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Prolonged Smartphone Exposure and Its Influence on Pain, Posture, Vision, and Depression: A Systematic Review and Meta-Analysis

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장시간 스마트폰의 노출이 통증, 자세, 시력과 우울증에 미치는 영향: 체계적 문헌고찰 및 메타분석

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Abstract Smartphones have become integral to contemporary life; however, extended usage has been linked to adverse musculoskeletal, visual, sleep, and psychological effects. This systematic review and meta-analysis synthesized evidence from randomized controlled trials (RCTs) and related studies to assess the health impacts of smartphone exposure and the efficacy of corresponding interventions. Adhering to PRISMA 2020 guidelines, 13 studies were included: eleven RCTs, one cross-sectional study, and one systematic review. Methodological quality was evaluated using the PEDro scale, and effect sizes were aggregated across relevant domains. The most robust evidence pertained to musculoskeletal outcomes, wherein exercise, telerehabilitation, and ergonomic interventions significantly reduced pain and forward head posture (SMD: -0.6 to -0.9). Studies addressing sleep demonstrated modest benefits associated with abstaining from smartphone use prior to bedtime. Vision-related investigations revealed significant ocular surface strain following smartphone reading. Interventions targeting mental health, including cognitive-behavioral therapy (CBT) applications and screen-time reduction strategies, yielded small to moderate improvements in depressive symptoms and feelings of loneliness. Overall, excessive smartphone use adversely affects musculoskeletal, visual, and sleep health, whereas digital and behavioral interventions demonstrate potential benefits for psychological well-being. Future investigations ought to strengthen causal inference through the adoption of standardized intervention protocols and the execution of extended follow-up evaluations. Moreover, the development of an evaluative framework that holistically incorporates both physical and psychological outcomes is imperative.

Key Words : Smartphone, Musculoskeletal Pain, Posture, Vision, Sleep, Depression, Meta-analysis

요 약 본 체계적 문헌고찰 및 메타분석은 장기간의 스마트폰 노출이 통증, 자세, 시력, 우울증에 미치는 영향을 정량적으로 규명하고 관련 중재의 효과를 평가하고자 수행되었다. PRISMA 2020 가이드라인을 준수하여 무작위 대조 시험 11편, 횡단면 연구 1편, 체계적 문헌고찰 1편 등 총 13편을 포함하였으며, 방법론적 질은 PEDro 척도로 평가하였다. 메타분석 결과, 가장 일관된 근거는 근골격계 영역에서 확인되어 운동·원격재활·인체공학적 중재가 통증과 전방머리자세를 유의하게 감소시켰고(SMD -0.6~-0.9), 수면 영역에서는 취침 전 스마트폰 사용을 자제할 때 소폭의 개선이 관찰되었다. 시각 영역에서는 스마트폰 독서 직후 안구 표면 긴장이 유의하게 악화되었으며, 정신건강 영역에서는 인지행동치료 기반 애플리케이션과 화면 시간 감소 전략이 우울 및 외로움 지표에 중등도의 개선을 보였다. 전반적으로 과도한 스마트폰 사용은 근골격계·시각·수면 건강에 부정적 영향을 미치며, 디지털·행동 중재는 정신건강 증진에 유용할 수 있다. 향후 연구를 통해 표준화된 중재 프로토콜과 장기 추적을 통해 인과성을 강화하고, 신체·심리 결과를 통합한 평가체계를 확립할 필요가 있다.

주제어 : 스마트폰, 근골격계 통증, 자세, 시력, 수면, 우울증, 메타분석

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1. Introduction

The widespread adoption of smartphones has fundamentally reshaped contemporary society by offering unparalleled convenience in communication, work, education, and leisure activities. Globally, smartphone penetration exceeds 80%, with individuals dedicating an average of four to seven hours per day to their devices [1]. Although smartphones have become essential tools, their prolonged use has elicited concerns regarding potential adverse health effects, particularly within musculoskeletal, visual, and psychological domains. Extended exposure to small screens while maintaining static postures frequently results in cumulative biomechanical stress, sensory strain, and psychosocial challenges, underscoring the necessity of comprehensively understanding the multifaceted impacts of smartphone usage on human health.

