Osteoporosis
Zheng et al. (2023)	China	2,780	people aged 20-89 years	Smoking	Never smoking	Osteoporosis
lee et al. (2023)	South Korea	5,830	Individual aged ≥50 Year	Current smoker, heavy alcohol consumption, low physical activity	Non-smoker, never drinking, high physical activity	Osteoporosis
Zhang et al. (2020)	China	1,007	Patient rheumatics above 50 year	Current smoker, always drinking	Non-smoker, never drinking	Osteoporosis
Abdolalipor et al. (2021)	Iran	445	Menopause women 50-65 years old	Low physical activity	High physical activity	Osteoporosis
Huang et al. (2022)	United States of America	5,988	Adults older than 50 years old with cancer	smoking status, alcohol use,	No smoking status, no alcohol use	Bone mineral density
Felix-Beltran and Brayan (2021)	Brazil	9,323	Adults over 50 years	Daily smoking, eventually drinking	No daily smoking, never drinking	Osteoporosis
Ahmed and Muneera (2023)	India	72,250	Adults 45 years old and older	Physical inactivity	Physical activity	Osteoporosis
Min et.al (2020)	South Korea	6,868	People aged ≥50 years old	Low physical activity	High physical activity	Osteoporosis
Ladan et al. (2023)	Iran	1,359	Women above 45 years old	Regular exercise	No-regular exercise	Osteoporosis

Author (Years)	Country	Sample	P	I	C	O
Mavinga et al. (2022)	Democratic Republic of Congo	685	Patients aged ≥40 years old	Smoking	No-smoking	Osteoporosis
Wongsuttilert et al. (2015)	Thailand	155	People 45-60 years old	Low physical activity	Moderate/high physical activity	Osteoporosis

Table 2 is a description of 15 articles with cross-sectional studies selected based on predetermined criteria. The total number of samples amounted to 111,478 samples from Ireland, Nepal, Taiwan, South Korea, China, Iran, America, Brazil, India, Congo, and Thailand. The articles used in this study were articles published from 2013 to 2023.

Table 3. aOR and CI 95% data of smoking and osteoporosis in adults

Author (Year)	aOR	CI 95%	
		Lower Limit	Upper Limit
Chaudary et al. (2019)	3.85	1.18	12.56
Yang et al. (2021)	1.24	1.08	1.42
Choi et al. (2013)	1.18	0.44	3.16
Zheng et al. (2023)	2.26	2.23	2.28
Lee et al. (2023)	1.41	1.09	1.83
Zhang et al. (2020)	1.40	0.35	5.37
Huang et al. (2022)	0.95	0.75	1.21
Felix-Beltran & Brayan (2021)	1.14	1.00	1.29
Mavinga et al. (2022)	14.65	1.38	156.10

