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RESEARCH ARTICLE



Musculoskeletal disorders in smartphone gamers: a scoping review

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ABSTRACT

Smartphones are among the most innovative technologies of our time, becoming an integral part of daily life. Smartphone gaming has gained immense popularity worldwide; however, prolonged and excessive gaming can pose risks to the musculoskeletal system. This study aims to review the prevalence, risk factors, and strategies for preventing musculoskeletal disorders among smartphone gamers. A scoping review was conducted on studies published between 2007 and 2024 in English. The search was performed across multiple databases, including Medline, Web of Science, Scopus, CINAHL, Embase, OVID, Google Scholar, and the Cochrane Library. The methodological quality of the included studies was assessed using the Critical Appraisal Skills Program checklists. Out of an initial 1,042 articles, 19 studies met the inclusion criteria. These included 14 observational studies, 3 clinical trials, 1 case report, and 1 pilot study. The data were extracted and narratively analyzed. Key risk factors identified were poor posture, prolonged gaming duration and frequency, and repetitive hand movements. The neck, upper back, and upper extremities were the most commonly affected body regions. Strategies to mitigate musculoskeletal disorders among smartphone gamers include reducing gaming duration and frequency, improving posture, minimizing repetitive movements, enhancing the gaming environment, and implementing educational interventions.

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KEYWORDS

Smartphone; gamers;
musculoskeletal disorders;
mobile gaming

Relevance to human factors/ergonomics theory

The influence of smartphones on human health is crucial. Smartphone gaming, which is popular in smartphone users, can cause musculoskeletal issues, while ergonomics science can help preventing them. By reviewing smartphone gamers' musculoskeletal disorders, their risk factors and existing preventive measures, we tried to address these issues. The findings can be used as ergonomics advices for developing guidelines regards smartphone gaming.

Introduction

Smartphones are among the most innovative technologies of the twenty first century (Madianou 2014), becoming an inseparable part of daily life due to their extensive applications across various domains (Reddy, Sharma, and Chaudhary 2020). Today, the frequency and duration of using smartphones has increased because these devices are portable, small and easy to use in many settings (King et al. 2020). Smartphones play a significant role in people's everyday activities, including work, entertainment, and communication (Eitivipart, Viriyarojanakul, and Redhead 2018). Approximately 6.92 billion people globally own a smartphone (Gorce and Jacquier-Bret 2023). A study found that 85% of Americans aged 18–29 own a smartphone, with 46% reporting that they cannot live without it (Smith 2015). Additionally, research indicates that 79% of individuals aged 18–24 keep their smartphones with them nearly all the time (Neupane, Ali, and Mathew 2017). Smartphone addiction has emerged as a major global health concern, exacerbated by the COVID-19 pandemic (Mokhtarinia et al. 2024).

Among the various uses of smartphones, mobile gaming has seen a notable increase in recent years (Tarannum and Anand 2023). Mobile gaming, as a predominant form of playing games (Syvertsen et al. 2022), has gained immense popularity worldwide, particularly among young people (Lam, Liu, et al. 2022). Currently, there are nearly 3 billion mobile gamers globally, and it is estimated that in 2025, over half of the world's population will engage in mobile gaming (Lynkova 2024). The recent rise in smartphone gaming has the potential to become a serious public health concern (66C51 Gaming Disorder 2018). Playing mobile games for short periods may have positive health effects (Kogan et al. 2017). Improving cognitive functions such as memory, attention, and problem solving skills (Quiles and Verdoux 2023), enhancing reading ability, and improving reaction time are among the benefits of mobile gaming (Peters et al. 2021). However, prolonged gaming sessions can have significant negative effects on both mental and physical health (Alshehri and Mohamed 2019). Common unhealthy behaviours among gamers include extended periods of sitting and adopting poor postures while using smartphones (Lam, Liu, et al. 2022). Prolonged sitting has been linked to chronic diseases (Owen, Bauman, and Brown 2009), while poor posture can lead to orthopaedic injuries (McGee and Ho 2021). Elite gamers, who may spend more than eight hours a day playing, are particularly at risk (Khan and Chaikumarn 2024). They often train for several hours daily to enhance reaction speed, rapid decision-making, and hand-eye coordination (DiFrancisco-Donoghue et al. 2019). However, this high-intensity training can lead to muscle fatigue, strain, postural adaptations, and repetitive stress injuries. Among elite smartphone gamers, common health issues include headaches, neck pain, finger pain, and injuries affecting the head and trunk (Lam, Liu, et al. 2022).

