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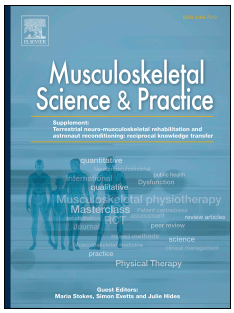

A systematic review of musculoskeletal disorders related to mobile phone usage

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TITLE PAGE

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A Systematic Review of Musculoskeletal Complaints, Symptoms, and Pathologies Related to Mobile Phone Usage

Abstract

BACKGROUND: In the past decade, mobile phone usage rates have increased and there have been concerns that overuse of mobile phones may contribute to various musculoskeletal (MSK) problems.

OBJECTIVES: The aim of the present study was to systematically review available literature on the prevalence of MSK complaints, symptoms, and pathologies associated with mobile phone use.

STUDY DESIGN: Systematic review.

METHOD: In this systematic review, *Medline (Pubmed), Wiley, WOS*, and *EMBASE* electronic databases were searched for studies published in English between January 1, 2000 and March 25, 2019 using the following key terms: 'mobile phone', 'smartphone', 'musculoskeletal pain', 'pain', 'musculoskeletal symptoms', and 'musculoskeletal pathology'.

RESULTS: The search strategy identified 196 papers, of which 18 met the inclusion criteria. Among the studies included in the systematic review, five were high quality, twelve were of acceptable quality, and one was of low quality. The review demonstrated that the prevalence of MSK complaints among mobile phone users ranged 8.2%-89.9%, and that neck and upper back complaints had the highest prevalence rates ranging from 55.8%-89.9%. The most common MSK symptom associated with mobile phone use was pain. Myofascial pain syndrome, fibromyalgia, thoracic outlet syndrome, tendonitis, and De Quervain's syndrome were the most commonly associated MSK pathologies.

CONCLUSION: The evidence concerning MSK complaints among mobile phone is somewhat limited because the data were obtained from cross-sectional and case-control study results. Consequently, there is need for higher quality and prospective studies to better understand the relationship between mobile phone use and MSK symptoms and pathologies.

KEYWORDS

Mobile phone use, musculoskeletal symptoms, musculoskeletal pain syndromes, excessive phone use.

A Systematic Review of Musculoskeletal Complaints, Symptoms, and Pathologies Related to Mobile Phone Usage

1. Introduction

Mobile phones are commonly used devices for communication and entertainment. Before the first mobile phone was launched in 1983, among countries that constituted more than half of the world's population, there was a housephone for one in every 100 individuals, and two-thirds of the world's population had no access to a phone[1]. Once mobile phones became Wi-Fi enabled and allowed for non-communication activities to be carried out, mobile phones became more popularly known as 'smartphones'. Today, mobile phones are available for every budget so these devices can be easily obtained by individuals of all ages in society and are widely used[2,3].

As a result of the widespread use of mobile phones, many individuals spend a lot of time on their mobile devices[4]. Among individuals who use mobile phones excessively, symptoms of MSK system can occur as well as other problems including deteriorated social relationships, depression, low sleep quality, and behavioral disorders[5-7]. Generally, among individuals using mobile devices, the neck is constantly flexed and elbows are unsupported. This can cause an excessive static load on the neck and shoulder areas[8]. Furthermore, the device is typically held with one hand and controlled using one finger. These repetitive movements may cause micro-traumas in MSK system and as a result of this, chronic pain and paresthesia may occur in the neck and upper extremity[6,9]. Consequently, it is necessary to determine whether the physical changes that occur during the use of mobile phones, especially during the repetitive movement of the joints, is a risk factor that may lead to MSK disorders[10]. Despite the rapid increase in worldwide prevalence of mobile phone use, the number of studies investigating the relationship with mobile phone use and the MSK system problems appears to be limited[5,11,12].

Four systematic reviews have been conducted examining the association of technological device usage on the MSK complaints of the neck and upper extremity[1,4,13,14]. Xie et al.[4] evaluated the prevalence and risk factors for MSK complaints associated with mobile handheld devices and found that the prevalence of MSK complaints among mobile device users ranged from 1.0%-67.8% and that neck complaints had the highest prevalence rates ranging from 17.3%-67.8%. In another systematic review, Toh et al.[13] systematically reviewed the literature on MSK symptoms and exposures associated with mobile touch-screen devices. They concluded that there was limited evidence that mobile touch-screen device use,

or specific aspects of its use (i.e., amount of usage, features, and positions) were associated with MSK symptoms. A recent systematic review conducted by Eitivipart et al.[14] reported that the use of smartphones may contribute to the occurrence of clinical and subclinical MSK changes as well as associated factors in the head-neck, shoulder-arm, and hand-thumb area. Although there are systematic reviews examining the relationship with mobile handheld devices and MSK symptoms and exposure, to the best of the present authors' knowledge there has been no systematic review exclusively evaluating the association between mobile phone use on MSK complaints, symptoms, and pathologies.

In contrast to previous systematic reviews, the present review adds to the current literature by not only examining the prevalence of MSK complaints and symptoms associated with mobile phone use, but also examining the MSK pathologies associated with mobile phone use. Therefore, the aim of present study was to systematically review the empirical literature concerning the prevalence of MSK complaints, symptoms, and pathologies associated with mobile phone use.

