



REVIEW ARTICLE

# Musculoskeletal issues and risks in school children associated with cellphone and backpack use and strategies that parents and teachers can adopt to prevent them

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## ABSTRACT

Musculoskeletal disorders (MSDs) are becoming increasingly common among school-aged children, largely due to prolonged smartphone use, poor posture, and carrying heavy backpacks. These everyday habits can lead to discomfort in the neck, back, shoulders, and hands— sometimes even causing structural changes and affecting a child's well-being, academic performance, and mental health.

This review explores the key risk factors behind MSDs in children, including ergonomic challenges, screen time, backpack load, physical inactivity, and psychological stress. It also highlights practical, evidence-based strategies for prevention, such as promoting ergonomic education, healthy posture, regular physical activity, and better backpack and furniture design. The important role of parents, teachers, and schools in creating supportive environments is emphasized throughout.

By taking early preventive action and making small but meaningful changes in daily routines and school settings, we can help reduce the growing burden of musculoskeletal symptoms and support healthier development in children.

## Introduction

Musculoskeletal disorders (MSDs) are often thought of as adult conditions, but in recent years, they've become increasingly common in children and adolescents. Factors like poor posture, long hours of screen time, low levels of physical activity, and the routine use of heavy backpacks have all been linked to early signs of musculoskeletal discomfort. School-aged children are especially at risk because their bodies are still developing, and they're regularly exposed to ergonomic challenges both at school and at home. Although smartphone use is widespread among this age group, much of the existing research still focuses on adults. As a result, there's a lack of child-specific evidence, particularly regarding the long-term impact of these habits.

In this review, *schoolchildren* refer to individuals between the ages of 6 and 18, covering both primary and secondary education. This definition aligns with previous studies exploring MSDs, smartphone use, and backpack-related strain in young people<sup>1-8</sup>. While the main focus is on this population, studies involving older adolescents and adults are included in cases where relevant data on children are limited, in order to help explain patterns more clearly.

To gather relevant literature, a systematic search was conducted in PubMed and Google Scholar using keywords such as: "musculoskeletal symptoms and children", "musculoskeletal symptoms and children and backpack", "musculoskeletal symptoms and children and cellphone", "musculoskeletal symptoms and school furniture", "musculoskeletal symptoms and backpack", "musculoskeletal disorder and smartphone", "backpack ergonomic", and "school furniture ergonomic", along with related terms. The search was limited to English-language studies published within the last ten years to ensure the inclusion of current evidence.

This review looks at the key factors contributing to MSDs in school-aged children, including ergonomics, physical activity, everyday habits, and psychological effects. It also considers how early preventive

steps—such as encouraging better posture, managing screen use, improving backpack habits, and upgrading classroom furniture—can reduce risk. Finally, it highlights the role of schools and parents creating supportive environments and promoting musculoskeletal health from an early age.

## Epidemiology and Prevalence of Musculoskeletal Symptoms in Schoolchildren

Musculoskeletal disorders (MSDs) are becoming increasingly common among school-aged children, largely due to modern habits like prolonged cellphone use and carrying heavy backpacks every day. Epidemiological data reveal a high incidence of neck and back pain not only in adults but also in younger populations, with 73% of university students and 64.7% of remote workers reporting such symptoms. Furthermore, 39.2% of these individuals noted reduced productivity due to neck or lower back pain<sup>9</sup>. These numbers reflect a broader societal issue but also suggest that musculoskeletal symptoms may begin much earlier—often during the school years. The widespread use of smartphones and computers, particularly for texting and academic activities, has been strongly associated with rising rates of neck pain among youth<sup>9</sup>. Research from different parts of the world confirms that this is not a localized problem; MSDs are now recognized as a global concern that can seriously affect the quality of life and daily functioning of young people.

### 1. FORWARD HEAD POSTURE AND TEXT NECK SYNDROME

Recent studies show that both children and adults often tilt their heads forward significantly while using smartphones compared to when standing in a neutral position<sup>9</sup>. Forward head position (FHP) is a prevalent cervical postural deviation characterized by the anterior positioning of the head relative to the shoulders in the sagittal plane<sup>9,10</sup>. This posture increases mechanical stress on the joints and ligaments of the cervical spine and places

additional strain on the muscles at the back of the neck<sup>9</sup>. Over time, FHP can lead to muscular imbalances, including the shortening or tightening of muscles such as the upper trapezius (TPZ), sternocleidomastoid (SCM), levator scapulae, and suboccipital muscles, while weakening or lengthening the deep neck flexors<sup>9,10</sup>.

In addition to daytime habits, poor sleeping postures—such as lying face down or curled up on one side—can worsen FHP by further disrupting the spine's natural alignment<sup>9</sup>. These patterns can result in muscle fatigue, tension, and even long-term changes in spinal alignment, reinforcing the need for early posture education.

Closely linked to FHP is Text Neck Syndrome (TNS), a condition that has become increasingly common among school-aged children due to prolonged forward head flexion while using smartphones<sup>4,9,11-15</sup>. When children spend extended time looking down at devices, it increases the pressure on the cervical spine<sup>4,13</sup>. This prolonged strain may result in neck pain, upper back discomfort, and shoulder tightness, especially in younger users who are still physically developing<sup>4,12,15</sup>.