One of the primary physical consequences of prolonged mobile gaming is musculoskeletal disorders (MSDs) (Ahmed et al. 2024; Kurniawan et al. 2024; Tholl et al. 2022; Zaveri et al. 2024). MSDs refer to injuries or pain affecting the musculoskeletal system, including muscles, tendons, ligaments, nerves, and joints (Fernandes, Gonçalves, and Conti 2018). Studies revealed that four out of ten gamers experience musculoskeletal pain (Lindberg et al. 2020). Mobile esports can negatively affect the biomechanics of the spine (Lam, Chen, et al. 2022). Back pain is a common issue reported by esports athletes (Lindberg et al. 2020). Smartphone gamers often adopt a forward head posture during gameplay, making them

prone to neck discomfort and back pain (McGee and Ho 2021; Park et al. 2017). Research indicates that two-thirds of mobile gamers report musculoskeletal symptoms, predominantly in the neck and upper extremities (Kurniawan et al. 2024). Continuous mobile gaming can lead to muscle injuries in the thumbs (Wang et al. 2019). Repeated hand and finger movements, coupled with prolonged sitting, increase the risk of MSDs (Tholl et al. 2022). Terms such as ‘gamer’s thumb’ (De Quervain’s tenosynovitis) (Ilyas et al. 2007), internet gaming disorder (IGD) (Ko and Yen 2024), and ‘Text neck’ (Neupane, Ali, and Mathew 2017) have recently emerged in the literature addressing smartphone gaming-related complaints. This is while Mobile electronic sports (esports) have gained global popularity (Truong et al. 2020), with well-known smartphone esports games like PUBG Mobile, Clash Royale, and Call of Duty Mobile. The introduction of mobile play-to-earn (P2E) games, such as TapSwap, Hamster Kombat, and Rocky Rabbit, has further increased smartphone usage, potentially extending gaming durations (Gholami and Kalantari 2025), while more hours of gaming are associated with hand pain (Mariano et al. 2024). The duration and activities associated with smartphone use, such as gaming, are important risk factors for MSDs (Hanphitakphong, Thawinchai, and Poomsalood 2021). Notably, shorter durations of mobile gaming are associated with lower prevalence rates of MSDs in the shoulders, elbows, and wrists, underscoring the risks posed by extended gameplay (Sirajudeen et al. 2022).

Smartphone devices enable gamers to play in various environments, often increasing overall gaming time. However, factors such as small screen sizes, suboptimal viewing angles, and repetitive movements can lead to muscle fatigue and recurring injury patterns (Lam, Liu, et al. 2022). These risks are particularly concerning for children and teenagers, who may lack awareness about the dangers of MSDs (Cankurtaran et al. 2022). A study found that 57.5% of students were addicted to mobile games and were more susceptible to MSDs than their non-addicted peers (Ahmed et al. 2024). Despite the popularity of smartphone gaming, there is limited research on this topic compared to non-mobile gaming (Syvertsen et al. 2022). The shift from computer-based to mobile gaming in esports requires further investigation to better understand and design training strategies that can help reduce occupational health risks (Lam, Chen, et al. 2022). Given the recent emergence of mobile play-to-earn games and the widespread prevalence of smartphone gaming, it is essential to review the literature on MSDs among smartphone gamers. This study seeks to examine and summarize the available evidence on MSDs in this population.

Materials and methods

This scoping review was conducted following the latest version of the PRISMA extension for Scoping Reviews (PRISMA-ScR) and aimed to review the literature on musculoskeletal disorders (MSDs) in smartphone gamers. The research question focused on the prevalence and risk factors of MSDs in this group. The search terms were selected based on the study’s objective and included ‘mobile phone’, ‘smartphone’, ‘mobile games’, ‘gamers’, and ‘musculoskeletal disorders’. Connectors such as ‘and’, ‘on’, ‘effect’, and ‘of’ were used to refine the search. The literature was searched across various online databases, including Medline, Web of Science, Scopus, CINAHL, Embase, OVID, Google Scholar, and the Cochrane Library. Multiple keyword combinations were utilized during the search. The inclusion

criteria for publications were as follows: studies published between 2007 (the year smartphones were introduced) and November 2024, full-text access, written in English, focusing on musculoskeletal disorders (MSDs) and their risk factors in smartphone gamers, and meeting methodological quality standards.

All types of study designs were included, based on the recommendations of Whitemore and Knafl (2005), including original research articles, clinical trials, pilot studies, letters to the editor, case reports, and narrative reviews, published in English. Additionally, reference lists from review articles were cross-checked for potential supplementary studies. Articles published in non-peer-reviewed journals, duplicate studies, systematic reviews (because of potential bias due to potential double counting), articles without full-text access, and articles with low methodological quality were excluded.

Following the literature search, two independent authors screened the identified articles by title and abstract to assess eligibility. Any disagreements between the authors were resolved through discussion and re-evaluation, with the involvement of a third author when necessary, leading to complete consensus. The full texts of 19 included studies were thoroughly analyzed to extract relevant information on musculoskeletal disorders in smartphone gamers, which were then summarized. Data extraction was performed separately by two authors. The extracted information included general study details, participant characteristics, study type, main data collection tools, key findings, and implications. Methodological quality was assessed using the Critical Appraisal Skills Programme (CASP) checklists ('Critical Appraisal Skills Programme' 2023). The articles were independently assessed by two authors using a scale ranging from 0 to 8. Any discrepancies between the authors were resolved through discussion in a meeting with all authors. A score of 6 was chosen as the cutoff point, with articles scoring 6 or higher classified as high quality. After scoring, 19 publications met the high-quality criteria (five articles scored 6, six scored 7, and seven scored 8). Of the 19 included papers, one was a conference paper, and 18 were journal articles. Figure 1 presents the PRISMA-ScR flow chart for the study. The data were summarized narratively, and the results were grouped accordingly.

Results

Of the 19 studies included, 17 were conducted in Asia (89%) and 2 in Europe (11%). The majority of the publications were observational studies (14, 73.68%). There were also 3 clinical trials, 1 case report, and 1 pilot study. Five publications lacked practical conclusions and clear take-home messages. Table 1 presents the results of the synthesis.

