Association of Smartphone Overuse and Neck Pain: A Systematic Review and Meta-Analysis of Over 10,000 individuals.

Yan-Jyun Chen, Ching-Yuan Hu, Wen-Tien Wu, Ru-Ping Lee, Cheng-Huan Peng, Ting-Kuo Yao, Chia-Ming Chang, Hao-Wen Chen, Kuang-Ting Yeh

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Yan-Jyun Chen[1]; Ching-Yuan Hu[1]; Wen-Tien Wu[1]; Ru-Ping Lee[2]; Cheng-Huan Peng[1]; Ting-Kuo Yao[1]; Chia-Ming Chang[1]; Hao-Wen Chen[1]; Kuang-Ting Yeh[1]

[1]Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation Hualien TW
[2]Tzu Chi University Hualien TW

Corresponding Author:
Kuang-Ting Yeh
Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation
Department of Orthopedics
Hualien
TW

Abstract

Background: Smartphone overuse is associated with both psychological and physical health problems, including depression and musculoskeletal disorders. However, the association between smartphone overuse and neck pain remains unclear.

Objective: We performed a meta-analysis to examine the relation between smartphone overuse and neck pain, and to identify high-risk usage patterns.

Methods: PubMed, Embase and Cochrane CENTRAL databases were searched for relevant studies published up to August 16, 2023, using keywords including "smartphone" and "neck pain". Prospective, retrospective, and case-controlled studies assessing the correlation between smartphone overuse and neck pain were eligible. The Newcastle-Ottawa Scale (NOS) was used to assess the quality of the included studies. Meta-regression and sensitivity analysis using the leave-one-out approach were performed to test the robustness of the results.

Results: Seven retrospective studies including 10,715 participants were included in the systematic review and meta-analysis. The mean age of the participants ranged from 19.9 to 42.9 years. The meta-analysis revealed that compared to participants without smartphone overuse, those who overused a smartphone had a significantly higher risk of neck pain (pooled adjusted odds ratio [aOR] = 2.34, 95% CI: 1.44-3.82). A significant correlation between increasing age and higher ORs for neck pain was found (coefficient = 0.051, P < 0.001).

Conclusions: These results indicate a significant association between smartphone overuse and increased risk of neck pain, with risk escalating with age. Our findings underscore the necessity of addressing smartphone overuse as a health concern, especially considering its growing prevalence in modern society.

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Running title: Smartphone overuse and neck pain

Yan-Jyun Chen MD[1#], Ching-Yuan Hu MD [2#], Wen-Tien Wu MD PhD [1,2,3] , Ru-Ping Lee RN PhD [3], Cheng-Huan Peng MD PhD[1], Ting-Kuo Yao MD[1], Chia-Ming Chang MD[1], Hao-Wen Chen MD[1], and Kuang-Ting Yeh MD PhD [1,2,4*]

[1] Department of Orthopedics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

[2] Department of Anesthesiology, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

[3] Institute of Medical Sciences, Tzu Chi University, Hualien, Taiwan

[4] Graduate Institute of Clinical Pharmacy, Tzu Chi University, Hualien, Taiwan

[#] Share equal contribution.

*Corresponding author: Kuang-Ting Yeh

Department of Orthopedics, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

Phone: 886-905193778; Fax: 886-3-8577161; E-mail: micrograft@tzuchi.com.tw

ABSTRACT

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Conclusions: These results indicate a significant association between smartphone overuse and increased risk of neck pain, with risk escalating with age. Our findings underscore the necessity of addressing smartphone overuse as a health concern, especially considering its growing prevalence in modern society.

Keywords: Smartphone overuse, neck pain, musculoskeletal disorder, systematic review, meta-analysis

INTRODUCTION

By the end of 2022, 83% of the global population, amounting to 6.65 billion individuals, possessed smartphones [1]. This widespread use has led to a global concern of smartphone overuse. Research indicates that students excessively using smartphones often experience higher depression and anxiety levels [2]. Smartphone overuse also leads to serious physical consequences; a study found a strong link between addiction to smartphones and the onset of musculoskeletal disorders [3]. Smartphone overuse is a multifaceted issue, affecting mental and physical health across different demographic categories, necessitating comprehensive strategies to mitigate its adverse consequences.