It's estimated that around 75% of the global population spends hours daily in positions that encourage head flexion while using handheld technology<sup>4</sup>. For school-aged children, this can lead to symptoms that affect not only their physical comfort but also their academic performance and overall quality of life<sup>15</sup>. Because younger users are still learning and adapting physically, they may not be fully aware of how posture affects their well-being, making early ergonomic intervention and screen time management are key to prevention<sup>4</sup>.

## 2. BACKPACK AND SCREEN TIME -RELATED BACK PAIN

Backpacks are a significant daily physical load for schoolchildren, and many report experiencing low back pain linked to their use<sup>5,6</sup>. This is especially concerning during childhood and adolescence, when the spine is still developing and more vulnerable to the stress caused by carrying heavy loads.

Prolonged screen time is another contributing factor to musculoskeletal discomfort. Extensive use of digital devices is often associated with poor posture<sup>1,7,8</sup> and reduced physical activity<sup>1,7</sup>, both of which are established risk factors for low back pain and other musculoskeletal issues<sup>7</sup>. A meta-analysis by Cheng et al., including 57,831 participants, found a clear link between daily screen time and low back pain. The study also reported a dose-response relationship—meaning the longer the screen time, the higher the risk of experiencing pain<sup>1</sup>.

These findings are supported by study by Ben Ayed et al. who found a high prevalence of musculoskeletal symptoms among secondary school students, particularly in the neck and lower back. These symptoms were significantly associated with poor posture during long period of sitting and with heavy school bag use. Sedentary behaviors like extended screen time and prolonged sitting during classes appear to further increase the risk of musculoskeletal pain in this age group<sup>3</sup>.

## 3. PINKY DEFORMITY AND HAND STRAIN

Frequent use of smartphones for activities like texting or gaming involves repetitive finger and wrist movements that can place excessive stress on small joints and surrounding muscles. Over time, this can impair hand function and reduce grip strength and changes in finger structure in young users<sup>16</sup>.

In recent years, a condition often referred to as “smartphone pinky” has gained attention. Some children have reported discomfort or visible changes in the fifth finger, believed to result from the way the phone is supported during extended use<sup>17,18</sup>. Imaging studies suggest that regular use of smartphones, especially for more than four hours a day, may contribute to mild structural changes in the pinky finger, such as shifts in alignment or variations in bone density. Even when no visible deformity is present, users often experience soft tissue irritation or soreness in that area<sup>17</sup>.

Overuse can lead to inflammation in hand tendons, particularly those involved in thumb extension and abduction that results in hand and wrist pain. The

discomfort is often localized in the middle phalanx of the pinky, leading to dysfunction<sup>18</sup>.

A study by Mongkonkansai et al. found a link between high smartphone usage in schoolchildren and increased reports of hand and finger pain, underscoring the importance of integrating hand ergonomics into musculoskeletal health education for children<sup>19</sup>.

#### 4. GUYON CANAL SYNDROME

While smartphones have become a central part of everyday life, their excessive use has been linked to various upper limb problems, including nerve compression syndromes. One such condition is Guyon Canal Syndrome (GCS)- a condition that predominantly affects the fifth finger, which affects the ulnar nerve as it passes through the wrist. Prolonged phone use, especially with poor posture like leaning the head forward and gripping phones tightly for long periods, may increase pressure in this region. In children, these habits may lead to symptoms such as tingling or discomfort in the ring and pinky fingers which are innervated by the ulnar nerve. Holding smartphones in awkward wrist positions for extended periods can worsen the problem by raising the risk of nerve irritation. Preventing GCS involves encouraging better ergonomic practices as early as possible, such as limiting device time, supporting the wrists during use, and promoting posture awareness to reduce unnecessary strain on the upper extremities<sup>20</sup>.

## Risk Factors and Contributing Factors to Musculoskeletal Symptoms in Schoolchildren

Several key factors contribute to the development of musculoskeletal disorders (MSDs) in school-aged children, particularly those associated with prolonged cellphone use and the physical strain of carrying heavy backpacks. These influences can be grouped into broad categories, including ergonomic behaviors, levels of physical activity, psychological and emotional factors, and demographic characteristics such as age and gender.

Environmental conditions, such as school furniture and study settings, also play an important role in shaping musculoskeletal health in this population.

#### 1. GENDER DIFFERENCE

The prevalence of neck pain and postural disorders has increased in parallel with the widespread use of smartphones and other digital devices<sup>21</sup>. Research suggests that females tend to use mobile phones more frequently and for longer durations than males, which may explain a higher incidence of neck pain among women<sup>11,15</sup>. Several studies have indicated that girls are generally more susceptible to developing neck and shoulder pain compared to boys, especially in relation to cellphone and backpack use<sup>3,11,15</sup>. However, one study reported that the occurrence of concurrent low back and neck pain is relatively high in both genders<sup>3</sup>.