The extracted data grouped in four main domain, including risk factors of MSDs in smartphone gamers, prevalence of MSDs in the gamers, Hand MSDs, and implications for preventing MSDs.

Risk factors of MSDs in smartphone gamers

The included studies identified awkward gameplay postures, repetitive movements, and excessive gaming durations as the primary risk factors for musculoskeletal disorders (MSDs) in smartphone gamers. The combination of these factors can lead to more severe MSDs over time.

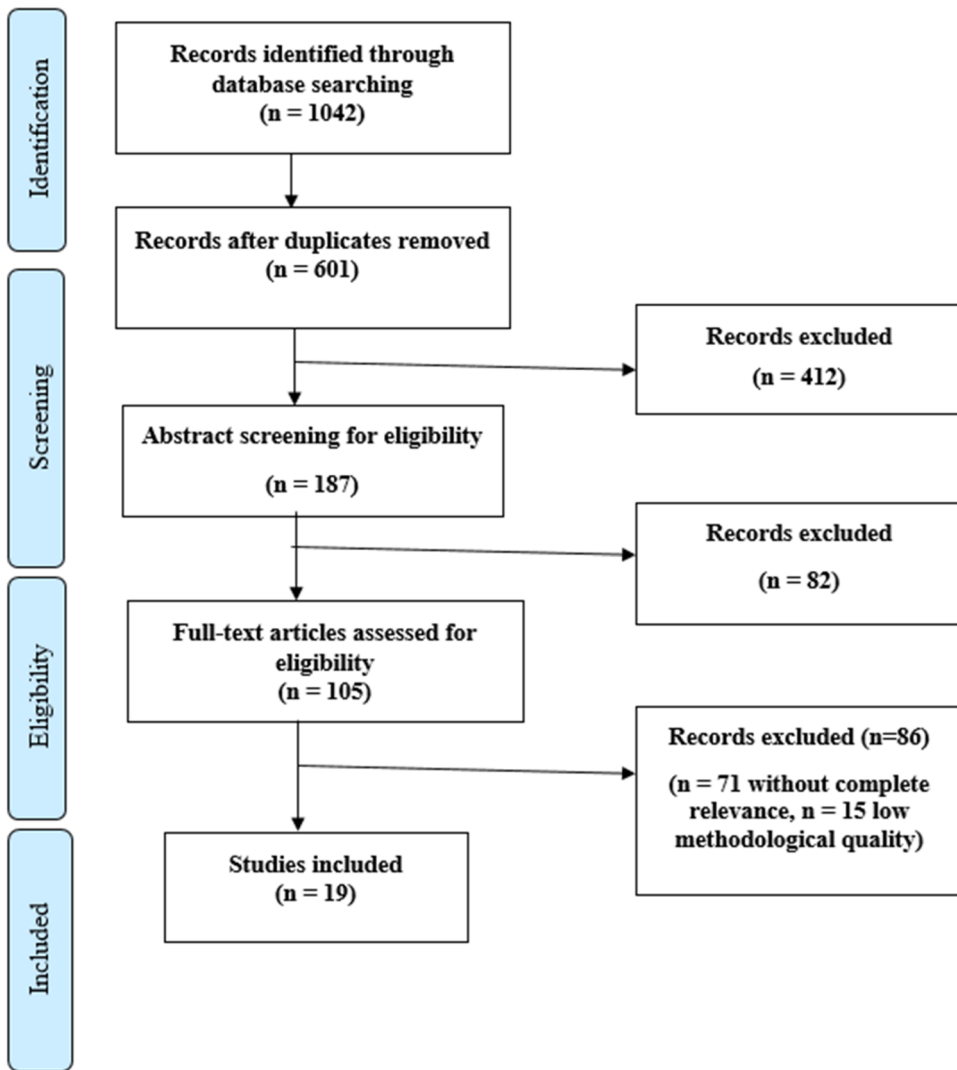


Figure 1. The PRISMA-ScR flow chart for study selection process.

Mobile game addiction increases susceptibility to MSDs across various body parts (Ahmed et al. 2024). Frequent gaming, prolonged sessions, and changes in wrist position are linked to hand pain in smartphone gamers (Ma et al. 2019). The prevalence of MSDs among those gaming for more than five hours daily is significantly higher compared to those with shorter gaming durations (Zaveri et al. 2024). Prolonged smartphone gaming increases muscle activity, spinal load, and discomfort. For example, an average neck flexion angle of 28.46 degrees was observed during one-hour smartphone gaming trials (Dandumahanti and Subramaniyam 2023). Interestingly, a study by Kurniawan et al. revealed that casual smartphone gamers reported higher rates of MSDs in the lower back, shoulders, neck, and wrists, along with greater feelings of stiffness and fatigue, compared to professional gamers (Kurniawan et al. 2024). Even relatively short gaming sessions in a

Table 1. The summary of included studies.