Neck pain, most prevalent of musculoskeletal ailments, was reported to affect 27 of every 1,000 people in 2019 [4]. Neck pain is often attributed to several factors, including prolonged use of computers, repetitive motion, and suboptimal ergonomic setups at the workplace. This is compounded by lifestyle choices such as insufficient physical activity and inadequate sleep quality [5]. Furthermore, individuals aged 40 and above, as well as those suffering from concurrent back pain, are more prone to developing neck pain, with many persons experiencing chronic symptoms [6]. The Global Burden of Disease study found that higher sociodemographic indices are associated with increased years lived with disability from neck pain, indicating a greater burden in more socioeconomically developed areas [7].

There is a rising concern about the potential link between smartphone usage and neck pain. Some studies indicate that a strong positive correlation exists between the total time spent daily on smartphones and neck pain intensity [8]. Similarly, a study of university students with neck pain due to smartphone use found an association with clinical myelopathic signs, indicating a potential impact on the spinal cord [9]. However, existing studies have produced varied and inconclusive results. For example, Bertozzi et al. [10] reported found that while half of young medical students reported neck pain, smartphone use was not correlated with neck pain or disability.

Thus, the purpose of this study was to perform a systematic review of the literature and meta-analysis to determine if there is an association between smartphone use/excessive use and neck pain. If the results show there is an association, we also hope to identify high-risk usage patterns.

METHODS

Search strategy

This systematic review and meta-analysis was carried out in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [11]. PubMed, EMBASE, and Cochrane CENTRAL databases were searched for studies published up to August 16, 2023. Searches were conducted with specific keywords including "smartphone" and "neck pain", combined with Boolean operators. Medical Subject-Headings (MeSH) terms were also employed where necessary. An example search string used to search PubMed was (smartphone OR smart phone OR smart device OR mobile phone OR digital device OR text neck) AND (neck pain OR neck disability)

Selection criteria

This systematic review and meta-analysis adhered to the PECOS criteria, covering participants, exposure, comparisons, outcomes, and study design (PECOS). Eligible studies were those that examined the association between excessive smartphone use and the presence of neck pain (P and E). The comparison involved participants without smartphone overuse (C). The main focus was on the subjective or objective neck pain, or any signs of neck pain experienced by the participants (O). Prospective, retrospective, and case-controlled studies and randomized controlled trials (RCTs) were eligible for inclusion (S).

We excluded review articles, letters, commentaries, editorials, proceedings research, meeting abstracts, case reports, and personal communications, as well as studies investigating smartphone

apps as an intervention to prevent or treat muscular pain.

Main outcome measures and data extraction

The primary outcome was the association between smartphone overuse and neck pain. We extracted the following data from eligible studies: the first author's name, year of publication, study design, study country, number of participants, mean age, male percentage, and definition of smartphone overuse when available.

Ethics statement

This study relied exclusively on published research and did not involve raw patient data or private information. As a result, the hospital's Institutional Review Board (IRB) exempted it from the usual protocol approval and informed consent requirements for study participants.

Quality assessment

The quality of the included studies was evaluated using the Newcastle-Ottawa Scale (NOS) for cohort studies, following the guidance of the Cochrane Non-Randomized Studies Methods Working Group [12]. The NOS allocates up to 9 points for a study: 4 points for selecting participants correctly, 2 for evaluating comparability, and 3 for confirming outcomes. A higher number of total points indicates higher overall quality. Two independent reviewers performed this evaluation, consulting a third reviewer to resolve any uncertainties.

Statistical analysis

Pooled crude odds ratios (ORs) and adjusted ORs (aORs) were calculated to assess the association between smartphone overuse and neck pain. Heterogeneity across the included studies was tested using the Cochran Q test and I^2 statistic. If I^2 was > 50%, indicating marked

heterogeneity, a random effects model of analysis was used; otherwise a fixed effects model was used. All analyses were 2-sided, with a significance level of $\alpha = 0.05$. A sensitivity analysis was conducted using the leave-one-out approach. We then used random-effects meta-regression to model ORs as linear functions of age. All analyses were conducted using R Studio 4.3.2, with the packages "meta", "dmetar", and "metafor".