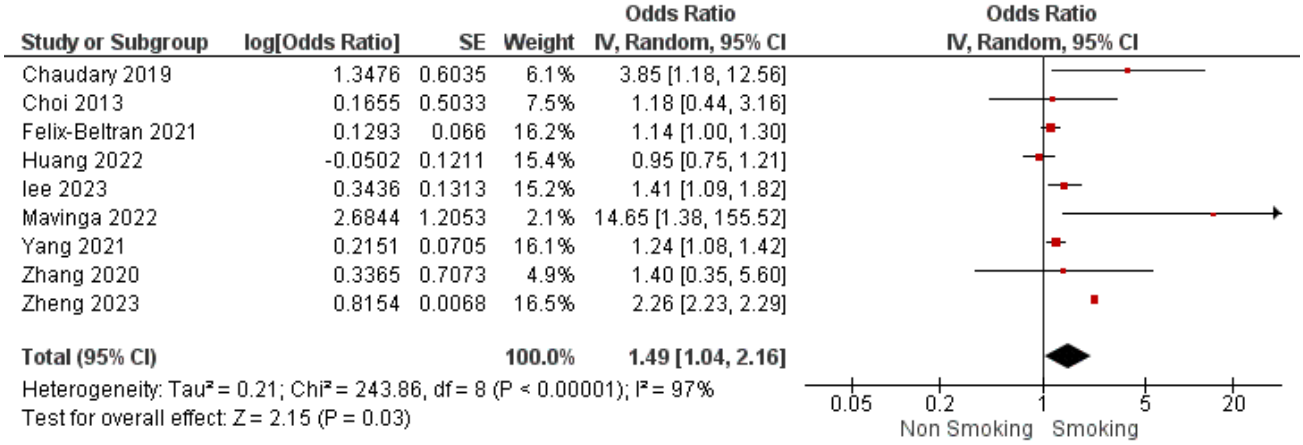

Figure 1. Forest plot of smoking and osteoporosis in adults

Forest plots were conducted on 9 primary articles to analyze the effect of smoking on osteoporosis in adults with a sample size of 30,157 samples found in Nepal, Taiwan, South Korea, China, America, Brazil, and Congo. The results of the meta-analysis showed that an individual who smoked was 1.49 times more likely to develop osteoporosis than a nonsmoker and it was statistically significant (aOR= 1.49; CI 95%= 1.04 to 2.16; p= 0.030). Data variations based on I^2 values showed 97% therefore the effect of smoking on osteoporosis used a random effect model (REM).

The funnel plot in Figure 4 explains the distribution of estimates from 9 selected journals to analyze the effect of smoking on osteoporosis in adults. The results of the funnel plot showed that the distributions of effect estimates across studies were more to the right of the average vertical line. Thus, the funnel plot stated that there was a study bias that indicated an overestimated bias.

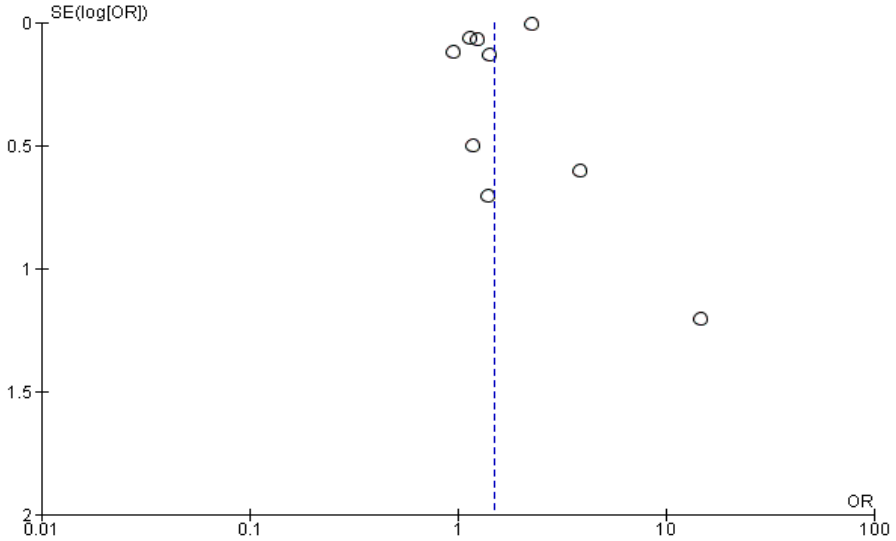

Figure 2. Funnel plot of smoking and osteoporosis in adults

Table 4. aOR and CI 95% data of alcohol consumption and osteoporosis in adults

Author (Years)	aOR	95% CI	
		Lower Limit	Upper Limit
Chaudary et al. (2019)	0.53	0.22	1.24
Yang et al. (2021)	1.04	0.69	1.56
Choi et al. (2013)	1.20	0.50	2.88
Lee et al. (2023)	0.86	0.71	1.05
Zhang et al. (2020)	0.69	0.18	5.38
Huang et al. (2022)	1.42	1.10	1.83
Felix-Beltran and Brayan (2021)	1.15	0.89	1.64