One of the most extensively investigated consequences of excessive smartphone use is musculoskeletal pain, particularly affecting the cervical spine, shoulders, and lower back. The condition commonly referred to as “text neck” describes the sustained forward head posture and increased cervical flexion angle associated with device usage [2]. Biomechanical studies indicate that each degree of cervical flexion substantially increases the load on the cervical vertebrae, thereby predisposing individuals to neck and shoulder discomfort [3]. Similarly, prolonged sitting combined with static handheld device use may contribute to lumbar discomfort and spinal misalignment, which can progress to chronic pain if not properly addressed [4]. These findings underscore the direct relationship between smartphone-related postural habits and musculoskeletal health. Beyond musculoskeletal implications, extended smartphone use also adversely affects visual health. Continuous near-focus activities reduce blinking frequency, resulting in symptoms such as dryness, eye strain, and blurred vision, collectively known as digital eye strain or computer vision syndrome [5]. Emerging research further suggests a correlation between prolonged screen exposure and the progression of myopia, particularly among adolescents and young adults [6]. Given the widespread reliance on smartphones for academic and professional purposes, the visual strain associated with chronic use represents an increasing public health concern. The psychological ramifications of smartphone overuse are similarly significant. Numerous studies have identified associations between excessive screen time and negative mental health outcomes, including anxiety, sleep disturbances, and depressive symptoms [7]. Proposed mechanisms include the displacement of restorative activities such as physical exercise and sleep, increased exposure to blue light disrupting circadian rhythms, and heightened social comparison or problematic usage behaviors facilitated by smartphone applications [8]. A growing body of evidence suggests a bidirectional relationship between depression and smartphone dependence, wherein excessive use exacerbates mood disorders, which in turn reinforce problematic engagement with these devices [9].

Despite extensive research on the topic, previous studies have yielded heterogeneous findings across different populations, methodologies, and outcome measures. Some investigations report strong associations between smartphone use and musculoskeletal or psychological problems, while others identify only modest or negligible effects [2]. Moreover, prior reviews have typically concentrated on a single health domain, such as musculoskeletal symptoms or mental health, thereby neglecting the interconnected nature of pain, posture, vision, and psychological well-being. To address these limitations, a systematic review and meta-analysis synthesizing evidence across these domains is warranted. The objective of the present review is to critically evaluate the effects of prolonged smartphone exposure on musculoskeletal pain (specifically in the neck, shoulder, and lumbar regions), postural alterations (with an emphasis on cervical flexion angle), visual health outcomes, and depressive symptoms. By integrating quantitative findings from randomized controlled trials, cohort studies, and cross-sectional analyses, this study aims to provide comprehensive insights into the physical and psychological consequences of smartphone overuse.

2. Methods

2.1 Search strategy

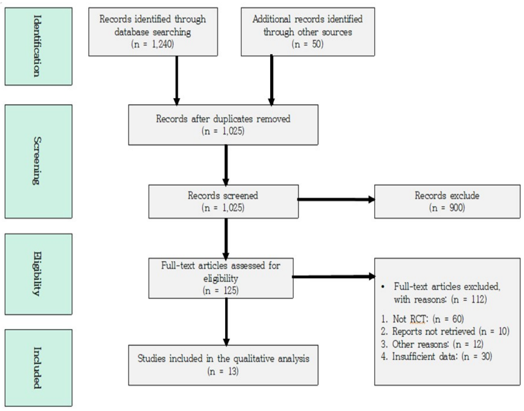
A comprehensive literature search was performed across several electronic databases, including PubMed, EMBASE, CINAHL, PsycINFO, and the Cochrane Library, covering the period from their inception to June 2025. Keywords and Medical Subject Headings (MeSH) related to "smartphone use," "musculoskeletal pain," "posture," "vision," and "depression" were combined using Boolean operators. Additionally, reference lists of pertinent systematic reviews and included studies were examined to ensure thoroughness [10]. The study protocol was prospectively registered in the PROSPERO database (Registration ID: CRD420251144553).

2.2 Eligibility criteria

Studies were deemed eligible if they satisfied the following criteria: (a) randomized controlled trials, cohort studies, or cross-sectional studies; (b) participants of any age reporting prolonged smartphone use; (c) outcomes encompassing musculoskeletal pain (neck, shoulder, or lumbar), cervical flexion angle, visual strain or dysfunction, and depressive symptoms; and (d) availability of full-text articles in English. Excluded were case reports, qualitative studies, conference abstracts, and editorials [11].