RESULTS

Study selection

The PRISMA flow diagram of study selection is shown in Figure 1. A total of 17 full-text articles were assessed for eligibility, and 10 were excluded. Finally, 7 studies [9, 13-18] with a total of 10,715 participants were included in the systematic review and meta-analysis.

Characteristics of the included studies

Characteristics of the included studies are summarized in Table 1. All studies were retrospective studies. Four studies were conducted in Asia, one in Europe, one in Africa, and one in America. The mean age of the participants ranged from 19.9 to 42.9 years, and the proportion of males ranged from 12% to 60%. (Table 1).

Meta-analysis of the association between smartphone overuse and neck pain

The result of the meta-analysis using crude ORs for the association between smartphone overuse and neck pain are presented in Figure 2. Six studies were included [9, 13, 15-18], and high heterogeneity was detected ($I^2 = 92\%$). Compared to the participants without smartphone overuse, those who overused a smartphone had a significantly higher risk of neck pain (pooled crude OR = 2.81, 95% confidence interval [CI]: 1.72-4.59) (Figure 2).

The results of the meta-analysis using adjusted ORs (aORs) to examine the association

between smartphone overuse and neck pain are shown in Figures 3. There were 7 studies [9, 13-18] included in the analysis, and high heterogeneity was detected (I^2 = 94%). Compared to the participants without smartphone overuse, those who overused a smartphone had a significantly higher risk of neck pain (pooled aOR = 2.34, 95% CI: 1.44-3.82) (Figure 2).

Sensitivity analyses

Results of the sensitivity analysis using the leave-one-out approach are shown in Table 2 and Table 3. The pooled OR and pooled aOR for the associations between smartphone overuse and neck pain did not change substantially upon excluding any single study, suggesting none of the included studies excessively influenced the pooled estimates.

Meta-regression on the correlation between age and ORs for neck pain

The results of the random effects univariate meta-regression between age and ORs for neck pain are shown in Figure 4. There was a significant correlation between increasing age and higher OR for neck pain (coefficient = 0.051, P < 0.001). These results suggest that increasing age is correlated with a stronger association between neck pain and smartphone overuse.

Risk of bias assessment

The results of the risk of bias assessment for the included studies are presented in Table 4. Across the studies, the NOS scores varied between 4 and 6, suggesting a moderate overall quality.

DISCUSSION

This systematic review and meta-analysis demonstrated that individuals with smartphone overuse are over 2-fold more likely to have neck pain, compared to those without smartphone overuse. Notably, the meta-regression also found a correlation between increasing age and stronger

association between smartphone overuse and neck pain. These findings highlight the importance of taking effective action in addressing smartphone overuse as a physical health concern, especially in light of the widespread use of smartphones in modern society.

With the rapid increase in the use of smartphones globally, it has become clear that some individuals develop physical and/or psychological problems associated with their use. For example, a search of PubMed for “smartphone addiction” produces 3,500 results, a search for “smartphone musculoskeletal” over 300 results, and a search for “text neck”, also referred to as text neck syndrome, produces 1,500 results. Our study, aligning with existing research, reveals a clear link between neck pain and excessive smartphone use. Although this connection has been documented in other studies, there remains a critique regarding the lack of adjustment for potential confounders in these analyses. For example, a recent study by Maayah et al. [19] used an online questionnaire asking university students about smartphone usage and neck pain. A total of 867 questionnaires were completed, and the analysis showed that time spent using the device was a significant predictor of neck or shoulder pain, and a history of neck or shoulder pain was a significant predictor of neck pain severity and was also a significant predictor of the duration of neck pain. Similarly, the study by Namwongsa et al. [20] found that the ideal neck flexion angle for smartphone usage lies between 0° and 15°, as determined by the activity levels of the cervical erector spinae and upper trapezius muscles. However, it was observed that the majority of users do not maintain their necks within this optimal range, and angles outside of it are linked to increased muscle activity. This excessive strain could potentially result in musculoskeletal disorders over time.