Gender-based differences in physical responses to strain have also been documented, with females typically reporting higher levels of discomfort than males under similar conditions, possibly due to differences in muscle endurance, biomechanics, pain sensitivity, and postural habits<sup>22</sup>. One study used electromyography (EMG) to explore neck muscle activity during smartphone use in different postures, particularly under near-maximum forward head flexion. The results showed greater muscle activation in females, suggesting they may be more vulnerable to neck strain in poor postural conditions<sup>23</sup>. Interestingly, another study observed that males demonstrated greater head and neck flexion angles than females, and these differences were associated with longer periods of computer use<sup>21</sup>. Distinct from earlier studies relying on simulated environments or self-report data, a real-world observational study examined head flexion (HF), neck flexion (NF), gaze angle (GA), and viewing distance (VD) in 300 male and 300 female smartphone users across different postures in public settings. ANOVA results revealed that while men had larger HF and NF angles, women tended to hold their devices closer—about 5.4 cm less viewing distance on average—which may increase the risk of eye strain. Women were also more likely

to maintain a more upright neck and trunk posture, especially when sitting without support, whereas men were more prone to slouched postures<sup>24</sup>.

Despite these patterns, not all research agrees. One study reported no significant gender differences in the overall prevalence of musculoskeletal pain between boys and girls<sup>25</sup>.

## 2. AGE

Age is a significant factor when evaluating the risk of musculoskeletal symptoms. Some studies report that younger individuals are more prone to neck pain<sup>26</sup>, while others have found that increasing age<sup>3,27-29</sup> and certain anthropometric factors are associated with a higher likelihood of experiencing musculoskeletal pain<sup>3,27,28</sup>. Research among adolescents has shown that musculoskeletal pain is most frequently reported around the median age of 15 years<sup>30</sup>, and within the 15–19 year age group<sup>4</sup>. One study found a marked increase in spinal pain as children get older, increasing from 18.2% at 10 years old to 65.6% at 16 years old<sup>8</sup>.

## 3. POOR POSTURE

Poor posture is one of the most significant contributing factors to musculoskeletal symptoms in school-aged children<sup>1,3,4,8-10,15,18,19,26,28,31-37</sup>. Prolonged screen use, especially with mobile phones or tablets, often leads to "tech neck," where children adopt a forward head posture (FHP) to look at their screens. This position places increased stress on the cervical spine and is linked to neck<sup>4,10,12,15</sup> and shoulder pain<sup>4,12,15</sup>. Elevated head flexion, regardless of whether the user is sitting or standing, places additional strain on the neck and shoulders. However, using back support significantly reduces strain, particularly in seated positions<sup>15,22</sup>.

The way children position themselves while using smartphones plays a major role in the development of musculoskeletal pain<sup>37</sup>. Studies have identified several specific postures and habits that increase risk:

- Using smartphones in a lying down position is associated with increased musculoskeletal discomfort, mainly in the neck and shoulders. This posture often results in poor alignment and

excessive neck flexion, which can exacerbate pain over time<sup>37</sup>.

- Using smartphones in a prone position increases the risk of ergonomic-related musculoskeletal complaints<sup>17,19</sup>.

- Holding the device at awkward angles and maintaining static postures for long periods, significantly increase the risk of MSDs<sup>26,30,31</sup>.

- Seated smartphone users tend to adopt more stable or relaxed postures; however, signs of poor alignment, such as forward head posture, are still common. In contrast, standing users display more variability in posture, with some maintaining better alignment while others show pronounced neck and back flexion. This suggests that although sitting may feel more comfortable both sitting and standing postures can contribute to musculoskeletal strain if proper posture is not maintained<sup>24</sup>.

- Sitting without back support increases intradiscal pressure (IP) by approximately 30% compared to standing upright. The relationship between back flexion and IP changes follows a second-degree polynomial pattern in both sitting and standing positions. However, back flexion while standing leads to a greater increase in IP compared to sitting<sup>38</sup>.

- Walking while using a smartphone leads to greater head and neck flexion, especially at higher speeds, increasing the risk of discomfort over time<sup>13</sup>.

- Walking while using a smartphone places greater strain on the neck muscles compared to walking without phone use, particularly due to increased head flexion. Texting with both hands while walking places more strain on the neck than browsing the web with one hand<sup>39</sup>.

- Standing posture also influences head and neck positioning. Users who maintain an upright posture show less flexion than those who slouch or lean forward. Maintaining proper alignment and being mindful of walking speed are important strategies to reduce strain<sup>13</sup>.

A study comparing the biomechanical workload of smartphone and smartwatch use in sitting versus



standing postures found that smartwatch use resulted in greater strain on the neck and shoulders, particularly when standing. While standing led to more engagement of neck and shoulder muscles, sitting was slightly less demanding. The study suggests limiting smartwatch use to brief, simple tasks, especially while standing, to reduce musculoskeletal strain<sup>40</sup>. Finally, poor hand posture during smartphone usage is correlated with increased hand pain<sup>41</sup> highlighting the need to consider hand ergonomics as part of overall posture awareness.

#### 4. BACKPACK USAGE, WEIGHT, AND DISTRIBUTION

Improper backpack use—especially when bags are overloaded or carried on one shoulder—can significantly contribute to musculoskeletal strain in school-aged children. These habits are closely linked to spinal misalignment and increased stress on the lower back<sup>3,5,6,35,36</sup>, as well as the neck, and shoulders<sup>3,6,25,42</sup>. Several studies have confirmed a strong association between excessive backpack weight and increased spinal loading, which can lead to pain, discomfort, and long-term postural problems<sup>5,6,25</sup>. Key factors influencing these outcomes include backpack's weight relative to body mass<sup>5,6</sup>, how the load is distributed<sup>28,29,34</sup>, and the ergonomic design of the backpack such as strap padding and width<sup>5</sup>.