2. Methods

2.1 Search strategy

The study was conducted in accordance with guidelines based on evidence-based criteria in the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement[15]. The study protocol was designed a priori according to PRISMA guidelines. The following databases were searched: Medline (PubMed), Wiley Online Library, Web of Science (WOS), and EMBASE. Papers in English (the language spoken by the review authors) which were published between 1 January 2000 and 25 March 2019 were searched by using keywords. Key search terms included 'mobile phone', 'smartphone', 'musculoskeletal pain', 'pain', 'musculoskeletal symptoms', and 'musculoskeletal pathology'. The specific search strategy is outlined in Appendix 1. Initially, two of the authors independently screened all titles, abstracts, and full texts for eligibility. Disagreement for inclusion was resolved through a consensus meeting or consulting one of the other co-authors.

2.2 Eligibility criteria

Studies were selected according to the following inclusion criteria: (i) empirical studies concerning the incidence or prevalence of musculoskeletal system disorders resulting from mobile phone use; (ii) empirical studies that were published in peer-reviewed English-language journals; and (iii) cross-sectional, and observational studies. The exclusion criteria

were as follows: (i) studies that used mobile phones as an intervention/evaluation tool; and (ii) review papers, conference papers, and case reports.

2.3 Risk of bias

Two quality assessment tools were used to assess the risk of bias of cross-sectional and case-control studies. For cross-sectional studies, risk of bias was assessed using a risk of bias tool developed for evaluating the risk of bias in prevalence studies[16]. Two Scottish Intercollegiate Guidelines Network (SIGN) checklists were used to assess the risk of bias of case-control and prospective cohort studies[17]. There is no standard checklist to assess the risk of bias of case-control and prospective cohort studies, so the SIGN checklist was used which has been reported to be the most appropriate, valid, and useful tool available[18]. The overall risk of bias of each included study was assessed as being either high quality ([++] low risk of bias), acceptable ([+] moderate risk of bias) or low quality ([-] high risk of bias)[16,17].

Each item in the list comprised different categories (i.e., purpose of the study, outcome measurements, and data presentation), and the study was rated as “positive” (+), “negative” (-) or “can’t say” (?). For each study, the overall quality score was calculated by counting the number of categories rated positively for reliability or accuracy. According to these ratings, the studies were categorized as high, acceptable, or low quality. A high-quality study was defined as a study that scored positively on at least 50% of the validity or precision items of the relevant study quality list, implying that a minimum score required for a classification as a high-quality study was 7 for cross-sectional studies, and 8 for cohort studies. The overall risk of bias was rated based on the assessment of the judgment that the raters gave to each item in the quality assessment tools.

2.4 Data extraction

In the present review, relevant data from included studies was extracted as follows: author, publication year, country, study design, age of participants, number and characteristics of participants, purpose of the studies, evaluation methods, prevalence of MSK complaints, MSK symptoms, and MSK pathologies related to mobile phone use.

2.5 Strength of evidence

For further analysis, each study’s findings the following were examined: statistical analyses and results in relation to prevalence rates of musculoskeletal complaints, symptoms,

and pathologies, and relevant results of risk factors assessed, including the values of correlation coefficients (r), frequencies (%), offs ratios, and/or *p*-values[19,20].

The GRADE approach was used to assess the quality of the evidence across studies. Careful consideration was given to the general limitations of observational studies, as suggested by Guyatt et al.[21]. According to the GRADE framework, which categorizes evidence quality into four groups evidence quality ratings ('high', 'moderate', 'low', or 'very low'), starting at high for randomized studies and low for all other experimental and observational studies. The quality of evidence is downgraded if there are limitations across studies because of serious risk of bias, inconsistency of relative treatment effects, indirectness, imprecision, or other factors.

3. Results

A total of 179 papers were retrieved from the following electronic databases: *Medline/PubMed* (n=73), *WOS* (n=46), *EMBASE* (n=45), and *Wiley* (n=15). In addition, 17 studies were identified by hand searching of the included papers' reference lists. Sixty-six duplications were identified and removed. In addition, 28 studies were excluded because full-texts were not available. Studies that were inappropriate for the purpose of the study (n=73), reviews (n=4), and non-English papers (n=7) were also excluded. Consequently, 196 papers were screened for eligibility and 18 were included in the review for final evaluation. Details of the eligibility and search process are demonstrated in Figure 1.

3.1 Study selection

A total of 196 papers were screened for eligibility and 18 studies were included for final review and evaluation (Figure 1). Fifteen of the selected studies were cross-sectional studies[3,5,6,22-33], two were case-control studies[10,34], and one was a prospective cohort study[12]. The selected studies were examined in terms of study quality, purpose of the studies, study characteristics, outcome measures, and main results.

3.2 Risk of bias

Among the studies included in the systematic review, five of the studies were of high quality[5,22,23,27,30], twelve were of acceptable quality[3,6,10,12,24-26,28,29,31,32,34], and one study was of low quality[33] (Tables 2-3). Selection bias was identified in most of the studies (Tables 2-3). Moreover, there was a lack of an acceptable definition of participants and information on the

reliability and validity of the assessment tools used in a majority of cross-sectional studies was generally lacking[3,5,6,24-26,28,29,31,33].

3.3 Quality of evidence

Overall, the quality of evidence ranged from low to very low. The most common reasons for downgrading the quality of evidence were (i) serious risk of bias, which reduces confidence in the observed effects, and (ii) indirectness of the interventions and comparisons being assessed. Common sources of bias included reasons for and/or unknown validity/reliability of outcome measures. For specific details regarding the quality of evidence, see Table 4.

3.4 Purpose of the studies

The studies included in the systematic review primarily investigated MSK problems (e.g., pain, numbness, tiredness) and physiological problems (e.g., fatigue, sleep disturbance, and restlessness) among mobile phone users (Table 1).

3.5 Sample characteristics

The age of participants ranged from 18 to 65 years. Three studies used college/high school students[23,26,30], five studies used university students[24,25,27,33,34], eight studies used general populations[3,6,10,12,28,29,31,32], and two studies used mixed populations such as students and staff[5,22].