The results of the present meta-analysis contribute to the growing body of evidence on “text neck syndrome”, a condition marked by neck and upper body pain due to excessive smartphone use. This syndrome, resulting from prolonged strain on the cervical spine, highlights the physical impacts of our digital habits and underscores the importance of increasing awareness and adopting preventive strategies to reduce the associated risks [21]. The condition also potentially leads to developmental,

medical psychological, and social complications. Biomechanical study has shown that prolonged use of hand-held mobile devices results in adverse anatomical and biomechanical changes in the cervical and thoracic spine, muscular imbalances, and postural compensations [22]. Together, these changes result in muscular overuse and fatigue, eventually leading to pain. Proper posture during the use of such devices includes holding the device close to eye level and with a line of sight perpendicular to the surface of the device, standing or sitting and holding the device, texting with both hands, as well as using devices with larger screens. A recent systematic review of text neck syndrome defined non-specific/chronic musculoskeletal disorder in the neck, head, or low back as “upper disorders” [23]. Ten studies met the inclusion criteria and the overall results showed a strong association between upper disorders and mood disturbance, anxiety, depression, stress, alexithymia, and low social support.

Problems associated excessive smart phone use occur in both adults and younger populations, and have been studied in both. Abdullah et al. [24] studied smartphone addiction/overuse and hand and wrist complaints in 3,057 persons 18 to 65 years old. The prevalence of smartphone addiction was about 29%, and increased usage was associated with more wrist and hand musculoskeletal complaints. A retrospective study of musculoskeletal symptoms among adult smartphone users found that 60% of participants reported musculoskeletal symptoms during or after device use, and in 65% symptoms began within the first 30 minutes of use [25]. Notably, neck pain was the most common symptom.

Furthermore, although we did not assess smartphone addiction/overuse and other health condition, the impact of smartphone overuse transcends physical health, correlating with a range of mental health conditions, including depression and anxiety. A study of Korean adults found that smartphone overuse was significantly associated with depression, anxiety disorder, alcohol dependence and nicotine dependence [26]. A previous systematic review of smartphone addiction and health problems in adults also concluded that addition was associated with depression and

anxiety disorder, and adverse physical health outcomes such as pain [27].

Our meta-regression result suggests that the association between smartphone overuse is stronger when age advances. The observed stronger association can be explained by factors such as decreased physical resilience along with aging, pre-existing musculoskeletal conditions, and age-related lifestyle changes leading to more sedentary behavior. Nevertheless, the implications of smartphone overuse extend across all age groups, affecting both adults and younger populations [28-33]. Studies by Correia et al. [30] and Mustafaoglu et al. [33] both reported a relation between smartphone addiction and musculoskeletal pain in university students. Correia reported the prevalence of neck and upper limb pain was 34%, and Mustafaoglu reported the body pats with the higher prevalence of pain were the upper back (70%), neck (66%0, and wrists/hands (69%). Excessive smartphone use in adolescents and university students has been associated with anxiety, over sensitivity, poor self-reported health level, sleep disorders, poor academic performance, and reduced social interaction and self-esteem [28, 29].

Collectively, these findings urge the need for timely action to address the clinical and public health challenges posed by smartphone overuse. There's a clear necessity for educational initiatives that encourage proper device use and ergonomics, as well as healthcare screening for related musculoskeletal and mental health issues. Public health campaigns should also focus on raising awareness about the dangers of excessive smartphone use and promoting healthier digital habits. Addressing these issues is crucial for mitigating adverse health outcomes and fostering a balanced use of technology.