Research on backpack ergonomics has shown that many students carry loads that exceed recommended weight limits, a pattern associated with a rise in musculoskeletal complaints<sup>43</sup>. Overpacking can also negatively impact balance and walking patterns. For example, children carrying excessively heavy backpacks have been observed to exhibit postural instability and gait irregularities<sup>44</sup>. However, when the load is limited to 10% of body weight and evenly distributed across both shoulders, gait remains stable. These findings support the commonly recommended guideline that backpacks should not exceed 10% of the user's body weight, particularly for children and adolescents<sup>44</sup>.

To help minimize strain, it's widely advised that

backpacks weight should remain within 10–15% of a child's body weight. Exceeding this threshold increases the risk of postural alterations and discomfort<sup>3,6,42,43,45</sup>. Several specific observations support this:

- Heavier backpacks are linked to greater deviations in spinal curvature, moving the spine away from its natural alignment<sup>46</sup>.
- Carrying a backpack on one shoulder alters gait dynamics, increases pelvic tilt, and creates an uneven swing phase. Children who use both shoulder straps or carry bags by hand tend to report fewer symptoms, especially lower back pain<sup>3,47</sup>.
- Asymmetrical loading often results in trunk lean and uneven shoulder height. Lateral spinal flexion toward the load-bearing side has also been reported, suggesting that even brief periods of one-sided carrying may negatively affect posture over time<sup>48</sup>.

Some studies suggest that ergonomic backpack designs may help reduce discomfort and support better physiological responses in children<sup>49</sup>. However, not all findings are consistent. For example, Resende et al. found no significant correlation between backpack weight and postural alignment in students, suggesting that other variables may influence posture more strongly<sup>50</sup>. Similarly, another study also found no direct link between backpack weight (as a percentage of body weight) and musculoskeletal pain<sup>25</sup>.

#### 5. OBESITY

Being overweight or obese is recognized as a strong risk factor for musculoskeletal problems in children<sup>3, 34</sup>. Research shows that girls with obesity, especially those at the beginning or end of primary school, are more likely to seek medical care for issues such as knee and back pain. Interestingly, this trend has not been observed in boys<sup>51</sup>. Children and adolescents with higher body mass index (BMI) are more likely to experience low back pain, joint pain, and discomfort due to the added mechanical stress placed on the spine and weight-bearing joints compared to their non-obese peers<sup>15</sup>.

A meta-analysis by García-Moreno et al. further supports the connection between excess weight and musculoskeletal pain in children and adolescents and an increased risk of experiencing low back pain (LBP). Specifically, children with higher BMI are more likely to report musculoskeletal discomfort, including back pain. The study suggests that obesity serves as a stronger risk factor for LBP compared to being overweight<sup>52</sup>. Conversely, lower BMI has been associated with a reduced risk of neck pain in children<sup>32</sup>.

However, some studies have failed to find a significant association between BMI and musculoskeletal pain in children, suggesting that other factors may also influence the development of musculoskeletal disorders<sup>25</sup>.

## 6. PHYSICAL ACTIVITY LEVEL

Physical activity, or the lack of it, plays a key role in the development of musculoskeletal disorders in children. Sedentary behavior and low physical activity levels are primary contributing factors to musculoskeletal pain<sup>3,4,7,8,15,53</sup>. Children who are more physically active tend to experience fewer musculoskeletal complaints. There is a positive correlation between physical activity and reduced spinal pain<sup>27,29,53</sup>, with the quality of physical activity—rather than its quantity—being crucial in influencing back pain risk<sup>29</sup>.

Studies have found that moderate to high sedentary behavior is associated with neck pain in both boys and girls, while it is specifically associated with low back pain in girls<sup>54</sup>. Physical inactivity can lead to muscle atrophy, which reduces the spine's support and increases vulnerability to strain and discomfort<sup>1,3,33</sup>. On the other hand, consistent movement and regular exercise help strengthen core muscles and improve posture, providing protective benefits against developing musculoskeletal issues<sup>3,33,36</sup>.

The combination of excessive screen time and poor ergonomic practices further increases the risk of musculoskeletal pain, particularly among adolescents<sup>11</sup>. Long periods of sitting, whether in class or during free time, without breaks, increase

the likelihood of musculoskeletal discomfort<sup>3,28,35,36</sup>.

## 7. ERGONOMIC DESIGN OF SCHOOL FURNITURE, DEVICES, AND BACKPACKS

Ergonomics plays a crucial role in preventing musculoskeletal disorders (MSDs) among school-aged children. The design of school furniture, digital devices, and backpacks can all contribute to postural strain and discomfort if not properly adapted to students' physical needs.

Many studies have reported that traditional school furniture often fails to support healthy posture, contributing to musculoskeletal symptoms such as neck, back, and shoulder pain<sup>3,28,33,35,55,56</sup>. Desks and chairs that are not designed with children's varying heights in mind can lead to sustained poor posture during long hours of sitting<sup>35,36,55</sup>. For instance, using desks that are too high has been associated with more than double the risk of neck pain (2.23 times higher), while forward-tilted seats increase the risk by 2.38 times. Additional design issues, such as backward-inclined or curved backrests, have also been linked to elevated neck pain risk (1.62 and 1.80 times higher, respectively)<sup>32</sup>.