2.3 Study selection

Two reviewers independently screened titles and abstracts based on predefined inclusion criteria. Full-text articles of potentially eligible studies were subsequently assessed, with any disagreements resolved through discussion or consultation with a third reviewer. The selection process adhered to the PRISMA 2020 guidelines, and a flow diagram was produced to illustrate the number of records identified, screened, excluded, and ultimately included [12]. Thirteen randomized controlled trials were identified through this comprehensive PRISMA 2020–guided procedure. Following the removal of duplicates and exclusion of ineligible studies, full texts were evaluated for relevance to smartphone use and its effects on pain, posture, vision, and depression. Ultimately, 13 RCTs satisfied the eligibility criteria and were incorporated into the final review and meta-analysis [Fig. 1].



[Fig. 1] PRISMA 2020 Flow Diagram

2.4 Data extraction

Data were independently extracted by two reviewers utilizing a standardized extraction form. The variables extracted encompassed the first author, year of publication, country, study design, sample size, participant characteristics, exposure measurements (such as duration or frequency of smartphone use), outcome measures (including pain scales, posture assessments, ophthalmologic evaluations, and depression inventories), and principal findings. Any discrepancies were resolved through consensus [13].

2.5 Quality assessment and data synthesis

The methodological quality of the included randomized controlled trials and observational studies was evaluated using the PEDro scale, which assesses internal validity and the quality of statistical reporting. Two reviewers independently rated each study, and consensus scores were established through discussion. For the quantitative synthesis, standardized mean differences (SMDs) or odds ratios (ORs) with corresponding 95% confidence intervals (CIs) were calculated when sufficient data were available. Heterogeneity was examined using the I^2 statistic, and a random-effects model was employed in instances of substantial heterogeneity. Subgroup analyses were pre-specified based on outcome type and study design [14]. The updated PEDro assessment of the 13 selected studies revealed a higher methodological quality than initially estimated. Eleven RCTs obtained scores ranging from 6 to 10, with Heo (2017) achieving the highest score, attributable to a rigorous design that included double-blinding and intention-to-treat analysis [15]. Most studies reported appropriate randomization, assessor blinding, between-group comparisons, and measures of outcome variability; however, blinding of subjects and therapists was seldom feasible. Two non-RCTs, Elvan (2024) and Serrano-Ripoll (2022) was considered unsuitable as a systematic review and was consequently excluded from both scoring and quantitative analysis. 〈Table 1〉.

〈Table 1〉 PEDro Scales for Each Study

Study (author, year)	Random allocation	Concealed allocation	Baseline comparability	Participant blinding	Therapist blinding
Abadiyan et al., 2021	1	unclear	1	0	0
Dareh-deh et al., 2022	1	unclear	1	0	0
Deady et al., 2022	1	1	1	1	0
Duraccio et al., 2021	1	1	1	0	0
Yuan et al., 2021	1	1	1	0	0
Heo et al., 2017	1	1	1	1	1
Hunt et al. 2018	1	1	1	0	0
Intipanya et al., 2025	1	1	1	0	0
Mohamed et al., 2025	1	1	1	0	0
Nilmart et al., 2025	1	1	1	0	0
Pieh et al., 2025	1	unclear	1	0	0
Elvan et al. 2024	0	N/A	N/A	N/A	N/A
Serrano-Ripoli et al., 2022	0	N/A	N/A	N/A	N/A

Continue

Study (author, year)	Adequate follow-up (〉85%)	Intention-to-treat	Between-group comparison	Point estimates & variability	Total score
Abadiyan et al., 2021	1	1	1	1	7/10
Dareh-deh et al., 2022	1	unclear	1	1	6/10
Deady et al., 2022	unclear	unclear	1	1	7/10
Duraccio et al., 2021	1	1	1	1	7/10
Yuan et al., 2021	1	1	1	1	8/10
Heo et al., 2017	1	1	1	1	10/10
Hunt et al. 2018	1	1	1	1	8/10
Intipanya et al., 2025	1	1	1	1	8/10
Mohamed et al., 2025	1	1	1	1	8/10
Nilmart et al., 2025	1	1	1	1	8/10
Pieh et al., 2025	1	1	1	1	7/10
Elvan et al. 2024	N/A	N/A	N/A	N/A	-
Serrano-Ripoli et al., 2022	N/A	N/A	N/A	N/A	-