3.6 Assessment methods

In a number of studies[22-25,30,31,34], standardized scales and questionnaires were used mostly to evaluate depression level, pain severity, prevalence of MSK symptoms, upper extremity functions, physical activity levels, and duration and frequency of technology use. For instance, Shan et al.[30] used the Epidemiological Research Center Depression Scale to assess participants' depression levels. Bueno et al.[22], Ali et al.[24] and Sharan et al.[32] used the Visual Analogue Scale to assess participants' pain severity. Eapen et al.[34] and Balakrishnan et al.[25] used Numerical Pain Rate Scale and Visual Analogue Scale to assess participants' pain severity, in addition to the Disabilities of the Arm, Shoulder and Hand Score to assess upper extremity functioning. Bueno et al.[22] and Toh et al.[23] used the Nordic Musculoskeletal Questionnaire to assess MSK symptoms. Toh et al.[23] used the Physical Activity Questionnaire for Adolescents to measure physical activity levels and the Technology Use Questionnaire was used for assess the duration and frequency of technology use. In the 14 of the

studies[3,5,6,12,24-34], the use of mobile phones and its correlation with pain, MSK, and general health status were assessed using non-validated (non-standard) questions and questionnaires.

In addition to the scales and questionnaires, more reliable tools (devices and systems) were used to obtain more objective results in the studies reviewed. Kim et al.[10], used a surface EMG (electromyography) system to assess the level of fatigue of participants' neck and upper extremity muscles during mobile phone use. In addition, an algometer was used to assess participants' pressure pain thresholds in the upper trapezius muscle area. Eapen et al.[34], used the Jamar Hydraulic Pinch Gauge to assess the lateral grip strength of the thumb and index finger, as well as ultrasound imaging to identify the presence of acute or degenerative changes in the thumb muscle tendons. Ali et al.[24] and Eapen et al.[34] assessed De Quervain's tenosynovitis using the Finkelstein Test. When the evaluation methods used in the studies were examined, findings suggested that there were limited standardized scales evaluating both the symptoms of MSK system and use of the mobile phone.

3.7 Prevelance of musculoskeletal complaints

Participants reported pain in at least one area of the body. Nine studies[6,12,22,23,28-30,33,34] reported that particpants had pain discomfort and/or numbness in their neck and upper/lower back ranging from 55.8% to 89.9%. In five studies[5,24,26,30,34], the range of symptoms in thumb was between 19% and 53%. Eight studies[6,23,25,28-30,33,34] reported that the participants had shoulder pain ranging from 37.8% to 71.6%. Three studies[6,29,33] reported that the participants had pain in in their waist and hip (8.2%-62%), four studies[26,28,30,34] reported elbow pain (14.1%-15%), and five studies[12,22,23,25,30] reported hand and wrist pain (13%-32%), and three studies[6,28,29] reported feet complaints (23.8%-57%).

3.8 Musculoskeletal symptoms

The symptoms reported in the studies included in the present review were pain, fatigue, stiffness, weakness, and sensorial problems such as burning, numbness and tingling. Pain was the most reported symptom ranging from 18.8% to 89% in the studies[3,5,10,26,27,32,34]. The other most reported symptom was fatigue especially in their upper extremities[3,10,26,27]. Moreover, stiffness[26,32], burning, and numbness[6,28] were the other most reported MSK symptoms.

3.9 Musculoskeletal system pathologies

In the studies reviewed, a variety of MSK pathologies were reported among individuals using mobile phones. The most reported pathology in the studies was tendinitis of upper extremity muscles (2.9%-70.37%)[24,26,31,32,34]. The next most reported pathology was myofascial pain and fibromyalgia syndromes (10%-69%)[31,32]. Additionally, thoracic outlet syndrome (51.85%) was another pathology reported in one of the studies[28].

4. Discussion

To the best of the authors' knowledge, the present review is the first to systematically investigate the current literature by not only examining the prevalence of MSK complaints and symptoms associated with mobile phone use, but also examining the MSK pathologies associated with mobile phone use. Although heterogeneity of studies prevented meta-analysis, the review showed that the body areas most associated with mobile phone use were thumbs, hands and wrists, elbows, shoulders, neck, upper backs, waists, hips and feet. The most common MSK symptoms were pain, tenderness, numbness, stiffness, and fatigue. In addition, the most common MSK pathologies were tendonitis in the hand and wrist muscles, myofascial pain syndrome, thoracic outlet syndrome, and De Quervain's syndrome.

All but three[23,24,31] of the included studies' assessments were made by using self-report questionnaires, or questionnaires developed by researchers without any type of psychometric testing. Only eight studies[22-25,30,32] used validated and reliable assessment methods and only three studies[24,31,32] included physical examination. When the two case-control studies[10,34] were analyzed, surface EMG was used to assess muscle fatigue and activity, digital pressure algometer to assess pain pressure threshold, Jamar Hydraulic Pinch Gauge device to assess grip strength, and ultrasound to investigate changes in anatomical structures. Cross-sectional studies are unable to determine the causal relationship between mobile phone use and MSK symptoms. In order to get more robust results, higher quality and prospective studies are needed.