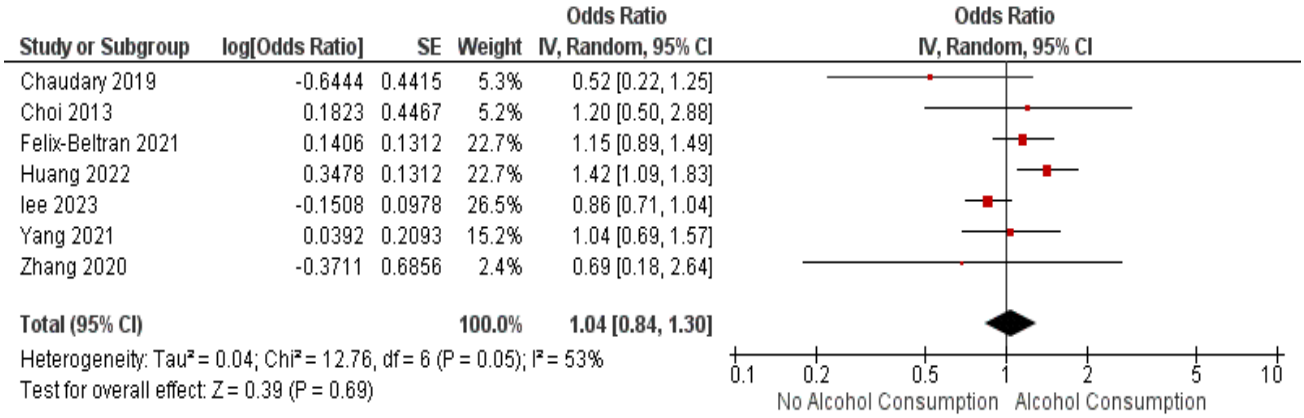

Figure 3. Forest plot of alcohol consumption and osteoporosis in adults

Forest plots were conducted on 7 primary articles with a sample size of 26,692 samples in Nepal, Taiwan, South Korea, China, America, and Brazil. The results of the meta-analysis showed that an individual who consumed alcohol was 1.04 times more likely to develop osteoporosis than one who did not consume alcohol but statistically showed no significance (aOR= 1.04; CI 95%= 0.84 to 1.30; p= 0.690). Data variation based on the I^2 value indicated 53% therefore the effect of alcohol consumption on osteoporosis used a random effect model (REM).

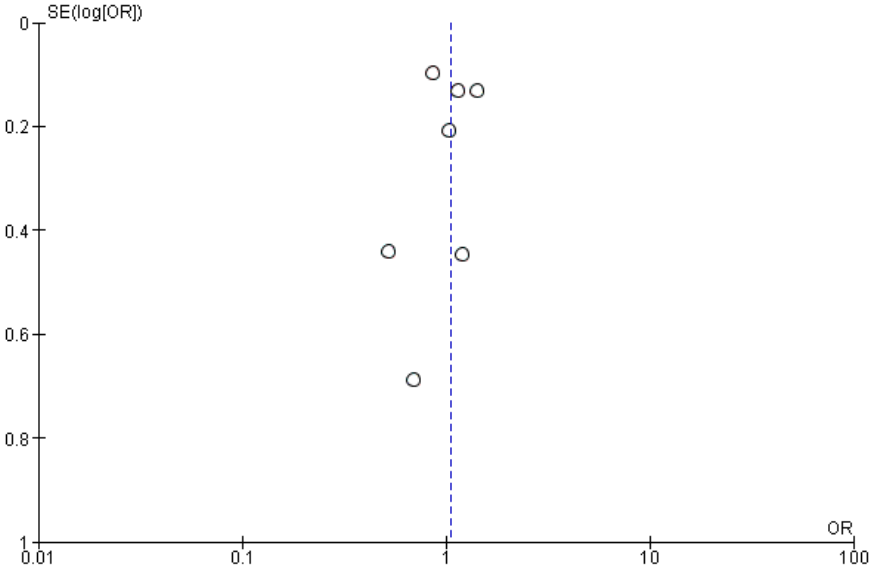

Figure 4. Funnel plot of alcohol consumption and osteoporosis in adults

The funnel plot in Figure 6 shows the distribution of estimates on 7 articles. The funnel plot explains that the distributions of effect estimates across studies were fairly symmetrical, that is, the distributions of effect estimates to the right and left of the vertical average line were relatively the same. Thus, the Funnel plot stated that there was no bias in the study.

Table 5. aOR and CI 95% data of physical activity and osteoporosis in adults

Author (Years)	aOR	CI 95%	
		Lower Limit	Upper Limit
Burke et al. (2021)	13.72	4.57	41.20
Yang et al. (2021)	0.78	0.71	0.86
Choi et al. (2013)	0.87	0.38	1.96
Lee et al. (2023)	1.25	1.03	1.51
Abdolalipor et al. (2021)	0.98	0.91	1.05
Ahmed and muneera (2023)	1.17	0.99	1.37
Min et al. (2020)	0.47	0.28	0.79
Ladan et al. 2023	2.22	1.19	4.15
wongsuttilert et al. (2015)	8.10	1.60	40.3

Forest plots were conducted in 9 primary articles to analyze the effect of alcohol consumption on osteoporosis in adults with a sample size of 91,451 samples in Ireland, Taiwan, South Korea, Iran, India, and Thailand. The results of the meta-analysis showed that an inividual who had low physical activity was 1.17 times more likely

to develop osteoporosis than one who had high physical activity but statistically showed no significance (aOR= 1.17; CI 95%= 0.92 to 1.48; P= 0.210). Data variation based on the I^2 value indicated 89% so that the effect of physical activity on osteoporosis used Random Effect Model (REM).