Author (year)	Article title	Studied population	Study type- main survey tools	Major (the most relevant) findings	Implications
Ahmed et al. (2024)	Mobile game addiction and its association with musculoskeletal pain among students: A cross-sectional study	840 high school and college students in Bangladesh	– Cross-sectionalGame addiction scale – Nordic musculoskeletal questionnaire	– 39% of the participants played mobile games for 1 to 4 h a day. 4.3% played more than 4 h – Musculoskeletal pain affected 52.1% of participants – Mobile gaming addiction was significantly associated with different musculoskeletal pain in the neck, shoulders, upper back, elbows, wrists, hands, lower back, and knees.	– Mobile gamers should consider the findings with an active lifestyle. – A cross-sectional study should be conducted across the country.
Lam, Chen, et al. (2022)	Health Risks and Musculoskeletal Problems of Elite Mobile Esports Players: A Cross-Sectional Descriptive Study	50 elite mobile-gaming athletes in China	– Cross-sectionalBody diagram – Pain rating scale – A Supervised survey	– The occurrence of head and trunk injuries in elite gamers was high. – The neck was the most prevalent body site with pain (40%) – The prevalence of MSDs in fingers was 38%, in upper back was 24%, and in back was 20%. – After 4 h of gaming, 28% of the participants experienced leg numbness. – Carrier duration was not associated with total confirmed injuries.	– To consider investigating the influence of different intensities and exposures to mobile games and direct preventive measures for game players.
Khan and Chaikumam (2024)	Musculoskeletal disorders, perceived stress, and ergonomic risk factors among smartphone eSports athletes: A cross-sectional study	145 18–30 years old smartphone gamers with over a year of eSports experience in Pakistan	– Cross-sectionalPerceived stress scale – Nordic musculoskeletal questionnaire – Health risk questionnaire – Rapid Upper Limb Assessment (RULA)	– The mean (SD) gaming time in the studied population was 8.14 ± 3.951 h a day. – The neck was the body part with the highest prevalence of MSDs (41.4%), followed by the shoulders (31%). – The RULA scores showed moderate to high risk of MSDs in esports gamers. – Esport athletes are exposed to high ergonomic risk due to poor posture. – The 7-day prevalence of pain in elbows was associated with perceived stress.	– Evidence-based guidelines must be presented by experts for the wise use of digital games. – Future research should examine more extensive and diverse groups of eSports competitors. – Experimental studies are necessary to promote cause-and-effect linkages.

(Continued)

Table 1. Continued.

Author (year)	Article title	Studied population	Study type- main survey tools	Major (the most relevant) findings	Implications
Kurniawan et al. (2024)	Comparing health risks and musculoskeletal issues between professional and casual mobile esports players: a cross-sectional descriptive study in Jakarta	94 mobile-gaming athletes (43 professional gamer, 51 casual gamers) in Indonesia	– Cross-sectional study/Nordic musculoskeletal questionnaire – Dynamometer – Sit and reach test – Eye problems questionnaire	– 56.4% of the gamers played for more than 3 h a day. – Eye fatigue was the major complaint. – A total of 65.96% of the gamers experienced MSDs complaints, with the shoulder (26.2%), neck (25.4%), and hand/wrist (21.3%) being the top three affected body regions. – No statistically significant difference were detected between the professional and casual gamers concerning MSDs indicators. – The majority of the participants had poor or very poor hand strength	– Future studies should investigate the impact of different mobile gaming exposure and intensity, and consider implementing preventative measures to promote safe and healthy gaming habits.
Zaveri et al. (2024)	The prevalence of neck pain in mobile gaming players among undergraduate students in Karachi	405 undergraduate male and female students aged between 18 to 24 years in Pakistan	– Cross-sectional study/Neck discomfort scale – Numeric pain rating scale	– 29.6% of gamers played for more than 5 h a day. Also 74.6% played for 1–4 h without any break. – The prevalence of neck pain was 74.1%. – There was significant and strong association between the incidence of neck pain and daily gaming time. – 23.5% of the participants found no disability, 43.7% found mild disability, 23.5% found moderate disability, 7.2% found severe disability and 2.2% found complete disability	– The findings underscore the importance of addressing ergonomic practices and posture to mitigate the risk of neck pain among the young population.
Kaczmarek, Behnke, and Dzon (2022)	Eye problems and musculoskeletal pain in Pokémon Go players	445 Pokémon Go players aged 18–53 in Poland	– Cross-sectional study/A researcher made eight itemed questionnaire – Problematic smartphone use scale – Phubbing scale – A MSDs prevalence questionnaire	– PG players with higher levels of problematic PG gaming reported more severe symptoms regarding eye and pain in back, legs, and arms than players low on problematic PG gaming. – Time spent gaming was not associated with physical syndromes in PG gamers.	– PG players can benefit from increasing their awareness of computer vision problems and posture pain prevention. – Understanding the possible adverse effects and correlates of PG gaming is vital to developing engaging games that facilitate health behaviours.

(Continued)



Table 1. Continued.