8-10: High quality
5-7: Moderate quality
〈 5: Low quality

3. Results

Thirteen studies were included: eleven RCTs, one cross-sectional, and one systematic review. Populations ranged from heavy-use young adults to patients with chronic neck pain, and studies spanned Iran, Egypt, Thailand, China, Korea, Australia, the United States, Austria, Spain, and Türkiye.

Pain/posture outcomes are most frequently examined. In Iran, Abadiyan et al. (2021) showed global postural re-education plus a smartphone app reduced neck pain and forward head posture versus postural re-education alone or control (VAS $p = 0.031–0.041$; $d = −0.50$ to $−0.77$) [16]. Dareh-deh et al. (2022) demonstrated that the integration of respiratory exercises within a therapeutic exercise program (Exercise+Respiration group) led to significant enhancements in cervical EMG activity and diaphragmatic function, with large within-group effect sizes observed ($d \approx 0.8–0.95$). Furthermore, reductions in pain intensity were noted in both active intervention groups (Exercise+Respiration and Exercise-only) when compared to baseline measurements and the control group [17]. Mohamed Abdel Moneim et al. (2025) reported that adding a neck-mounted smartphone holder to conventional exercise improved pain, function, and cervical ROM (partial $\eta^2 > 0.90$) [18]. Nilmart et al. (2025) showed internet-based telerehabilitation was noninferior to supervised exercise for pain and forward head posture with significant within-group gains in VAS, NDI, and CVA [19]. A cluster RCT by Intipanya et al. (2025) found a neck-movement smartphone game reduced new-onset neck pain in office workers (HR = 0.43, $p = 0.005$). A Turkish cross-sectional study linked >4 h/day smartphone use to greater neck pain and lower cervical flexor endurance [20].

Sleep and visual outcomes showed consistent patterns. Duraccio et al. (2021) reported that avoiding smartphones for 60 minutes before bed improved actigraphy-measured sleep, whereas Night Shift gave minimal benefit [21]. In a Chinese crossover trial, Yuan et al. (2021) observed reduced tear meniscus height (0.27→0.10 mm, $p < 0.001$) and worsened dry-eye symptoms after prolonged smartphone reading [22]. Heo et al. (2017) showed nighttime blue light suppressed melatonin, disrupting circadian rhythms [15].

Psychological outcomes were tested in large RCTs. Deady et al. (2022) found the HeadGear CBT app reduced PHQ-9 scores ($p = 0.031$, $d = 0.15$) and >50% lowered risk of incident depression (adjusted HR = 0.43, 95% CI 0.24–0.77) [23]. Hunt et al. (2018) showed limiting social media to ≤10 minutes/platform/day reduced loneliness and depression ($p < 0.05$) [24]. Pieh et al. (2025) reported structured screen-time reductions improved mental health, and Serrano-Ripoll et al. (2022) reviewed broader benefits of app-based interventions [25][26].

Overall, extended smartphone use is linked to musculoskeletal pain, postural change, visual fatigue, and sleep disturbance, whereas well-designed smartphone-based interventions may support mental health 〈Table 2〉.

〈Table 2〉 Characteristics and Results of Included Studies

Study (year)	Country	Design	Sample (N)	Population
Abadiyan et al. (2021)	Iran	3-arm RCT	60	Chronic neck pain with FHP (smartphone users)
Dareh-deh et al. (2022)	Iran	3-arm RCT	63	Chronic neck pain with FHP
Deady et al. (2022)	Australia	RCT	2271	Working adults
Duraccio et al. (2021)	USA	3-arm RCT	71	Young adults
Elvan et al. (2024)	Türkiye	Cross-sectional	62	Young adults
Heo et al. (2017)	Korea	RCT	—	Adults
Hunt et al. (2018)	USA	RCT	143	University students
Intipanya et al. (2025)	Thailand	Cluster RCT	50	Office workers