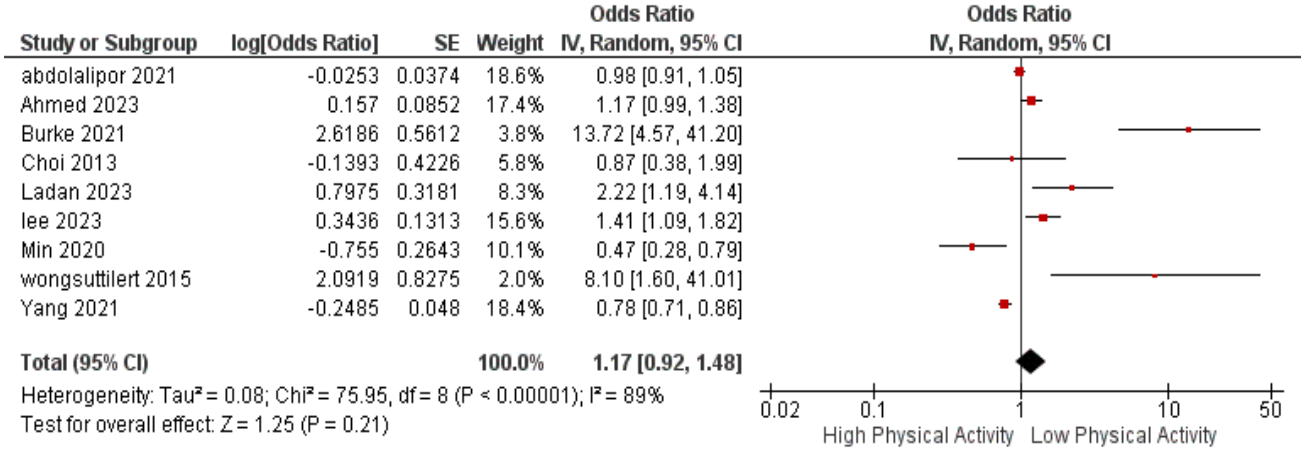

Figure 5. Forest plot of physical activity and osteoporosis in adults

The funnel plot in figure 8 explains that the distributions of effect estimates across studies were more to the right of the average vertical line. Thus, in the Funnel plot stated that there was a bias that indicated an Over Estimate bias.

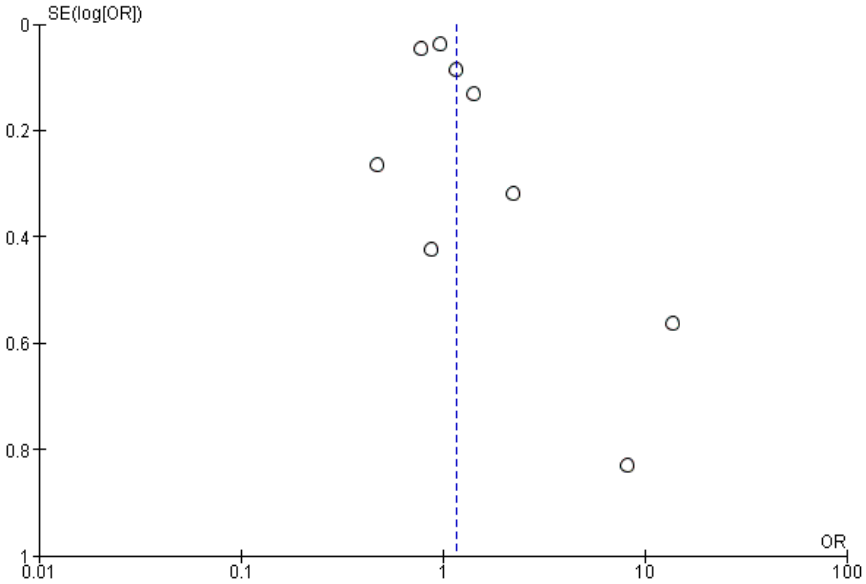

Figure 8. Funnel plot of low physical activity and osteoporosis in adults

DISCUSSION

1. The effect of smoking on osteoporosis in adults

Smoking is a risk factor for osteoporosis and is involved in bone loss. The mechanism of bone loss caused by smoking causes very complex periodontal damage. Suppressive effects on osteoprotegerin levels in serum and gingival sulcus fluid are observed in smokers and results in an imbalance in the RANKL/OPG ratio which has been associated with increased osteoclastic resorption and bone loss induced by smoking (Anam and Insogna, 2021). This meta-analysis

study states that someone who smokes are 1.49 times more likely to develop osteoporosis than people who do not smoke (aOR= 1.49; CI 95%= 1.04 to 2.16; p= 0.030).