Strength and limitations

The current meta-analysis excels in comprehensively integrating the latest evidence on the relation between smartphone overuse and neck pain, leveraging a substantial sample size of over 10,000 participants. In addition, the meta-analysis was conducted using both crude and adjusted ORs. However, several limitations should be noted. First, all included studies were of retrospective

in design, which possibly introduced selection bias and thus affected reliability of the analysis. The overall quality of the included studies was only moderate, which also may have affected the reliability of the analysis. High heterogeneity was detected among the studies, and the precise definition of smartphone overuse varied among the studies, potentially contributing to the observed heterogeneity. This underscores the importance of conducting future longitudinal studies to establish a more definitive understanding of the associations found.

Conclusions

This systematic review and meta-analysis showed that smartphone overuse significantly increases neck pain risk, with the likelihood escalating as individuals age. These findings underscore the need to address smartphone overuse as a crucial health issue.

Conflict of interest: The authors declare no conflict of interest.

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FIGURE LEGENDS

Figure 1. PRISMA flow diagram of study selection

The number of search hits corresponding to each step of the systematic literature search, qualitative review, and quantitative analysis are shown. The reasons for search hit exclusion are described.

Figure 2. Meta-analysis using crude odds ratios for the association between smartphone overuse and neck pain

Figure 3. Meta-analysis using adjusted odds ratios for the association between smartphone overuse and neck pain

Figure 4. Random-effects univariate meta-regression between age and odds ratios for neck pain

Table 1. Characteristics of the included studies

Study	Country	Study design	Number of patients	Age, mean	Male, %	Definition of smartphone overuse
Puntumetakul R (2022)	Thailand	Retrospective	237	20.5	59.9	≥ 9.15 h/day
Sirajudeen MS (2022)	Saudi Arabia	Retrospective	313	22.6	45.7	≥ 5 h/day
Wah SW (2022)	Thailand	Retrospective	81	19.9	12.4	≥ 4 h/day
Ayhualem S (2021)	Ethiopia	Retrospective	808	21.9	57.9	> 6 h/day
Correia IMT (2021)	Brazil	Retrospective	582	27.4	28.4	NA
Derakhshanrad N (2021)	Iran	Retrospective	1602	42.9	35.9	SAS-SV: Male ≥ 31; Female ≥ 33
Gustafsson E (2016)	Sweden	Retrospective	7092	22.0	38.9	> 20 SMS/day

SAS-SV, smartphone addiction scale; SMS, short message service.

Table 2. Sensitivity analyses for the pooled crude OR on the association between smartphone overuse and neck pain

Study left out	Pooled crude OR (95% CI)	P-value	tau^2	tau	I^2
Puntumetakul R (2022)	3.05 (1.72-5.41)	<0.001	0.435	0.660	93.1%
Sirajudeen MS (2022)	3.05 (1.71-5.42)	<0.001	0.439	0.663	93.1%
Wah SW (2022)	2.37 (1.59-3.53)	<0.001	0.204	0.451	92.1%
Ayhualem S (2021)*	2.98 (1.64-5.39)	<0.001	0.469	0.685	93.2%
Derakhshanrad N (2021)	2.07 (1.59-2.70)	<0.001	0.048	0.219	73.8%
Gustafsson E (2016)_Male**	2.97 (1.63-5.42)	<0.001	0.478	0.692	93.2%
Gustafsson E (2016)_Female**	3.18 (1.86-5.43)	<0.001	0.363	0.602	88.7%
Pooled estimate when no study left out	2.81 (1.71-4.59)	<0.001	0.365	0.604	91.9%

* Multi-category comparison in the model, with the reference group < 3 h/day.

** Multi-category comparison in the model, with the reference group SMS: 0-5.

OR, odds ratio; CI, confidence interval.