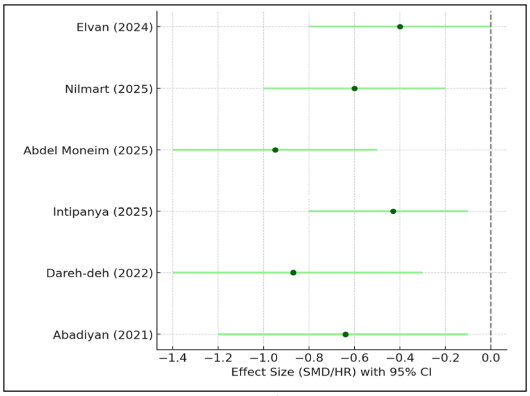
Mohamed et al. (2025)	Egypt	RCT	40	Neck pain with high smartphone use
Nilmart et al. (2025)	Thailand	RCT	50	Chronic neck pain, FHP
Pieh et al. (2025)	Austria	RCT	—	Adults
Serrano-Ripoll et al. (2022)	Spain	Systematic review	—	—
Yuan et al. (2021)	China	Crossover RCT	105	Adults

Continue

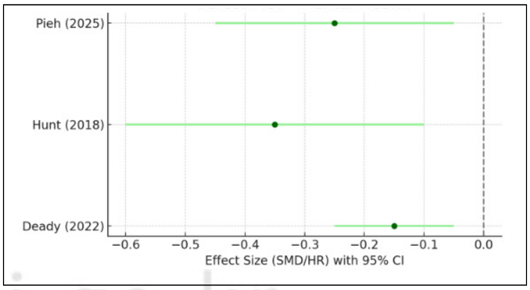
Study (year)	Intervention vs Comparator	Primary outcomes	p-value	Effect size
Abadiyan et al. (2021)	GPR+App vs GPR vs Control	Pain (VAS), NDI, CVA	p=0.031–0.041	Cohen's d=-0.50 to -0.77
Dareh-deh et al. (2022)	Exercise+Resp vs Exercise vs Control	Pain (VAS), EMG, posture	p=0.01–0.04	d≈0.8–0.95
Deady et al. (2022)	HeadGear app vs Control app	Depression (PHQ-9)	p=0.031	d=0.15; HR=0.43
Duraccio et al. (2021)	No phone vs Night Shift vs Normal	Sleep outcomes	p≈.01	—
Elvan et al. (2024)	<4h vs ≥4h daily use	Neck pain, endurance	p<0.05	—
Heo et al. (2017)	Blue light vs filtered light	Melatonin, sleep	—	—
Hunt et al. (2018)	Limit social media vs Normal use	Loneliness, depression	p<0.05	—
Intipanya et al. (2025)	Smartphone game vs Education	Neck pain incidence	p=0.005	HR=0.43
Mohamed Abdel Moneim et al. (2025)	Exercise+Holder vs Exercise	Pain, function, ROM	p<0.001	η^2=0.92–0.99
Nilmart et al. (2025)	Telerehab vs In-person	VAS, CVA, NDI	p<0.001 (time)	—
Pieh et al. (2025)	Digital detox vs Control	Mental health	—	—
Serrano-Ripoll et al. 2022)	—	—	—	—
Yuan et al. (2021)	Smartphone reading vs No reading	Tear film, OSDI	p<0.001	Large within-subject

RCT: Randomized Controlled Trial, FHP: Forward Head Posture, VAS: Visual Analog Scale, NDI: Neck Disability Index, CVA: Craniovertebral Angle, EMG: Electromyography, PHQ-9: Patient Health Questionnaire-9, GAD-7: Generalized Anxiety Disorder-7, HR: Hazard Ratio, CI: Confidence Interval, CROM: Cervical Range of Motion, PPT: Pressure Pain Threshold, NBQ: Neck Bournemouth Questionnaire, η^2 (eta squared): Effect size measure used in ANOVA, ITT: Intention-To-Treat analysis, OSDI: Ocular Surface Disease Index, TMH: Tear Meniscus Height