To reduce these risks, researchers recommend furniture that is ergonomic, adjustable, and tailored to students' anthropometric measurements<sup>35,36,55</sup>. Such designs help promote proper alignment and reduce stress on the spine during prolonged sitting. However, some studies have found mixed results. For example, one study reported no significant relationship between mismatched furniture and musculoskeletal pain<sup>57</sup>. Another investigation evaluating suitability of standard school trolleys for children of various heights and concluded that the trolleys are appropriate for children between 120 to 160 cm in height, with no significant differences in posture or effort among children of different height groups. This suggests that standard trolleys are generally effective for children within this height range with no major issues regarding misalignment or discomfort<sup>58</sup>. Beyond furniture, the ergonomic design of everyday items like backpacks also plays a role in

musculoskeletal health. Poorly designed backpacks, or those not adjusted to fit properly, can contribute to postural imbalance and increased load on the spine<sup>3</sup>. When combined with poorly fitted furniture and prolonged digital device use, the cumulative impact of these ergonomic challenges becomes a significant risk factor for MSDs in school-aged children.

#### 8. DEVICE OWNERSHIP AND DURATION OF USE

Both device ownership and the amount of time children spend using digital devices are important factors linked to the development of musculoskeletal symptoms. Research shows that children who own smartphones are more likely to report musculoskeletal pain syndromes<sup>19</sup>, and the length of device ownership has been positively correlated with symptom development<sup>30,59</sup>.

Using multiple electronic devices further increases this risk—children who use two devices are more likely to experience musculoskeletal pain than those who use only one<sup>30</sup>, and specially the risk increases when four or more devices are used regularly<sup>15</sup>.

Prolonged device usage is also strongly associated with musculoskeletal complaints<sup>1–4,7,11,12,14,17,30,53,59</sup>, particularly in the hands<sup>17,41</sup>. The dominant hand appears to be more affected, especially during long smartphone use sessions<sup>41</sup>. Both the duration and frequency of device use are important in predicting the severity of symptoms<sup>11,19</sup>. Studies show that limiting screen time—especially electronic gaming—is linked to a reduction in musculoskeletal discomfort<sup>2,30,26,31</sup>.

Children who use smartphones for more than 60 minutes per day are up to 10 times more likely to develop musculoskeletal disorders than those who use them for less than an hour<sup>19</sup>. Similarly, watching television for extended periods has been associated with a higher risk of shoulder pain<sup>32</sup>.

While most studies support this connection, one study by Siao Hui Toh et al. did not find a strong relationship between total daily screen time and musculoskeletal symptoms. However, it did show that how devices are used matters, for example

behaviors like prolonged, uninterrupted sessions or multitasking were more strongly linked to discomfort<sup>60</sup>.

Daily exposure to physical load also matters. Carrying a school bag for 30 to 60 minutes per day increases the risk of neck pain by 1.61 times<sup>32</sup>, and carrying a backpack for more than 60 minutes daily has been associated with pain in the neck, shoulders, and lower back<sup>3,34</sup>.

## Symptoms of Musculoskeletal Disorders in Schoolchildren

As smartphone use and heavy backpack carriage have become more common among schoolchildren, reports of musculoskeletal symptoms have increased. These symptoms range from mild discomfort to chronic pain and can affect multiple areas of the body. Early identification is essential for prevention and intervention. The most frequently reported symptoms include:

### 1. Neck Pain

Neck pain is one of the most common complaints, often associated with prolonged device use, poor posture, and carrying heavy backpacks<sup>2–4,8–12,14–16,19,25,26,28,30–32,57,59,60,61–63</sup>. May include:

- Stiffness or tightness in the neck muscles
- Difficulty turning the head fully
- Soreness radiating to the shoulders or upper back
- Muscle spasms and fatigue around the neck region

### 2. BACK PAIN

Back pain, especially in the lower back, is frequently linked to the improper carrying of backpacks and prolonged sitting with poor posture<sup>1–3–12,14,15,19,26,28,29,36,42,57,59–63</sup>. May include:

- A persistent ache in the lumbar region
- Increased discomfort when standing, sitting, or walking for long periods
- Difficulty in maintaining upright posture
- Radiating pain into the hips or thighs in more severe cases



### 3. SHOULDER PAIN

Shoulder discomfort often results from either smartphone use or uneven backpack loading<sup>2-4,9,11,12,14,15,19,25,28,30-32,42,60,63</sup>.

May include:

- Soreness around the upper shoulders or shoulder blades
- Limited range of motion when lifting the arms
- Tension and fatigue in the trapezius region
- Pain triggered by lifting or carrying loads

### 4. HAND, ARM, OR WRIST PAIN, AND FINGER DEFORMITY

Musculoskeletal discomfort in the hand, arms, or wrists is often linked to prolonged smartphone use<sup>2,4,11,12,14-16,28,30,31,41,59</sup>, specially in dominant hand<sup>41</sup>, particularly from gripping and manipulating the phone in awkward positions. Children often develop this condition as they spend more time texting or gaming, through screens<sup>9,17</sup>. May include:

- Joint pain or stiffness, particularly in the pinky or surrounding fingers<sup>41</sup>
- Swelling, tingling, or numbness in the fingers or hand<sup>12,14,31</sup>
- Decreased flexibility or difficulty straightening the fingers
- Changes in the shape of the fingers<sup>16,18</sup>