Author (year)	Article title	Studied population	Study type- main survey tools	Major (the most relevant) findings	Implications
Lam, Chen, et al. (2022)	Spine Posture, Mobility, and Stability of Top Mobile Esports Athletes: A Case Series	48 athletes from ten esports teams in China	- Case series - Spinal mouse for spine assessment	- Professional mobile esports athletes had significantly poorer spine posture, and weaker spine mobility and stability than non-athletes. - They may be more susceptible than non-athletes to spine-related musculoskeletal problems, such as back pain or neck pain.	Physical-training programs and other ergonomic considerations should be sought to mitigate the risk of musculoskeletal problems and potential injuries for the athletes.
Gilman et al. (2015)	Tendon Rupture Associated With Excessive Smartphone Gaming	A 29-year-old, right handed man with chronic left thumb pain and loss of active motion from playing a Match-3 puzzle video game on his smartphone all day for 6 to 8 wk	- Physical examination - MRI - Surgery	- The diagnosis was rupture of the left extensor pollicis longus tendon. - The patient underwent an extensor indicis proprius (1 of 2 tendons that extend the index finger) to extensor pollicis longus tendon transfer. - During the surgery, rupture of the extensor pollicis longus tendon was seen between the metacarpophalangeal and wrist joints.	The potential for video games to reduce pain perception raises clinical and social considerations about excessive use, abuse, and addiction. Future studies should consider whether pain reduction is a reason some individuals play video games excessively, manifest addiction, or sustain injuries associated with smartphone gaming.
Yao, Sundar, and Ramalingam (2021)	Predictors of Mobile Video Gaming on Musculoskeletal Pain among University Students in Selangor, Malaysia	163 university students in Malaysia	- Cross-sectional - Mobile gaming behaviour questionnaire - Internet gaming disorder test - Modified Nordic musculoskeletal questionnaire	- Approximately, more than 66% of the participants played mobile games for two hours and more. - The neck (74.2%) was the most commonly reported body part with musculoskeletal pain, followed by the shoulders (60.7 %), lower back (55.8 %), and upper back (50.9 %). - The body position was the only predictor of mobile video gaming with musculoskeletal pain in the lower back. - Participants who sat while playing mobile video games were more likely to develop low back pain.	Future studies can assess the participants' posture when playing mobile games objectively as different postures may lead to different types of musculoskeletal pain.

(Continued)

Table 1. Continued.

Author (year)	Article title	Studied population	Study type- main survey tools	Major (the most relevant) findings	Implications
Ma et al. (2019)	Relationship between the incidence of de Quervain's disease among teenagers and mobile gaming	500 junior college students aged 16 to 20 years in China	– Cross-sectionalFinkelstein's test – A researcher made questionnaire	– 71% of the gamers played more than two hours a day. – The incidence of de Quervain's disease in students in the school was 49.0%. – The more frequent play, prolonged mobile gaming time per day, and changes in wrist position were significantly correlated with the positive rate of Finkelstein's test. – Playing mobile games with the wrist in dorsiflexion position is a risk factor for de Quervain's disease.	– Restricting mobile gaming frequency and it's time to less than 2.25 h per day can prevent or reduce de Quervain's disease.
Ali et al. (2022)	Incidence of Forward Head Posture in Mobile Gamers: Cross Sectional Study	194 mobile gamers aged 18 to 30 years who have their personal mobiles since 2 years in Pakistan	– Cross-sectionalDigital imaging technique – Visual analogue scale – Goniometer	– Almost 74% of the participants who tended to flex their neck while gaming, played for more than 3 h each/day. – Female mobile gamers (55.6%) had larger percentage of forward head posture than males (44.4%). – Almost 74% of participants play for more than 3 h each day. – There was a positive correlation between the number of hours played and forward head posture having p-value	– Screen time should be minimized for all individuals, especially young students.
Hanphitakphong, Thawinchai, and Poomsaloos (2021)	Effect of prolonged continuous smartphone gaming on upper body postures and fatigue of the neck muscles in school students aged between 10 and 18 years	44 healthy smartphone user students in Thailand	– Quasi experimentalEMG – Numeric rating scale for neck pain – STT-IBS (STT Systems, San Sebastian, Spain)	– The mean time of smartphone usage in the participants was 4.34 h a day. – A sustained (20-min) smartphone game playing induced significant awkward posture and resulted in muscle fatigue and discomfort especially in the posterior neck area.	– Prolonged smartphone use should not exceed 10 min for students aged 10–18 years with respect to minimizing the biomechanical effects in the neck. – Habitual awkward posture should be carefully noticed during the sustained smartphone use.

(Continued)

Table 1. Continued.

Author (year)	Article title	Studied population	Study type- main survey tools	Major (the most relevant) findings	Implications
Park et al. (2017)	The effects of smart phone gaming duration on muscle activation and spinal posture: Pilot study	18 volunteer male college students in South Korea	- Pilot study - Motion analysis - EMG	- Smartphone use changed posture and muscle activation within a short amount of time, just 5 min - Smartphone use induced more flexed posture on the neck and trunk than other visual display terminal (VDT) work. - Smartphone use changed posture and muscle activation within 5 min. - Pain after 16 min of smartphone use was observed.	Clinicians should consider the influences of smartphone use in posture and muscle activity in evaluation, intervention, and prevention of neck and trunk conditions.
Tarannum and Anand (2023)	Effects of Smart Phone Gaming on Hand Strength and Dexterity	288 college students of age ranged between 18–25 years (144 gamers and 144 non-gamers. In India	- Case-control - Jamar hand dynamometer and pinch meter - Jebsen Taylor hand function scale	- A significance relationship was found between the hand strength (grip and pinch strength) and dexterity in gaming and non-gaming participants. - There was positive association in hand strength and hand function among participants who belong to gaming population.	To lower the prevalence of hand disorders, prevention efforts should be considered, specifically on the duration of playing and position of hand during the game.
Dandumahanti and Subramaniyam (2023)	Influence of smartphone game play on head flexion angle, muscle activity, and load at C7 among adolescents	40 right-handed men having prior experience in smartphone gaming in India	- Experimental - EMG - RULA	- Approximately 80% of the participants played smartphone games. - Almost all the participants used their smartphone for more than two hours a day for work and entertainment. - A significant increase in muscle activity (1.61 times), spinal loads (4.6 times) and subjective discomfort (2.9 times) after prolonged smartphone usage was seen. - Various aspects (duration, posture, content) play a vital role in smartphone-related MSD and there is a potential risk of cervical spine problems. - The increased loads reduced muscle stiffness and increased intervertebral disc pressure.	The methodology can be implemented in various fields such as human-computer interaction, rehabilitation, industrial workers fatigue and athletes.