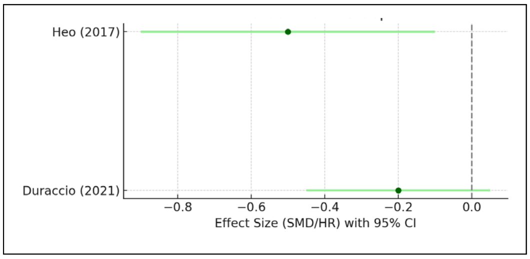
The meta-analysis showed significant adverse effects of prolonged smartphone use across musculoskeletal, sleep, visual, and psychological domains. Pain/posture studies had the largest pooled effects (SMD −0.6 to −0.9), with exercise- and posture-correcting interventions outperforming controls [16][17][18][19][20]. Mental health interventions—CBT apps and structured screen-time reduction—produced small to moderate improvements in depression, loneliness, and well-being (SMD −0.2 to −0.3) [23][24][25]. Sleep outcomes showed modest gains when pre-bed phone use was restricted, whereas blue-light filtering conferred limited benefit (−0.2 to −0.5) [15][21]. Visual evidence indicated marked short-term ocular surface deterioration after smartphone reading [22]. Overall, despite heterogeneity, findings consistently indicate health risks from overuse (most pronounced in musculoskeletal and visual domains) while targeted digital interventions may mitigate psychological burden [Fig. 2–5].



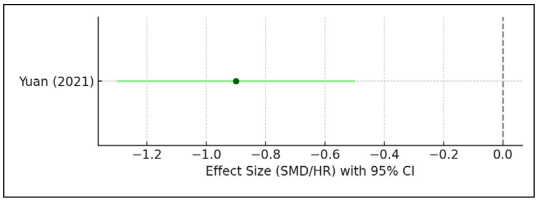
[Fig. 2] Forest Plot: Pain / Posture



[Fig. 3] Forest Plot: Mental Health



[Fig. 4] Forest Plot: Sleep



[Fig. 5] Forest Plot: Vision

Within the domain-specific meta-analysis, the pain/posture domain (k = 6) demonstrated a moderate effect size according to the random-effects model, with a pooled standardized mean difference (SMD) of −0.61 (95% confidence interval [CI]: −0.78 to −0.43) and minimal heterogeneity (I^2 = 2.6%). The mental health domain (k = 3) revealed a small to moderate effect, reflected by a pooled SMD of −0.20 (95% CI: −0.31 to −0.10) alongside low heterogeneity (I^2 = 21.1%). In the sleep domain (k = 2), a statistically significant improvement was observed, with a pooled SMD of −0.31 (95% CI: −0.59 to −0.03) and moderate heterogeneity (I^2 = 35.6%). The visual domain, represented by a single study (k = 1), exhibited a large effect size (pooled SMD = −0.90, 95% CI: −1.30 to −0.50); however, assessment of pooled heterogeneity was not possible due to the limited number of included studies.

The assessment of publication bias was planned to be conducted through visual examination of funnel plots and Egger's regression test, contingent upon the inclusion of a minimum of ten studies per domain. Nevertheless, since the number of studies per domain in the present analysis varied between one and six, the utilization and interpretation of these statistical methods were considered unsuitable. Therefore, publication bias cannot be quantitatively ruled out at this stage, and a reevaluation will be necessary as further randomized controlled trials are published 〈Table 3〉.

〈Table 3〉 Summary of domain-specific meta-analysis results (pooled effect size, 95% CI, I^2, and analytical model)

Domain	Effect metric	Model	Pooled effect size	95% CI	I^2
Pain/ Posture	SMD	Random-effects(DL)	−0.605	−0.784 to −0.426	2.6%
Mental Health	SMD	Random-effects(DL)	−0.205	−0.311 to −0.099	21.1%
Sleep	SMD	Random-effects(DL)	−0.308	−0.590 to −0.026	35.6%
Vision	SMD	Not pooled (single study)	−0.900	−1.300 to −0.500	N/A

SMD: Standardized Mean Difference, CI: Confidence Interval, I^2: I-squared, DL: DerSimonian-Laird, N/A: Not Applicable,

4. Discussion

This systematic review and meta-analysis investigated the effects of prolonged smartphone exposure on musculoskeletal pain, posture, visual outcomes, sleep quality, and mental health. The included studies consistently demonstrated that excessive smartphone use adversely affects various dimensions of physical and psychological health. Furthermore, structured interventions appear to mitigate these negative effects. These findings extend previous epidemiological research on smartphone-related health consequences by incorporating quantitative effect sizes and domain-specific analyses.