2. The effect of alcohol consumption on osteoporosis in adults

Alcohol consumption is one of the risk factors for osteoporosis in adults. Alcohol consumption of more than 2 or 3 drinks daily for men can be detrimental to bone health. This is because alcohol consumption can reduce calcium absorption and increase the risk of falls resulting from loss of consciousness (LeBoff et al., 2022). This meta-analysis study indicates that there is a 1.04 times possibility of osteoporosis in adults who consume alcohol compared to adults who do not consume alcohol (aOR= 1.04; CI 95%= 0.84 to 1.30; p= 0.690).

3. The effect of physical activity on osteoporosis in adults

Low physical activity is one of the risk factors that can cause osteoporosis. This is because physical activity can contribute to building and maintaining bone and muscle strength and improving balance and coordination of movements in adults. It can be concluded that physical activity is beneficial in reducing the risk of fractures, both directly and factor-wise, caused by osteoporosis (Rondanelli et al., 2021). This meta-analysis study indicated that an individual with low physical activity is 1.17 times more likely to develop osteoporosis than one with high physical activity (aOR= 1.17; CI 95%= 0.92 to 1.48; p= 0.210).

From 15 cross-sectional studies includ in this meta-analysis the risk of osteoporosis increased in adults with smoking, alcohol consumption, and low physical activity. The results of this study support existing theories about osteoporosis risk factors in adults. This study has limitations including the lack of articles included in this meta-analysis study.

AUTHOR CONTRIBUTION

Muhammad Fahrezi Al Ghifari was the main researcher of this study who determined the topic, searched for articles and collected data, and wrote articles. Yulia Himawati was the second author to search for articles and collect data. Bhishma Murti and Aem Ismail were assistants in the study.

ACKNOWLEDGEMENT

The researcher would like to express gratitude to everyone involved in the preparation and implementation of this study.

FUNDINGS AND SPONSORSHIP

The fund for the study came from the main researcher and the second researcher.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

REFERENCES

Abdolalipour S, Mirghafourvand M, Ghassab-Abdollahi N, Farshbaf-Khalili A (2021). Health-promoting lifestyle and quality of life in affected and unaffected menopausal women by primary osteoporosis. J Educ Health Promot. 10(1): 45. doi: 10.41-03/jehp.-jehp_450_20.

Ahmed W, Muhammad T, Muneera K (2023). Prevalence of early and late onset of chronic diseases and multimorbidity and its association with physical, mental and functional health among older Indian adults. BMC Geriatrics. 23(1): 1–15. doi: 10.1186/s-12877-023-04264-8

Aibar-Almazán A, Voltes-Martínez A, Castellote-Caballero Y, Afanador-Restrepo DF, Carcelén-Fraile M del C, López-Ruiz E (2022). Current status of the diagnosis and management of osteoporosis. Int J Mol Sci. 23(16): 1–27. doi: 10.3390/ijms23169465.

Anam AK, Insogna K (2021). Update on osteoporosis.screening.and.management. Med Clin North Am, 105(6):1117–1134. doi:10.1016/j.m-cna.2021.05.016

Burke ÉA, Carroll R, Ding AW, Yaman M, Walsh JB, McCallion P, McCarron M (2021). Men's Bones Matter Too, a Cross Sectional Study Examining Bone Health among Men with Intellectual Disability in Ireland. OBM Geriatrics. 05(04):.1–22. doi: 10.21926/obm.geriatr.2104182

Chaudhary NK, Timilsena MN, Sunuwar DR, Pradhan PMS, Sangroula RK (2019). Association of Lifestyle and Food Consumption with Bone Mineral Density among People Aged 50 Years and Above Attending the Hospitals of Kathmandu, Nepal. J Osteoporos. 2019: 1–6. doi:10.1155/2019/15-36394

Choi KH, Park SM, Park JS, Park JH, Kim KH, Kim MJ (2013). Prevalence of and Factors Associated with Osteoporosis among Korean Cancer Survivors: A Cross-Sectional Analysis of the Fourth and Fifth Korea National Health and Nutrition Examination Surveys. Asian Pac j Cancer Prev. 14(8): 4743–4750. doi: 10.7314/APJCP.2013.14.8.4743.