(Continued)

Table 1. Continued.

Author (year)	Article title	Studied population	Study type- main survey tools	Major (the most relevant) findings	Implications
Wang et al. (2019)	Analysis of the effect of overusing thumbs on smartphone games	12 healthy volunteers in China	ExperimentalEMG – Visual analogue scale (VAS)	– After 30 min of continuously smartphone gaming, the Median frequency of the abductor pollicis brevis and extensor pollicis brevis muscles had significantly reduced. – The VAS scores for discomfort had increased significantly after 30-min of playing the smartphone game. – The mean power frequency of the abductor pollicis brevis and extensor pollicis brevis muscles reduced during the 30-min game duration.	– Continuous gaming time should be kept below 20 min. – The players should find a way to play the game that reduces their dependence on thumb movements.
Ayaz et al. (2022)	Prevalence of De-Quervain's Tenosynovitis among Smartphone Gamers among University Students of Multan	300 18–30 years old students playing mobile games for 2 h in Pakistan	Cross-sectionalSelf-made questionnaire – Finkelstein's test	– The majority of the participants (80%) played smartphone games for more than 5 h a day. – There were 13% gamers having De Quervain's tenosynovitis. – Increase in game playing hours increased the incidence of De Quervain's tenosynovitis.	– Future studies must be conducted using larger sample size and must be involving all age group
Lui, Sze-to, and Jones (2011)	The pattern of electronic game use and related bodily discomfort in Hong Kong primary school children	476 8–13 years old students in a local primary school in Hong Kong	Cross-sectionalSelf-made questionnaire	– Neck was the body part with the most commonly reported symptoms, followed by shoulders and fingers. – Use of more than 2 h daily of small-screen handheld game devices significantly increased the risk of developing bodily discomfort in any region with an odds ratio of 4.75.	– It is important to monitor primary school children's exposure to electronic games, especially with small handheld devices.
Majid et al. (2022)	Mobile Games Among University Students: A symptom and functional severity for Carpal Tunnel Syndrome	373 undergraduate students aged 18–25 in one of the public universities in Malaysia	Cross-sectionalBoston Carpal Tunnel Syndrome Questionnaire	– The majority of the respondents reported that they have mild symptoms of CTS, such as numbness and tingling. – The most common CTS-related functional severity was carrying grocery bags with 173 (46.4%).	– Awareness programs for CTS are needed. – Students should decrease their time in playing mobile games to reduce repetitive wrist movement.

flexed posture have been found to cause pain in the neck and trunk (Park et al. 2017). For teenagers, as little as 20 min of sustained smartphone gaming can lead to awkward posture, muscle fatigue, pain, and discomfort in the neck region (Hanphitakphong, Thawinchai, and Poomsalood 2021).

Forward head posture is particularly linked to a higher prevalence of neck stiffness (Ali et al. 2022; Khan and Chaikumarn 2024), while poor spinal posture, reduced spine mobility, and instability increase the risk of neck and back pain for mobile esports athletes (Lam, Chen, et al. 2022). Poor hand positioning and excessive gaming duration are major contributors to hand disorders (Tarannum and Anand 2023). Highly repetitive movements of the thumb and fingers, along with frequent tapping on touchscreens, are common during smartphone gaming and are associated with musculoskeletal discomfort in school children (Lui, Szeto, and Jones 2011). Overuse of the thumb during gaming can lead to chronic injuries in the abductor pollicis brevis and extensor pollicis brevis muscles, especially after just 20 min of continuous gaming (Wang et al. 2019).

Former studies reported three main hand problems and their associated risk factors. A previous study reported tendon rupture due to excessive smartphone gaming. Playing a match-3 puzzle game for 6–8 wk continuously led to the rupture of the left extensor pollicis longus tendon (Gilman et al. 2015). Carpal Tunnel Syndrome (CTS) was also seen in smartphone gamers. Chronic compression of the median nerve in the wrist was observed in Malaysian students aged 18–25. Among 373 participants, the majority exhibited mild symptoms of CTS, such as tingling and numbness (Majid et al. 2022). De Quervain's Tenosynovitis (DQT) refers to an inflammatory condition of the wrist joint causes tenderness, pain, and swelling near the thumb. In one study, 13% of gamers were affected by DQT, with a strong correlation between gaming hours and the condition. Over a quarter of participants reported feeling stressed during gaming and while gripping objects (Ayaz et al. 2022). Another study revealed that 49% of teenagers tested positive for Finkelstein's test, indicating DQT due to prolonged gaming, frequent play, and wrist posture changes (Ma et al. 2019).