It was also noted that mobile phone usage was associated with MSK problems in many regions of the body. The reported frequency of MSK complaints in the reviewed studies was 19%-53% for thumbs, 13%-32% for hands and wrists, 14.1%-15% for elbows, 37.8%-71.6% for shoulders, 55.8%-89.9% for neck and upper back, and 8.2%-62% for waist and hips. In systematic reviews, the prevalence rates of MSK pain symptoms in the general population were reported to be 2.3%-41% in upper extremities, and 6.7%-66.7% in the shoulder[35,36]. However, it should be noted that high prevalence MSK rates are correlated with increased age (>65 years), and self-reported pain complaints (which are usually not based on physical

examination) were typically reported among individuals who have jobs that require repetitive motion such as textile and industrial workers. In another systematic review of the prevalence rates of neck pain symptoms, the symptom frequencies were found to be between 22%-52% in Scandinavian countries, 13%-39% in Europe, and 0%-58% in Asia[37]. In a systematic review investigating occupational MSK symptoms among health professionals, it was reported that neck, shoulder, and upper back pain varied between 35% and 45%[38]. The onset of MSK problems is believed to be triggered by specific factors such as frequent repetitive movements of a particular body part, occupational factors, specific positions such as prolonged standing, sitting, or as a consequence of the upper extremity unsupported mobile phone usage. Therefore, mobile phone users have more frequent upper extremity related MSK problems than the general population apart those working in jobs that require repetitive upper extremity movements.

In the literature investigating the relationship between mobile phone use and MSK problems, the reported prevalence of chronic MSK pain varied from 4.2%-13.3%[39]. Other studies examining MSK pain among other target populations have reported a variety of findings. King et al.[40] reported that MSK related pain varied from 4%-40% in the young population. It was also reported that the prevalence of weekly pain was 8%-32%, and monthly pain was 39% among young individuals[40]. In a study conducted among adolescents playing videogames, the prevalence of MSK pain symptoms was 65.1%, being more prevalent in the thoracolumbar spine (46.9%), followed by pain in the upper limbs (20%). Increased cervical and lumbar pain among adolescents has been attributed to excessive use of electronic devices[41]. A systematic review by Toh et al.[13] reported that the percentage of pain in the neck and/or shoulder region varied between 26.3%-60%[13] among mobile touch-screen device users. In another systematic review investigating the associations of mobile touch-screen device use with MSK symptoms and exposure, it was reported that the frequency of MSK symptoms varied from 1%-67.8%, and the most frequent body part experiencing pain was the neck region with 17.3%-67.8%[4].

All of the studies examined in the present study reported that participants had symptoms of MSK system in at least one region of their body and that the most common symptom was pain. However, other MSK symptoms such as tenderness, burning, numbness, tingling, fatigue, stiffness and muscle weakness were also experienced. It has been suggested that the wide prevalence range originates from the broad definition (definitions of MSK system problems and anatomical areas) used to describe cases[4]. This may also explain the wide-ranging prevalence rates of MSK complaints in the present systematic review.

When pathologies associated with mobile phone use were evaluated, the prime pathologies were myofascial pain syndrome (69%-70.37%), fibromyalgia (10%-24.9%), thoracic outlet syndrome (49%-51.8%), tendonitis in upper extremity muscles (5.7%-14.8%), and De Quervain's syndrome (2.9%-50%). One empirical study reported the prevelance of fibromyalgia was 2.7% worldwide. It has also been reported that the prevelance of fibromyalgia was 3.1% in North and South America, 2.5% in Europe, and 1.7% in Asia[42]. A cross-sectional study[43] reported that the prevelance of MSK syndrome among young people who play videogames was 15.6%. The same study reported 5% with myofascial pain syndrome, 2% with tendonitis, and 1% with fibromyalgia[43]. Queiroz et al.[44] reported that the prevelance of MSK pain syndrome was 33% among adolescents. It is also known that repeated and sustained movement plays a role in the etiology of upper extremity pathologies[45]. Therefore, it could be that repeated and continuous movements and excessive use of hand muscles during mobile phone use cause these potential pathologies. In contemporary societies, mobile phones have become a necessity rather than a luxury. It is inevitable that pathologies associated with use of mobile phones will increase in the future, alongside increased MSK complaints and symptoms.

4.1 Limitations

There are a number of limitations in the present systematic review to consider when interpreting the findings. One of them is the non-inclusion of non-English written studies. This may have introduced bias and there is always the possibility that some studies were missed even though an extensive literature search was performed. Secondly, there are insufficient data to draw firm conclusions about relationship between mobile phone usage and MSK symptoms due to there can be many other factors including biopsychosocial factors, that negatively effect the MSK system. Thirdly, was the lack of validated and reliable assessment tools in the majority of the studies. Another methodological limitation is that 28 studies were not included because the full text was not available online. Therefore, it is possible that other good quality studies were not included in this review, which may have introduced selection bias. Finally, the study was not pre-registered prior to starting the review, which is now considered best practice. This was not routine practice in the research team at that time, which limits the transparency of the present study.

5. Conclusion

Mobile phone use has been associated with MSK complaints in various the parts of the body including thumbs, hands, wrists, elbows, shoulder, neck, upper back, lower back, and hip. The most common MSK symptom is pain. Other MSK symptoms include tenderness, burning, numbness, tingling, fatigue, stiffness, and muscle weakness. In addition, myofascial pain syndrome, fibromyalgia, thoracic outlet syndrome, tendonitis in the upper extremity muscles, and De Quervain's syndrome are the most common MSK pathologies among mobile phone users. However, the evidence is somewhat limited because these data were obtained from cross-sectional and case-control study results, which were generally not of high quality. There is a need for higher quality and prospective studies with less risk bias to help better delineate the relationship between mobile phone use and MSK symptoms and pathologies.