Eckstrom E, Neukam S, Kalin L, Wright J (2020). Physical activity and healthy aging. Clin Geriatr Med. 36(4): 671–683. doi: 10.1016/j.cger.2020.06.009.

Félix-Beltrán L, Seixas BV (2021). Childhood hunger experiences and chronic health conditions later in life among Brazilian older adults. Rev Panam Salud Publica. 45:.1–10. doi: 10.26633/RPSP.-2021.39

Huang JF, Tan QC, Bai H, Wang J, Bergman M, Wu Z (2022). Bone mineral density, osteopenia and osteoporosis among US adults with cancer. QJM-Int J Med. 115(10):.653–660. doi: 10.-1093/qjmed/hcac015.

IOF (2023). Diagnosis of Osteoporosis. International Osteoporosis Foundation.

Johnston CB, Dagar M (2020). Osteoporosis in older adults. Med Clin North Am. 104(5):.873–884. doi: 10.1016/j.mcna-.2020.06.004

LeBoff MS, Greenspan SL, Insogna KL, Lewiecki EM, Saag KG, Singer AJ, Siris ES (2022). The clinician's guide to prevention and treatment of osteoporosis. Osteoporos Int. 33(10): 2049–2102. doi: 10.1007/s00198-021-0590-0-y.

Lee S, Ko K, Shin S, Park HS, Hong N, Rhee Y (2023). Adipopenia is associated with osteoporosis in community-dwelling non-underweight adults independent of sarcopenia. Arch Osteoporos. 18(1): 44. doi: 10.1007/s11657-023-01233-x

Mavinga A, Mbuyi J, Matanda D, Lebughe P, Mulumba JC, Nyembue V, Lukusa A, et al. (2022). Prevalence and determinants of osteoporosis in Congolese patients with axial rheumatism: a cross-sectional hospital-based study. Pan Afr Med J. 43:1–11. doi: 10.116-04/pamj.2022.43.100.31519

Min C, Yoo DM, Wee JH, Lee HJ, Choi HG (2021). High-Intensity Physical Activity with High Serum Vitamin D Levels is Associated with a Low Prevalence of Osteopenia and Osteoporosis: A Population-Based Study. Osteoporos Int..32(5):.883–891. doi: 10.1007/s00-198-020-05746-w

Murti B (2023) Penilaian kritis (critical appraisal) studi cross-sectional analitik (bukan survey) untuk penelitian meta-analisis. Universitas Sebelas Maret.

Rondanelli M, Faliva MA, Barrile GC, Cavioni A, Mansueto F, Mazzola G, Oberto L, et al. (2021). Nutrition,

physical activity, and dietary supplementation to prevent bone mineral density loss: A food pyramid. Nutrients. 14(1); 1–60. doi: 10.3390/nu14-010074.

Tański W, Kosiorowska J, Szymańska-Chabowska A (2021). Osteoporosis – risk factors, pharmaceutical and non-pharmaceutical treatment. Eur Rev Med Pharmacol Sci. 25(9): 3557–3566. doi: 10.26355/eurrev_202105_25838.

Wongsuttilert A, Chanchai S, Jaidee W (2015). Risk Factors Affecting Bone Health in Middle-aged Group. Burapha Univ. Int Conf.

Yang CY, Lai JCY, Huang WL, Hsu CL, Chen SJ (2021). Effects of sex, tobacco smoking, and alcohol consumption osteoporosis development: Evidence from Taiwan biobank participants. Tob Induc Dis. 19(6): 1–8. doi: 10.18332/-tid/136419

Younesi AL, Kashanian M, Najmi Z, Mahdavi A, SafarpourLima Z (2023). Risk factors of osteoporosis and osteopenia in postmenopausal women based on the L2–L4 BMD T score of the lumbar spine: a study in Iran. Gynecol Endocrinol. 39(1): 1–7. doi: 10.1080/09513590.2023.2205959.

Zhang X, Dai Z, Lau EHY, Cui C, Lin H, Qi J, Ni W, et al. (2020). Prevalence of bone mineral density loss and potential risk factors for osteopenia and osteoporosis in rheumatic patients in China: logistic regression and random forest analysis. Ann Transl Med. 8(5): 226. doi: 10.2-1037/atm.2020.01.08

Zheng M, Wan Y, Liu G, Gao Y, Pan X, You W, Yuan D, et al. (2023). Differences in the prevalence and risk factors of osteoporosis in chinese urban and rural regions: a cross-sectional study. BMC Musculoskelet Disord. 24(1): 46. doi: 10.1186/s12891-023-06147-w.