The only study focused on the specific effects of a single smartphone game on MSDs examined Pokémon Go players. It found that problematic gaming (compulsive gameplay with negative impacts on the gamer's life) was associated with pain in the back, legs, and arms (Kaczmarek, Behnke, and Dzon 2022).

The prevalence of MSDs in smartphone gamers

Research on the prevalence of musculoskeletal disorders (MSDs) among smartphone gamers is limited. However, existing studies report a high prevalence of MSDs. Ahmed et al. found that the overall prevalence of MSDs in smartphone gamers was 52.1% (Ahmed et al. 2024), while other study reported this rate as 65.96% (Kurniawan et al. 2024). When assessing MSDs in specific body regions, the neck consistently showed the highest prevalence. Among elite smartphone gamers, the neck had the highest prevalence of MSDs (40%), followed by the fingers (38%), upper back (24%), lower back (20%), and shoulders (16%) (Lam, Liu, et al. 2022). In smartphone esports athletes aged 18–30 years, the 7-day prevalence of MSDs was 41.4% in the neck, 35.1% in the shoulders, 32.4% in the lower back, 23.4% in the upper back, 20.7% in the wrists, and 18.6% in the elbows (Khan and Chaikumarn 2024). Similarly, a study on university student smartphone gamers found the neck to be the most affected body part, with a

7-day prevalence of 40.5%. Other affected regions included the lower back (38.7%), shoulders (33.1%), upper back (22.7%), hands/wrists (19%), and elbows (6.1%). However, when assessing a 12-month period, the prevalence rates were significantly higher, reaching 74.2% in the neck, 60.7% in the shoulders, 55.8% in the lower back, 50.9% in the upper back, 44.2% in the hands/wrists, and 15.3% in the elbows (Yao, Sundar, and Ramalingam 2021). Prolonged sitting postures may lead to lower-back pain in the smartphone gamers (Lam, Chen, et al. 2022).

Implications for prevention and control of MSDs in smartphone gamers

Given the high prevalence and risk factors associated with MSDs in smartphone gamers, effective prevention and control strategies are essential. Reducing smartphone gaming to 10-minute intervals has been recommended for individuals aged 10–18 to minimize neck strain (Hanphitakphong, Thawinchai, and Poomsalood 2021). Similarly, keeping continuous gaming sessions under 20 min and reducing reliance on the thumb for gaming were advised (Wang et al. 2019). Raising awareness among student gamers about CTS and encouraging reduced playing time to limit repetitive wrist movements is another key strategy (Majid et al. 2022). Decreasing screen time has also been suggested to mitigate forward head posture and associated neck strain (Ali et al. 2022). Ma et al. recommended limiting gaming duration to less than 2.25 h per day and reducing gaming frequency to lower the risk of De Quervain's Tenosynovitis (Ma et al. 2019). Ergonomic practices and proper posture were highlighted as effective ways to reduce neck-related MSDs (Zaveri et al. 2024). Additionally, improving the gaming environment, including seating and screen positioning, was cited as an important preventive measure (Kurniawan et al. 2024).

Discussion

This study is the first attempt to review musculoskeletal disorders (MSDs) in mobile phone gamers. The results indicate that MSDs are highly prevalent among smartphone gamers. Poor posture, extended gaming frequency and duration, and repetitive movements are the main risk factors for MSDs in this population. The neck, upper back, and upper extremities are the most affected body regions.

Among the reviewed studies reporting the prevalence of MSDs, the neck was the body region with the highest frequency of complaints (Khan and Chaikumarn 2024; Lam, Liu, et al. 2022; Yao, Sundar, and Ramalingam 2021). Smartphone gamers tend to flex their necks during gameplay, which places significant pressure on cervical intervertebral discs, as well as the neck and upper-back muscles. The study by Dandumahanti and Subramaniyam confirmed that gamers maintain a flexed neck posture during most of their gaming time (Dandumahanti and Subramaniyam 2023). The engaging nature of smartphone games often distracts players from maintaining proper trunk and neck posture, even among those who are aware of the correct posture, leading to neck flexion. This issue is further exacerbated in play-to-earn games, where holding a smartphone at eye level for extended periods can be challenging (Gholami and Kalantari 2025). As both casual and professional gamers tend to flex their necks during gameplay, it is crucial to raise awareness among all smartphone gamers about the potential consequences and encourage the elimination of poor neck posture habits. Fatigue and reduced stiffness and activation of neck muscles occur after just 20 min of gaming (Sarıkaya et al. 2023), so smartphone gaming sessions should be kept

under 20 min each. For teenagers, this duration should be limited to no more than 10 min (Hanphitakphong, Thawinchai, and Poomsalood 2021).