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Figure Captions

Figure 1 - PRISMA flow diagram demonstrating flow of studies through the review

Appendix

MEDLINE Search Strategy

For the Medline database the following combination was used:

“ Mobile phone/ OR Smartphone/OR ("smart-phone*" OR "smartphone" OR “mobile phone*”) [tiab]” AND “ Musculoskeletal injury OR Musculoskeletal pain/ OR Pain [tiab]” AND “Musculoskeletal symptom/ OR (“symptom*” OR “pain”) [tiab]” AND “Musculoskeletal pathology/ OR (“upper extremity pathology*” OR “pathology” OR “Musculoskeletal pathology*”) [tiab]” in clinical trials.

Table 1. Symptoms and pathologies in studies examining musculoskeletal problems and mobile phone usage

Author, year, country, study design	Sample characteristics (n)	Purpose of the studies	Evaluation methods	Main findings
Eapen et al. (2010) India Cross-sectional	College students between the ages of 18-19 (n=1500)	To determine the prevalence of cumulative traumatic impairment of the upper extremity in mobile phone users	- Nonstandard questionnaire	Cumulative traumatic disorder of the upper extremity was found in 18.5% of the participants. 61.7% had pain, 44.3% had tiredness, 16.6% had stiffness and 15.8% had weakness in their upper extremities. 54.5% reported that the symptoms lasted less than five minutes. 23.3% were influenced by daily activities such as writing articles and holding small objects. Symptoms were mostly seen in the thumb (53%), elbow (15%), and wrist (13%)
Berolo et al. (2011) Canada Cross-sectional	University students, staff and faculty members (n=137)	To determine the distribution of symptoms of upper extremity, upper back and neck musculoskeletal symptoms among college students, staff and instructors, and the relationship between musculoskeletal symptoms and mobile device use	- Nonstandard questionnaire	Any severe pain in at least one part of the body in 84% of participants. The most common painful parts of the body were the right and left hand thumb. 32% of the participants had pain in right elbow and forearm, 27% in left elbow and forearm, 52% in right shoulder, 46% in left shoulder, 68% in neck, and 62% in upper back. There was a significant relationship between total time spent with mobile phone during the day and pain on the left shoulder, right shoulder, and neck. A significant correlation was found between the pain scores and the duration of mobile device use during the day in individuals who reported that there was moderate to severe pain in the right shoulder, left shoulder, right shoulder, and neck.
Kim et al. (2012) Korea Case-control	Young adults between the ages of 20-27 years; using telephone (n=15), using computer (n=15) and not using both technological devices (n=10)	To determine the effect of smartphone use on the upper extremity and whether this effect differs between smartphone use and computer use	- Digital Pressure Algometer - Surface EMG (electromyography) system	Both smartphone users and computer users reported a significant reduction in pressure pain thresholds after the task of writing messages. When evaluated in terms of muscle fatigue, it was found that there was an increased fatigue in brachioradialis in smartphone users and brachioradialis and flexor carpi ulnaris in computer users. There was no statistically significant difference between the groups on both parameters. When compared with the control group, upper trapezius muscle activity was higher in the computer-using group and brachioradialis muscle activity in the smartphone group.
Sharan et al. (2012) India Cross-sectional	Mobile phone users aged 15-50 years, (n=28)	To evaluate the clinical features and risk factors of musculoskeletal problems associated with the use of handheld devices	- Nonstandard questionnaire - Physical examination	There was a development of tendonitis in extensor pollicis longus, myofascial pain syndrome (70.37%) of adductor pollicis, first interossei and extensor digitorum communis and other associated problems diagnosed were thoracic outlet syndrome (51.85%), fibromyalgia syndrome (25.93%), wrist tendonitis (14.81%), and De Quervain's syndrome (7.41%).
Shan et al. (2014) China Cross-sectional	College students between the ages of 15-19 years (n=3016)	To examine the prevalence of neck-shoulder and back pain in digital technology use and the relationship between physical activity and psychological pressure status according to the pain levels	- Center for Epidemiologic Studies Depression Scale, - Nonstandard questions/questionnaire	A 40.8% had neck-shoulder pain and 33.1% had back pain, which were related to class level, mobile device usage, and mental status. The prevalence of neck-shoulder back pain was significantly higher in females than that of males, and the prevelance of pain increased as the class level increased. 85.4% of all participants used telephones and had very low back pain complaints but in two-hour long+ users, there was a significant increase in the prevalence of neck-shoulder and back pain. Participants with higher levels of physical activity had lower neck-shoulder and lower back pain levels than those with lower levels of physical activity. Participants