Table 3. Sensitivity analyses for the adjusted OR on the association between smartphone overuse and neck pain

Study left out	Pooled adjusted OR (95% CI)	P-value	tau^2	tau	I^2
Puntumetakul R (2022)	2.46 (1.39-4.33)	0.002	0.493	0.702	95.2%
Sirajudeen MS (2022)	2.52 (1.47-4.32)	0.001	0.448	0.670	95.2%
Wah SW (2022)	2.01 (1.32-3.08)	0.001	0.274	0.523	94.7%
Ayhualem S (2021)*	2.31 (1.32-4.06)	0.004	0.486	0.697	95.0%
Correia IMT (2021)	2.66 (1.61-4.41)	<0.001	0.363	0.603	90.0%
Derakhshanrad N (2021)	1.82 (1.29-2.57)	0.001	0.140	0.374	81.8%
Gustafsson E (2016)_Male**	2.44 (1.37-4.34)	0.003	0.505	0.711	95.1%
Gustafsson E (2016)_Female**	2.57 (1.48-4.47)	0.001	0.453	0.673	95.2%
Pooled estimate when no study left out	2.34 (1.44-3.82)	0.001	0.407	0.638	94.4%

* Multi-category comparison in the model, with the reference group < 3 h/day.

** Multi-category comparison in the model, with the reference group SMS: 0-5.

OR, odds ratio; CI, confidence interval.

Table 4. Quality assessment of included studies based on the NOS

Study	Selection (4)	Comparability (2)	Outcome (3)	Total NOS score
Wah SW 2022	★★★★	★	★	6/9
Sirajudeen MS 2022	★★	★	★★	5/9
Puntumetakul R 2022	★★★	★	★	5/9
Correia IMT 2021	★★	★	★	4/9
Ayhualem S 2021	★★★★	★	★	6/9
Derakhshanrad N 2021	★★★	★	★	5/9
Gustafsson E 2016	★★★	★	★★	6/9

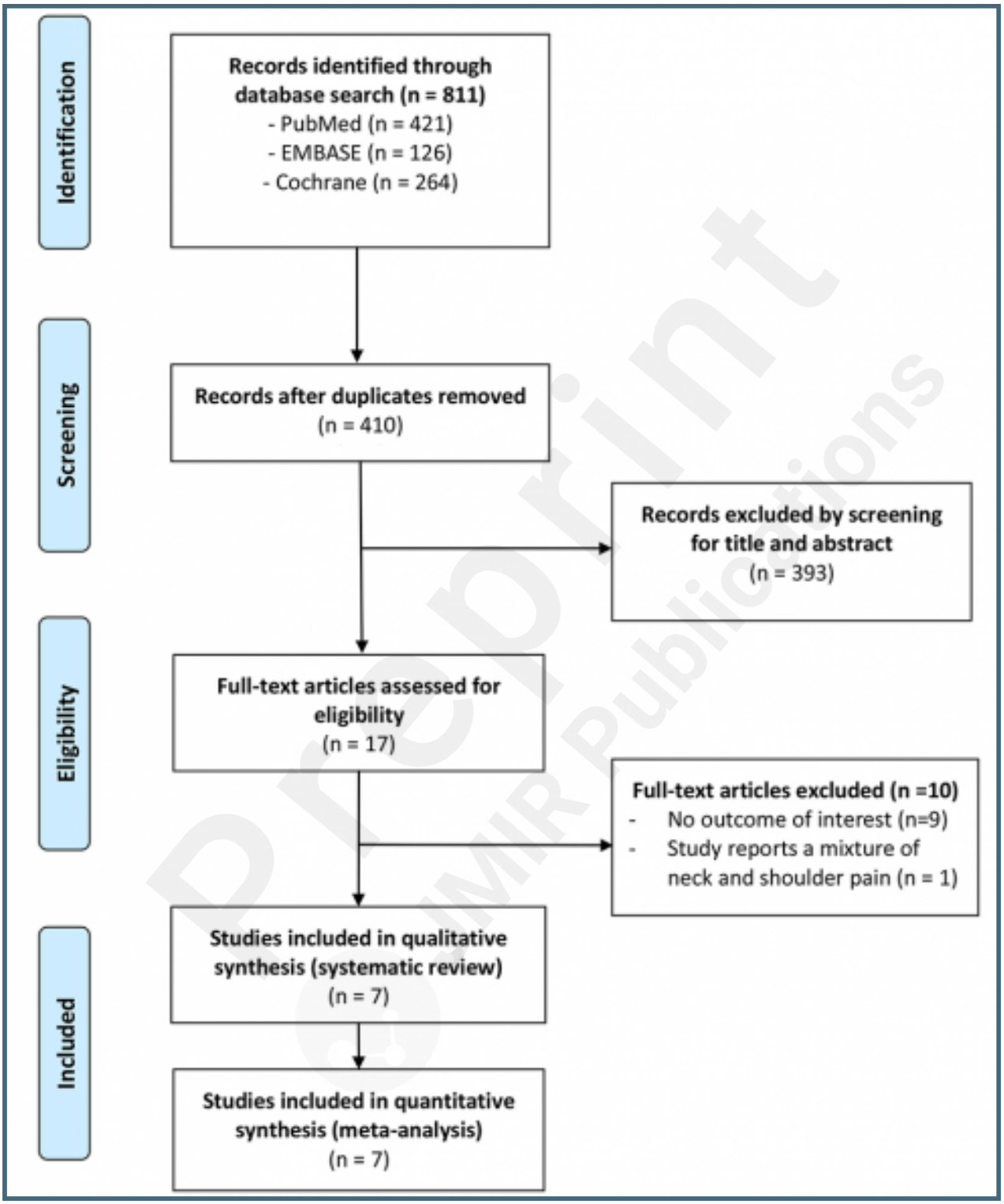
NOS, Newcastle-Ottawa Scale (NOS).