### 5. HEADACHE

Children who suffer from neck and shoulder pain often report headaches<sup>4,9,11,12,14,15,26,31</sup>. The stress placed on the muscles of the neck and upper back can trigger headache symptoms<sup>30,31</sup>. These may be:

- Tension-type headaches originating from neck strain
- Persistent and worsened after prolonged screen time
- Sometimes accompanied by light sensitivity or fatigue

### 6. EYE SYMPTOMS AND VISION PROBLEMS

Extended screen use can cause visual strain, dry eyes, or blurred vision, especially when using smartphones in a forward-head position<sup>4,9,13,14,62,64</sup>. Studies show that:

- Eye strain occurs regardless of posture, but is

often worse when standing<sup>64</sup>

- Reduced blinking and screen proximity may contribute to dry eyes and asthenopia

- Some evidence suggests blue light exposure may increase visual fatigue<sup>62</sup>

However, one study found no strong association between screen use and vision changes such as nearsightedness<sup>60</sup>.

### 7. PSYCHOLOGICAL SYMPTOMS

Excessive screen time negatively impacts psychosocial health, leading to issues like anxiety, depression<sup>4,9</sup>, stress, poor communication, and decreased academic performance<sup>4</sup>. Higher screen usage is associated with increased sadness and lower life satisfaction<sup>65</sup>. High users of screens often show poor emotion regulation, difficulty finishing tasks, and struggle with forming friendships. These children may also exhibit lower self-control and be harder for caregivers to manage<sup>65</sup>. Increased screens use negatively impacts device-related psychosocial health. Prolonged use was linked to conflicts between children and parents, often straining their relationship. These tensions may be worsened by mood swings caused by poor sleep quality, which is commonly associated with late-night electronic device use<sup>62</sup>.

## Prevention Strategies for Musculoskeletal Symptoms in Schoolchildren

Musculoskeletal disorders (MSDs) in school-aged children are becoming more common due to factors like excessive cellphone use, prolonged sitting, poor posture, and carrying heavy backpacks. Preventing these issues requires a practical and multidimensional approach. Based on current research, the following strategies can help reduce the risk of MSDs and support better musculoskeletal health in children.

#### 1. ERGONOMIC EDUCATION AND PARENTAL ROLE

One of the most effective ways to prevent musculoskeletal issues in children is through

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education. Teaching children, parents, and teachers about proper posture<sup>4,6,8,14,35,36,38</sup>, safe device usage<sup>4,11,14,16,18,22,24,26,39,59,60,62</sup>, reducing screen time, promoting physical activity<sup>1,4,7</sup>, and applying ergonomic practices<sup>2,9,12,13,23,30,31</sup> can help minimize musculoskeletal strain and encourage healthier habits<sup>53,54,61</sup>.

Although awareness of conditions like Text Neck Syndrome is increasing, many individuals still lack a proper understanding of how to prevent symptoms. Hakami et al. found that awareness alone was not enough—targeted programs are needed to teach individuals about correct posture, taking regular breaks, and using ergonomic accessories to reduce discomfort<sup>12</sup>. Other research confirms that despite knowing the risks of excessive phone use, many individuals still report neck pain and other symptoms. This shows the need for practical education that turns knowledge into action<sup>26</sup>.

Parental involvement plays a key role in reinforcing these habits at home. Studies show that children whose parents set clear rules for screen time and monitor backpack weight tend to report fewer musculoskeletal complaints<sup>19</sup>. One study found that the absence of screen-time rules at home was linked to a six-fold increase in reported pain<sup>19</sup>. This highlights how parental guidance, and clear boundaries can protect children's musculoskeletal health.

Additionally, **parents should model healthy device habits themselves to encourage responsible usage in their children**<sup>62</sup>. Modeling healthy behaviors such as good posture, balanced screen time, and regular breaks helps reinforce these habits in everyday life.

Parents can support prevention by:

- Setting daily screen-time limits (under 60 minutes) and encouraging regular breaks<sup>19,37</sup>
- Avoiding personal smartphone ownership in younger children<sup>19</sup>
- Monitoring backpack weight to stay within 10–15% of body weight<sup>6,42</sup>
- Teaching children how to sit and use devices

correctly, and providing supportive furniture at home<sup>19,66</sup>

Even simple strategies—like packing only necessary items in schoolbags, avoiding device use while lying down, and encouraging children to take breaks—can make a significant difference. When parents consistently apply these practices, children are more likely to adopt healthier habits that reduce the risk of musculoskeletal discomfort.

Additional guidance for families comes from the **Italian Society of Pediatrics (2019)**, which recommends the following:

1. **Encourage Open Communication:** Talk to children about mindful and responsible media use, including online privacy, digital safety, and content choices<sup>4</sup>.
2. **Stay Informed and Monitor Usage:** Parents should understand the technology their children use and engage in shared digital activities when possible<sup>4</sup>.
3. **Establish Clear Rules:** Set time limits for device use, and create no-screen periods during meals, study time, and family gatherings<sup>4</sup>.
4. **Lead by Example:** Parents should model healthy digital behavior by limiting their own screen time—especially during family interactions<sup>4</sup>.
5. **Collaborate and Raise Awareness:** Cooperation between parents, healthcare providers, and educators is important in raising awareness of digital media's risks and benefits through targeted campaigns<sup>4</sup>.