				with higher levels of depression were found to have a higher incidence of neck-shoulder and lower back pain.
Korpinenet al. (2013) Finland Cross-Sectional	Workers aged 18-65 years (n=6121)	To investigate possible associations between self-reported neck symptoms (pain, discomfort, or numbness) and computer / mobile phone use	- Nonstandard questions/questionnaire	A 83.9% with frequent neck pain symptoms used mobile phones in their spare time and 36.8% used them during work. The frequencies of the participants who experienced pain, numbness or aches (very often) were as follows: 21.3% in fingers, 14.1% in elbows or forearms, 44.8% in shoulders, 31% in hip or lower back, and 23.8% in feet.
Ali et al. (2014) Pakistan Cross-Sectional	Physiotherapy students (n=300)	To determine the frequency of De Quervain's tenosynovitis in their studies and to evaluate their relationship with text messaging	- Nonstandard questions/questionnaire -VAS -Finkelstein Test	A 55% regularly used mobile phones. 42% reported that they had pain in the thumb and wrist. It was also found that 50% had De Quervain's syndrome and a linear relationship with the frequency of mobile phone use. In De Quervain's syndrome cases, it was found that there was a significant relationship between thumb finger pain and quick text messaging.
Eapen et al. (2014) India Case-control	University students aged 18-29 years, participants with pain symptoms (n=98), participants with no pain symptoms (n=107)	To make clinical and ultrasonic evaluations of individuals with head and neck pain were performed during writing messages.	- Nonstandard questions/questionnaire -Jamar Hydraulic Pinch Gauge -Numeric Pain Scale -Finkelstein Test -DASH -Ultrasonic device	Tenderness of the wrist was seen in 18.8% of participants with pain, but there was no edema in the extansor compartment. In addition, De Quervain's syndrome was seen in 40%. Pain in resistive movements of abduction and extension of the thumb: pain in one movement= 21% and pain in two movements= 34. Both tip and lateral pinches were significantly reduced among participants with pain symptoms when compared with the control group. No limitations were reported in activities of daily living. 19% of participants had fluid accumulation in the dorsal compartments of the thumb and 2% in the thumb flexors. Ultrasonographic findings were negative in all of the control group.
Sharan et al. (2014) India Retrospective	Individuals aged 5-56 years (n=70)	To define the clinical features and risk factors of the musculoskeletal problem associated with the use of handheld devices and the efficacy of the applied rehabilitation protocol	- Nonstandard questions/questionnaire - Physical examination - VAS	All participants reported pain in the thumb and forefoot, burning in the elbow area, numbness, tingling, and stiffness in the hand and wrist. Symptoms were on the right side among 61% of the participants. In addition, 69% had myofascial pain syndrome in neck and upper back region, 49% had thoracic outlet syndrome, 10% had fibromyalgia syndrome, 5.7% had extender wrist tendonitis and 2.9% had De Quervain's syndrome. After the rehabilitation program, it was found that there was a significant decrease in pain levels.
Korpinenet al. (2015) Finland Cross-Sectional	Workers aged 18-65 years (n=6121)	To determine the frequency of use of computers and mobile phones in people with hip and back pain	-Nonstandard questions/questionnaire	Among participants with very frequent hip and back pain, 79.0% were using mobile phones in their leisure time, 35.8% used them at work, and 8.2% reported pain, numbness and tingling in their hip and waist. In addition, 57.4% had symptoms in their neck, 44.8% in the foot, and 37.8% in the shoulder. In addition, 9.8% reported complaints of fatigue at work and 12% reported sleeping problem.
Kim et al. (2015) Korea Cross-sectional	University students with an average age of 21.42 years (± 1.57) (n=292)	To investigate the effects of smartphone use on the musculoskeletal structure of each body region in university students	-Nonstandard questions/questionnaire	Muscle-skeletal symptoms were found to be more frequent among individuals who used the phone while sitting or lying down and used the mobile phone more than two hours a day. 55.8% reported pain in neck, 54.8% in shoulders, 42.1% in eyes, 29.8% in waist, 27.1% in wrists and 19.9% in fingers. The smartphone screen size was found to be positively correlated between the severity of back pain.
Stalin et al.	Individuals over the	To determine the prevalence	-Nonstandard	The mobile phone use rate was 69.8%, and most participants were between the ages

(2016) India Cross-sectional	age of 18 years (n=2121)	of mobile phone use in adult individuals and to assess the relationship between specific health problems and mobile phone use	questions/questionnaire	of 18-30 years (79.2%). There was a positive relationship between mobile phone use and health problems such as headache, earache, neck pain, tinnitus, finger pain, morning fatigue, fatigue, eye symptoms, sleep disturbances, and restlessness.
Balakrishnan et al. (2016) Malaysia Cross-sectional	University students aged between 18-30 years (n=200)	To determine the prevalence of upper extremity musculoskeletal problems in university students.	-Nonstandard questions/questionnaire -DASH - VAS	A 33% had mild, 13% had moderate, and 3.5% had severe pain in arm, shoulder and hand regions during daily activities. In addition, 27.5% stated that there was no hand pain, 44.5% had mild hand pain, 24% had moderate hand pain, and 3.5% had severe hand pain.
Hegazy et al. (2016) Saudi Arabia Cross-sectional	University students aged 19-25 years (n=472)	To determine the prevalence of using mobile phones among medical students and the possible relationship between the level of technology use and self-reported health effects	- Nonstandard questions/questionnaire	There was a positive relationship between health problems and the average duration of daily mobile phone use. There was a significant relationship between excessive mobile phone use and self-reported sleep disturbance, headache, fatigue, depression, nervousness, musculoskeletal pain, and eye problems.
Gustafsson et al. (2017) Sweden Prospective cohort	Mobile phone users aged 20-24 years (n=7092)	To determine whether text messaging is a risk factor for musculoskeletal problems in the neck and upper extremities in young adults	- Nonstandard questions/questionnaire	There was a correlation between writing messages and neck/upper extremity symptoms at baseline. Symptoms were seen in the hands/fingers after one year in participants who had no symptoms at baseline. Participants with symptoms at the beginning were found to have pain at the end of one year and to spread to the neck/upper back region. At the end of five years of follow-up, the pain was common in the shoulder/upper extremities in both groups.
Korpinen et al. (2018) Finland Cross-sectional	Workers aged 18-65 years (n=6121)	To determine a possible relationship between self-reported wrist and finger symptoms (aches, pain or numbness) and use of technological devices, and to analyze how the symptoms were specifically associated with the use of these devices	- Nonstandard questions/questionnaire	Among the participants who had symptoms on wrists and fingers very often, 80.8% used their mobile phone in their leisure time, but there was no significant difference compared to those who did not have these symptoms according to the frequency of the mobile phone use. 3.7% of the participants reported that these symptoms were caused by the desktop computer and not by the mobile phone. More than 89.8% of the participants had pain, discomfort, and numbness in their neck most of the time or often, 61.3% reported pain in the hip and waist region, 71.6% had pain in the shoulders, and 57% in the feet.
Bueno et al. (2019) Brazil Cross-sectional	University students aged 18-26 years (n=522)	To investigate the factors associated with musculo-skeletal symptoms due to the use of smartphones in university students.	- VAS - Nordic Musculoskeletal Questionnaire	A 61.5% reported having had a problem (such as pain and discomfort) in the neck region, 50.6% in the wrists/hands/fingers and 49.6% in the lumbar region in the past 12 months. When questioned about the relationship between the signs and symptoms with the use of the smartphone, the area most mentioned was the cervical region (43.9%), followed by hand/wrist (30.9%). Individuals using the device from 4 to 5 hours daily tended to present a higher score for symptoms of severity than those with less than 2 hours daily use.
Toh et al.	Adolescents aged 10-	To determine contemporary	- Nordic	Musculoskeletal symptoms in the previous month were most commonly reported in