A star system was employed to conduct a semi-quantitative evaluation of study quality. Each numbered item within the selection and e xposcure c atergories a m ouldo s ewceivec aaximum f a m f onet s tar, T s hile on for t Nhe s OSf 0 tpaf9ss Wrocm so a tahrs. ei t aategorized7 s o m tudnies s i tigh-quality received 4 to 6 stars, and poor-quality if they garnered fewer than 4 stars.

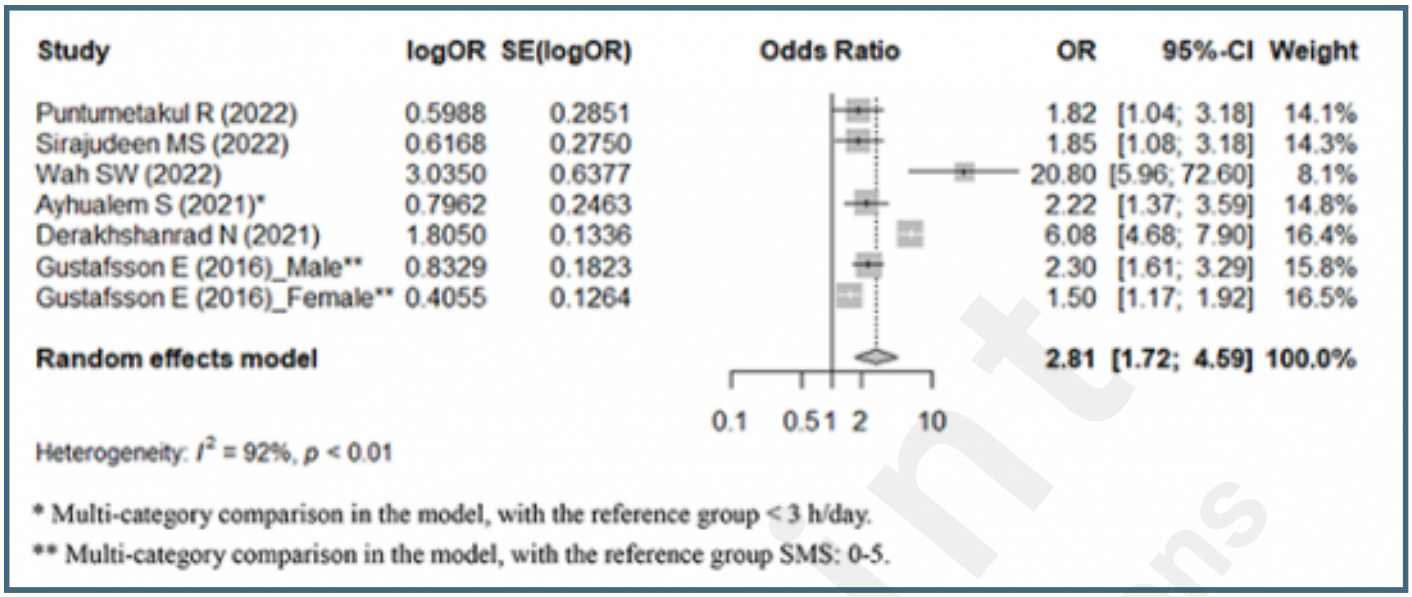
Supplementary Files

Figures

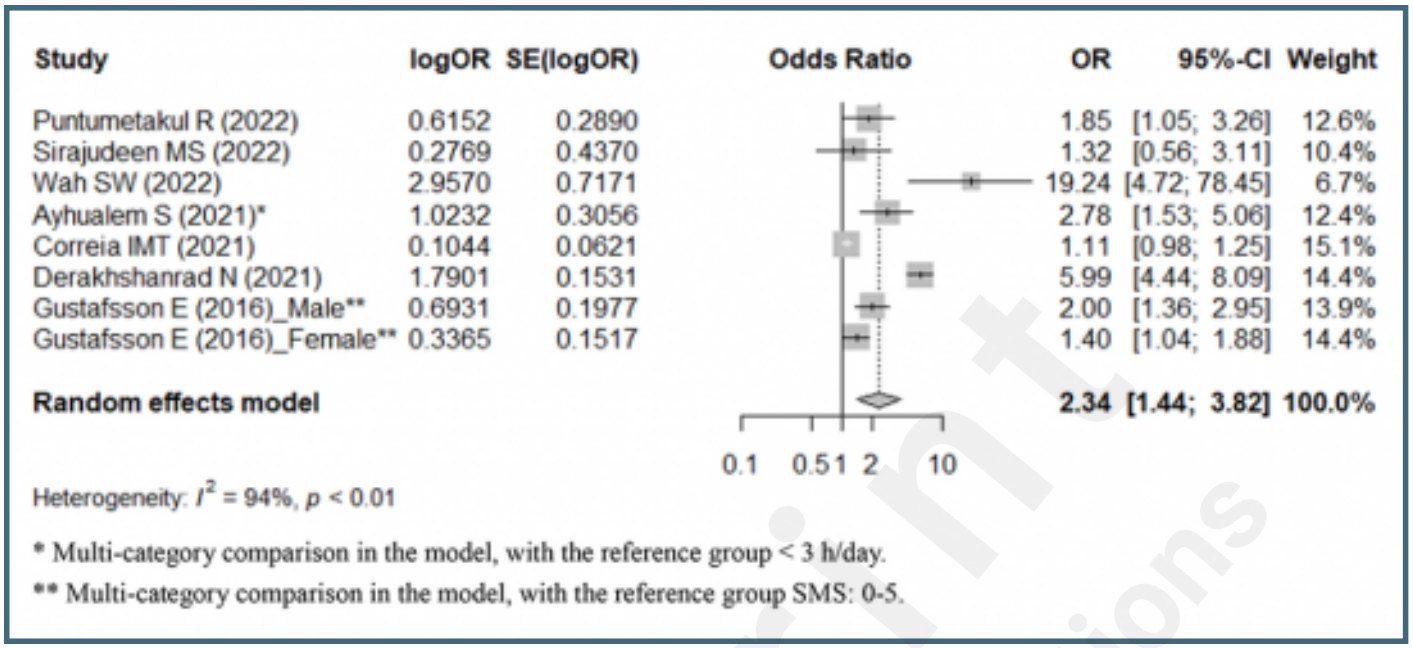
The number of search hits corresponding to each step of the systematic literature search, qualitative review, and quantitative analysis are shown. The reasons for search hit exclusion are described.



Meta-analysis using crude odds ratios for the association between smartphone overuse and neck pain.



Meta-analysis using adjusted odds ratios for the association between smartphone overuse and neck pain.



Random-effects univariate meta-regression between age and odds ratios for neck pain.