The average prevalence of musculoskeletal disorders (MSDs) in smartphone gamers is lower than in some occupational groups with repetitive upper limb movements and neck flexion, such as assembly line workers (Arghami et al. 2016; Samadi et al. 2018). However, it is comparable to work-related musculoskeletal disorders reported in the European workforce (de Kok et al. 2019). However, most participants in the reviewed studies were students, teenagers, and young adults. Given the role of occupation in causing MSDs and the multi-dimensional nature of the symptoms, this is unsurprising. A prevalence rate exceeding 50% in younger populations suggests a potential increased vulnerability to MSDs later in life. Smartphone gamers who play for more than two hours a day are at risk of developing musculoskeletal disorders across multiple body regions (Lui, Szeto, and Jones 2011). Therefore, limiting gaming time to under two hours per day may help prevent MSDs. Since gamers tend to sit for prolonged periods, setting up an ergonomic gaming station (such as using ergonomic chairs) can help reduce the risk of low back pain. Additionally, physical training programs can further reduce the risk of MSDs among gamers (Lam, Chen, et al. 2022).

Frequent and prolonged smartphone gaming is associated with a higher prevalence of MSDs (Ahmed et al. 2024; Ma et al. 2019; Zaveri et al. 2024). Gaming duration is a key risk factor: the longer the gaming session, the higher the risk of MSDs, likely due to more and longer awkward postures and repetitive movements. However, even shorter gaming sessions can trigger MSD symptoms. Studies show that symptoms can appear after just 20 min of gaming (Hanphitakphong, Thawinchai, and Poomsalood 2021). Interestingly, casual gamers reported more MSD complaints than professional gamers in one study (Kurniawan et al. 2024). This discrepancy may stem from the small sample size or the multifactorial nature of MSDs, with gaming being just one of several contributing factors. Additionally, casual gamers may play for longer periods per session, which is linked to increased MSD risk. Reducing gaming time to less than 2 h a day, along with limiting each gaming session to 10–20 min, can help lower the risk of MSDs (Khan and Chaikumarn 2024). Developing evidence-based guidelines for gaming could be beneficial in this regard.

Repetitive hand and finger movements are strongly associated with MSDs in the hands, wrists, and fingers (Lui, Szeto, and Jones 2011; Tarannum and Anand 2023; Wang et al. 2019). Overuse of the hands and fingers, combined with poor wrist posture (e.g. flexed, extended, or deviated), increases the risk of hand-related MSDs. Many smartphone games require repetitive and frequent tapping on the touchscreen. Holding a smartphone and repeatedly tapping the touch screen places strain on tendons, muscles, and joints. Common conditions include Carpal Tunnel Syndrome and De Quervain's Tenosynovitis (Ma et al. 2019; Majid et al. 2022). The thumb is particularly overused during gaming, as frequent tapping and movement for game tasks place high pressure on thumb muscles. In extreme cases, non-stop gaming has even led to tendon rupture. The exciting nature of gaming is thought to decrease players' pain perception, consequently allowing them to play longer and worsening the condition (Gilman et al. 2015). Reducing gaming time, minimizing repetitive hand and wrist movements, and increasing gamers' awareness of proper ergonomics can help mitigate the risk of conditions such as De Quervain's Tenosynovitis and Carpal Tunnel Syndrome. Additionally, using ergonomic joysticks may assist in improving hand posture.

Several of the reviewed studies proposed preventive strategies for MSDs in smartphone gamers. These strategies include increasing awareness of known risk factors, reducing gaming frequency and duration, avoiding awkward postures, and improving the gaming environment. However, it is important to note that relying on a single solution may not be enough. None of the studies implemented strong interventions or emphasized the need for a multi-strategy approach, despite evidence showing that single strategies have limited effectiveness in preventing MSDs (Samadi et al. 2018). Therefore, developing a smartphone gaming guideline could be valuable. A combination of educational interventions, shortened gaming duration, reduced gaming frequency, improved posture across all body regions, decreased repetitive hand movements and tapping, and an optimized gaming environment may help prevent MSDs in smartphone gamers. To prevent smartphone gaming-related MSDs in teenagers, it is essential for parents and guardians to monitor gaming duration and postural habits.

The body of research on MSDs in smartphone gamers is limited. Many studies broadly addressed gaming across all device types, leading to their exclusion from this review. Some studies were based on small sample sizes, while others acknowledged limitations and emphasized the need for further research. Future studies should incorporate larger, more diverse samples. Additionally, most existing research focuses on specific age groups, primarily students. Future studies should include participants from various occupations and age ranges, as people of all demographics engage in smartphone gaming. Notably, no studies were found on MSDs in play-to-earn gamers, despite the growing popularity of these games worldwide (Gholami and Kalantari 2025). Given the recent rise of smartphone play-to-earn games, we recommend that future research explore the prevalence and risk factors of MSDs in this specific gamer population.

A limitation of this study was the heterogeneity of the included articles, which is common in scoping reviews. The interpretation of the results was limited by differences in study design, populations studied, and outcome measures.

Conclusion

There is limited literature on musculoskeletal disorders (MSDs) in smartphone gamers, highlighting the need for more comprehensive and high-quality research. Smartphone gaming exposes players to a heightened risk of MSDs, particularly in the neck, back, and upper extremities. These issues are primarily associated with awkward postures, prolonged and frequent gaming sessions, and repetitive movements. To prevent MSDs in smartphone gamers, strategies such as shortening gaming duration, reducing gaming frequency, correcting body posture, avoiding repetitive hand movements and tapping, and improving the gaming environment and facilities may be effective. Educational interventions and efforts to raise awareness among gamers on gaming platforms are also crucial.

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Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Reza Kalantari and Arshia Ahmadi Shoar. The first draft of the manuscript was written by Milad Gholami and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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