(2019) Singapore Cross-sectional	18 years (n=1884)	technology use and examine associations with musculoskeletal symptoms among adolescents.	Musculoskeletal Questionnaire - Physical Activity Questionnaire for Adolescents - Technology Use Questionnaire - Depression Anxiety Stress Scale-21	the neck/shoulder region (42.4%), followed by arms (33.3%), upper back (29.1%), wrist/hand (26.8%) and lower back (22.7%). Females had a significantly higher prevalence of symptoms at neck/shoulder in the previous month compared to males. A higher amount of hours/day smartphone use was associated with a higher past-month prevalence of neck/shoulder, upper back, arms, and wrist/hand symptoms (OR=1.04 [1.01–1.07] to 1.07 [1.03–1.10]; $p<.05$).

DASH=The Disabilities Of The Arm, Shoulder And Hand; VAS=Visual Analog Scale

Table 2. Methodological quality scores of the 15 cross-sectional studies examining musculoskeletal problems and mobile phone usage

Included Studies	External validity criteria				Internal validity criteria						Overall quality
	1	2	3	4	5	6	7	8	9	10	11
Eapen et al. (2010)	N	N	N	Y	Y	Y	N	Y	N	Y	+
Berolo et al. (2011)	N	N	N	Y	Y	Y	N	Y	Y	Y	++
Sharan et al. (2012)	N	N	N	Y	Y	Y	N	Y	N	Y	+
Shan et al. (2013)	N	Y	Y	Y	Y	N	Y	Y	Y	Y	++
Korpinen et al. (2013)	N	N	N	Y	Y	N	N	Y	Y	Y	+
Sharan et al. (2014)	N	N	N	Y	Y	Y	Y	Y	N	Y	+
Ali et al. (2014)	N	N	N	Y	Y	Y	N	Y	N	Y	+
Kim et al. (2015)	N	N	N	Y	Y	N	N	Y	N	Y	-
Korpinen et al. (2015)	N	N	N	Y	Y	N	N	Y	Y	Y	+
Balakrishnan et al. (2016)	N	N	Y	Y	Y	N	N	Y	Y	Y	+
Hegazy et al. (2016)	N	Y	Y	Y	Y	N	Y	Y	Y	N	++
Stalin et al. (2016)	N	Y	N	Y	Y	N	N	Y	N	Y	+
Korpinen et al. (2018)	N	N	N	Y	Y	N	N	Y	Y	Y	+
Bueno et al. (2019)	N	N	N	Y	Y	Y	Y	Y	Y	Y	++
Toh et al. (2019)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	++

Note: N=No; Y=Yes; ++ = high quality (low risk of bias); + = acceptable (moderate risk of bias); - = low quality (high risk of bias);

1 = Was the study's target population a close representation of the national population in relation to relevant variables, e.g. age, sex, occupation?

2 = Was the sampling frame a true or close representation of the target population?

3 = Was some form of random selection used to select the sample, OR, was a census undertaken?

4 =Was the likelihood of non-response bias minimal?

5 = Were data collected directly from the subjects (as opposed to a proxy)?

6 = Was an acceptable case definition used in the study?

7= Was the study instrument that measured the parameter of interest (e. g. prevalence of low back pain) shown to have reliability and validity (if necessary)?

8 = Was the same mode of data collection used for all subjects?

9 = Was the length of the shortest prevalence period for the parameter of interest appropriate?

10 = Were the numerator(s) and denominator(s) for the parameter of interest appropriate?

11 = Summary item on the overall risk of bias.

Table 3. Methodological quality scores of two case-control and one prospective cohort study examining musculoskeletal problems and mobile phone usage

Included Studies	Items												Overall quality
	1	2	3	4	5	6	7	8	9	10	11		12
Kim et al. (2012)	Y	Y	Y	C	N	C	C	Y	Y	Y	N	+	
Eapen et al. (2014)	Y	Y	Y	C	N	Y	C	Y	Y	C	N	+	
Gustafsson et al. (2017)	Y	N	Y	C	C	Y	Y	C	N	Y	Y	+	

Note: N=No; Y=Yes; C=Can't say; + = acceptable (moderate risk of bias)

1 = The study addresses an appropriate and clearly focused question;

2 = The cases and controls are taken from comparable populations;

3 =The same exclusion criteria are used for both cases and controls;

4 = What percentage of each group (cases and controls) participated in the study?;

5 = Comparison is made between participants and non-participants to establish their similarities or differences;

6 =Cases are clearly defined and differentiated from controls;

7 = It is clearly established that controls are non-cases;

8 = Measures will have been taken to prevent knowledge of primary exposure influencing case ascertainment;

9 = Exposure status is measured in a standard, valid and reliable way;

10 = The main potential confounders are identified and taken into account in the design and analysis;

11 = Confidence intervals are provided;

12 = How well was the study done to minimize the risk of bias or confounding?