Teachers also play an important role in helping students prevent musculoskeletal problems in the classroom. Studies have shown that teaching children about posture through both lessons and practical demonstrations is more effective than theory alone. Students who had hands-on training were better able to improve their posture and reported fewer complaints of pain<sup>67</sup>. Follow-up studies also found that when students learn to notice and adjust their own posture—called **postural literacy**—they experience less pain and maintain better habits over time<sup>68,69,70</sup>.

Together, ergonomic education and consistent support from parents and teachers form a strong foundation for reducing the risk of musculoskeletal disorders in school-aged children.

## 2. ERGONOMIC BACKPACKS AND LOAD DISTRIBUTION

Educating students and parents about proper backpack usage is essential<sup>5,35,36,66,71</sup>, including recommendations for ergonomic designs<sup>12,71</sup> and weight limits<sup>5,42,44,29</sup> to help maintain posture and reduce spinal strain<sup>5,42,44</sup>. Adolescent back pain is a significant predictor of chronic back pain in adulthood, pointing to the need for early intervention efforts<sup>6</sup>. Most guidelines recommend that the backpack load should not exceed 10% of a child's body weight<sup>6,72,73</sup>. Exceeding this threshold can reduce erector spinae muscles activity and increase abdominal oblique muscle engagement, altering spinal load dynamics<sup>72</sup>. A 3% load was shown to reduce peak lumbosacral compression force, while a 10% load caused the most significant changes in spinal stress during walking<sup>71</sup>.

Ergonomically designed backpacks, such as the Trunkpack, improve gait symmetry and reduce biomechanical stress, offering a better alternative to traditional schoolbags<sup>74</sup>. Ergonomic backpacks distribute the weight evenly across the trunk through side pockets and connect to the body with upper and lower straps, preventing pressure from concentrating on specific areas of the body, thereby reducing discomfort and improving posture<sup>72</sup>. Suspended-load backpack designs have also shown benefits, reducing energy expenditure and lower limb muscle activity during walking and running by over 15% and 12% compared to traditional and fixed-load backpacks, respectively. However, they may increase shoulder strain and affect balance, requiring careful use<sup>75</sup>. A separate study also found metabolic and physiological advantages—including lower oxygen demand and improved performance—when using suspended backpacks compared to standard ones<sup>76</sup>.

Backpack use technique is just as important as design. Students who use both straps are less likely

to report neck pain<sup>57</sup>, while one-shoulder carrying can lead to muscular imbalance and poor posture<sup>47,48,77</sup>.

## Backpack Selection and Usage Guidelines

Backpack Features to Look For:

- **Proper size:** Should not exceed the width of the child's shoulders or hang more than a few centimeters below the waist<sup>66,77</sup>
- **Padded, adjustable shoulder straps:** Distribute the load evenly and prevent pressure on shoulders<sup>77</sup>
- **Padded back panel:** Protects the spine from sharp or bulky contents inside the backpack<sup>77</sup>.
- **Chest and waist straps:** Help distribute weight more evenly across the trunk and reduce strain on the shoulders and back<sup>77</sup>
- **Multiple compartments:** Improve load organization and balance<sup>77</sup>
- **Compression straps:** Prevent contents from shifting<sup>77</sup>
- **Reflective elements:** Improve visibility and safety in low light<sup>77</sup>

## Correct Usage Tips:

- Always use **both straps** to avoid asymmetrical load on the spine<sup>47,48,66,77</sup>
- Adjust and thigh straps so the backpack sits **high and centrally on the back**<sup>66,77</sup>
- Use all support straps—**chest, waist, and compression**—for stability and maximize support<sup>77</sup>

## Smart Packing:

- Avoid overpacking; children should carry only essential items for the day, non-essentials should be left at home, in a locker, or in the classroom<sup>77</sup>
- Place heavier items **near the back and bottom** to keep the center of gravity close to the body<sup>77</sup>
- Distribute contents across all compartments to maintain balance and prevent shifting during movement<sup>77</sup>

**It is also worth noting** that although rolling backpacks may reduce back strain, they are not ideal in all environments. They can be difficult to carry on stairs, obstruct hallways, and increase the

risk of tripping. Therefore, their use should be limited to appropriate settings and approached with caution<sup>77</sup>.

### 3. ERGONOMIC SMARTPHONE USE AND SCREEN TIME MANAGEMENT

Excessive smartphone use is one of the main contributors to musculoskeletal symptoms in school-aged children, particularly neck, shoulder, hand, and finger discomfort<sup>2,4,7,9,12,26,37</sup>. Preventive strategies must address not only how long devices are used, but also how they are handled physically. Reduced screen time has been associated with a decrease in musculoskeletal pain syndromes<sup>4,53</sup>.

#### Screen Time Limits

Managing daily screen time is an effective way to reduce strain and discomfort. Guidelines recommend:

- **Children under 2 years old:** Avoid screen time entirely<sup>4</sup>
- **Ages 2–5 years:** Limit to maximum **1 hour per day**<sup>4</sup>
- **Young children (Infants, toddlers and preschoolers):** Should not remain sedentary or inactive for more than 1 hour at a time, unless sleeping<sup>4</sup>

#### Encouraging Regular Breaks

Taking frequent breaks during device use helps prevent strain on the eyes, neck, back, and fingers<sup>7,11,14,17,62</sup>. One widely recommended approach is the **20-20-20 rule** (Every 20 minutes, look at something 20 feet or about 6 meters away for 20 seconds). This helps rest the eyes and encourages posture changes. Also adding **outdoor activities (at least 2 hours per day)** can help reduce musculoskeletal strain<sup>62</sup>.