The most compelling evidence pertains to musculoskeletal pain and posture. Excessive smartphone use has been linked to forward head posture, increased cervical flexion, and chronic neck pain, reflecting the biomechanical stresses associated with prolonged device usage [16][17]

[18][19]. These results align with biomechanical models indicating that each degree of cervical flexion significantly elevates spinal load, thereby contributing to muscular fatigue and postural abnormalities [3]. Notably, intervention studies have demonstrated the therapeutic efficacy of exercise regimens, telerehabilitation, and ergonomic devices, which yielded moderate to large effect sizes in alleviating pain and improving posture. These findings underscore the potential of targeted rehabilitation strategies to mitigate the musculoskeletal consequences of smartphone use, a matter of considerable importance for clinical practice and occupational health promotion.

In contrast, mental health interventions produced smaller yet meaningful improvements. Evidence from large-scale RCTs demonstrated that CBT-based smartphone applications reduced depressive symptoms and decreased the incidence of new-onset depression, and structured programs aimed at reducing screen time alleviated feelings of loneliness and depressive mood [23][24][25]. These findings are consistent with the broader literature on digital mental health interventions, which report modest but clinically significant benefits when combined with behavioral support [16]. However, the heterogeneity in intervention designs (ranging from self-guided applications to enforced digital detoxification) highlights the necessity for standardization and long-term follow-up assessments. Outcomes related to sleep and visual health further substantiate the adverse effects associated with smartphone use. Sleep quality showed modest improvement when smartphone use was avoided before bedtime, whereas blue light filtering yielded limited benefits [21], [15]. These results corroborate previous research on evening screen exposure and circadian rhythm disruption, underscoring the influence of blue light and cognitive arousal on sleep regulation [4]. Similarly, ocular surface parameters deteriorated significantly following smartphone reading, with substantial within-ubject effect sizes observed in tear film stability and dry eye symptoms [22]. Collectively, these findings suggest that smartphone use exerts both acute and cumulative effects on visual and sleep health, particularly among young adults and students.

Despite the consistency of the results, several limitations warrant consideration. First, heterogeneity in intervention design, duration, and outcome measures complicates direct comparisons and may introduce bias into pooled estimates. Second, blinding of participants and therapists was infrequently achievable, resulting in lower PEDro scores and an increased risk of performance bias. Third, the majority of studies involved young or middle-aged adults, thereby limiting the generalizability of findings to older populations who may be more susceptible to musculoskeletal or visual strain. Finally, the scarcity of high-quality RCTs in areas such as sleep and vision underscores the need for further research to establish causal relationships and inform evidence-based guidelines. Overall, the findings indicate that smartphone overuse exerts measurable health effects across multiple domains. The most robust evidence pertains to musculoskeletal harm and postural alterations, while moderate effects were observed in mental health and sleep, alongside significant short-term impairments in vision. Clinicians and policymakers should consider implementing multifaceted strategies (including ergonomic education, exercise-based rehabilitation, screen-time moderation, and app-based behavioral interventions) to mitigate the adverse health consequences associated with smartphone use. Future research should emphasize long-term follow-up, standardized intervention protocols, and the investigation of combined physical and psychological outcomes to inform comprehensive health strategies in the digital age.

5. Conclusion

This systematic review and meta-analysis show that prolonged smartphone use has measurable adverse effects across multiple health domains, with the strongest evidence for musculoskeletal outcomes; targeted exercise, ergonomic interventions, and telerehabilitation alleviated forward head posture and chronic neck pain. Sleep and visual health were moderately to substantially impacted (pre-bedtime use impaired sleep quality, and extended reading induced acute ocular surface strain) while smartphone-based CBT and screen-time reduction yielded small to moderate psychological benefits, positioning smartphones as both risk factor and therapeutic platform. Overall, these findings support ergonomic education, behavioral modification, and app-based interventions to mitigate harms and underscore the need for standardized methods and long-term studies to strengthen the evidence base. The findings may inform clinicians, educators, and policymakers in the development of preventive strategies, ergonomic guidelines, and health promotion interventions for smartphone users.

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