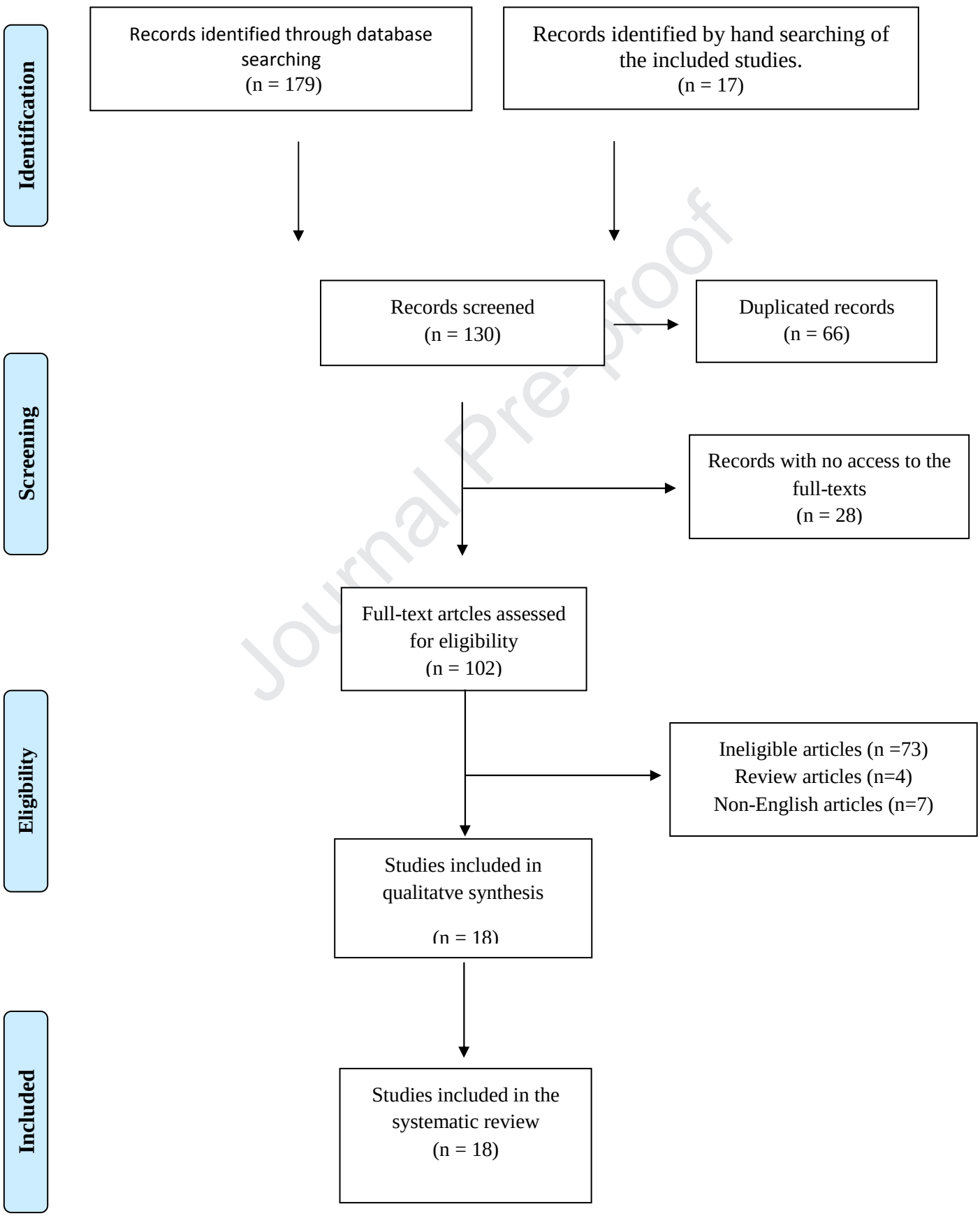
Table 4. Assessment of evidence quality in accordance with the GRADE approach.

Group	Risk Factor	Risk of Bias	Inconsistency	Indirectness	Imprecision	Other	Absolute Effect (95% CI, SE)	GRADE Score
Complaints and Symptoms	Pain	No serious limitation	Very serious inconsistency	Serious indirectness	No serious imprecision	None	Due to heterogeneity of study design and measurements meta-analyses were not possible.	Very low ⊕
	Fatigue	Serious limitation	No serious inconsistency	Serious indirectness	No serious imprecision	None		Very low ⊕
	Stiffness	Serious limitation	No serious inconsistency	Serious indirectness	No serious imprecision	None		Very low ⊕
	Sensorial problems(burning, tingling)	Serious limitation	Serious inconsistency	Serious indirectness	No serious imprecision	None		Very low ⊕
Pathologies	Tendinitis of upper extremity	No serious limitation	Very serious inconsistency	No serious indirectness	No serious imprecision	None		Very low ⊕⊕
	Myofascial pain syndrome	Serious limitation	No serious inconsistency	Serious indirectness	No serious imprecision	None		Very low ⊕
	Fibromyalgia	Serious limitation	No serious inconsistency	No serious indirectness	No serious imprecision	None		Low ⊕⊕

Note: CI=Confidence Interval; SE=Standard Error

Figure Captions

Figure 1 - PRISMA flow diagram demonstrating flow of studies through the review



Highlights

- The prevalence of MSK complaints in the reviewed studies ranged from 8.2% to 89.9%.
- Pain is the most common symptom associated with mobile phone usage.
- The most common reported pathology is tendinitis ranged from 2.9% to 70.37%.
- There are insufficient data exact relationships between mobile phone usage and MSK.