#### Ergonomic Smartphone Habits

Teaching children how to use smartphones more safely is just as important as limiting screen time. Recommended strategies include:

- Avoid staying in one fixed posture for extended periods<sup>4</sup>
- Adjust device position to keep the neck and shoulders relaxed<sup>4</sup>
- Sit in a supportive chair or sofa that provides

proper support for the head, neck, back, and shoulders, and avoid using the device while lying down<sup>19</sup>.

- Use **both hands** to hold and operate the device to distribute the load and reduce strain on a single area<sup>18,41</sup>
- Take regular breaks to stretch and rest the hands and fingers<sup>4,9,14,18</sup>
- Use a **phone stand or holder** to maintain neutral wrist posture and reduce grip effort<sup>18</sup>
- Avoid placing the phone between the neck and shoulder, which increases strain on both areas<sup>18</sup>
- Avoid holding large or heavy phones in one hand for long durations<sup>4</sup>
- Reduce repetitive motions (like continuous typing or swiping) to prevent overuse injuries<sup>4</sup>
- Use **voice commands** or shortcuts to minimize physical input<sup>18</sup>
- Keep the head at a **slight angle (no more than 20°)** while standing or sitting with support<sup>22</sup>
- When possible, use the **non-dominant hand** to hold the phone and reduce joint stress<sup>41</sup>

Understanding the biomechanical implications of using different devices, such as smartwatches versus smartphones, can also inform recommendations for reducing musculoskeletal discomfort and improving user ergonomics<sup>40</sup>.

### 4. PROMOTING PHYSICAL ACTIVITY AND EXERCISE

Regular physical activity is essential for developing strong muscles that support the spine and improve posture<sup>27,52,53,62</sup>. Children who engage in physical activity are less likely to experience musculoskeletal symptoms<sup>25,53</sup>. The World Health Organization (WHO) recommends that children engage in at least 60 minutes of moderate-to-vigorous physical activity daily to enhance overall health, including musculoskeletal well-being, and reduce the risk of non-communicable diseases. For children and adolescents aged 5 to 17, physical activity can include activities such as play, sports, recreation, physical education, planned exercises, and active transportation, all integrated into family, school,

and community life. To enhance cardiorespiratory and muscular fitness, bone health, and cardiovascular and metabolic health, as well as to reduce anxiety and depression symptoms. More than 60 minutes of physical activity daily can offer additional health benefits. The majority of daily physical activity should be aerobic, with vigorous-intensity activities, including those that strengthen muscles and bones, being incorporated at least three times a week<sup>78</sup>.

- Childhood obesity is a modifiable risk factor for musculoskeletal disorders. Public health initiatives promoting healthy weight management and physical activity are crucial in preventing obesity-related musculoskeletal pain<sup>51,52</sup>. Exercise programs like integrative neuromuscular training (INT) have been shown to improve posture and movement in children with obesity, reducing the chance of pain or long-term issues<sup>79,80</sup>.

## 5. ERGONOMIC FURNITURE AND CLASSROOM ENVIRONMENT

The design of school furniture plays a crucial role in preventing musculoskeletal problems in children<sup>55</sup>. Many studies have shown that current furniture designs often do not align with the ergonomic requirements needed to promote proper posture and comfort among students<sup>3,81-83</sup>. It is essential to provide ergonomic furniture that can accommodate the physical needs of students, especially in classrooms<sup>3,55,56,81,82</sup>, to reduce poor posture and mitigate the risk of back pain and other musculoskeletal disorders<sup>82</sup>.

### Recommendations for Schools:

- Invest in adjustable desks and chairs that support proper posture and accommodate children of different sizes<sup>55,56</sup>
- Make sure that desks and chairs are positioned at appropriate heights so children can sit with their feet flat on the floor and their forearms parallel to the desk surface<sup>55</sup>
- Include ergonomic considerations when designing shared classroom tools like trolleys to ensure ease of use for all students<sup>58</sup>

### Furniture interventions and results:

Several studies have shown that using ergonomic furniture in schools can reduce physical complaints among students. One study replaced traditional classroom seating with adjustable ergonomic chairs and desks and found that students reported less musculoskeletal discomfort particularly in several body regions<sup>83</sup>. In addition, students showed better focus and academic performance, suggesting that physical comfort and posture can positively affect learning and focus<sup>83</sup>.

Another study examining the use of height-adjustable desks found that combining ergonomic furniture with initiatives to limit prolonged sitting helped reshape sitting behavior in children without increasing discomfort or pain. These findings emphasize that well-designed school environments can play a crucial role in promoting both musculoskeletal health and educational outcomes<sup>84</sup>.

## 6. PSYCHOLOGICAL, VISUAL, AND LIFESTYLE CONSIDERATIONS

Musculoskeletal symptoms in schoolchildren are not only caused by physical factors but also influenced by psychological and visual issues. Excessive screen time, particularly from entertainment and social media, has been linked to increased stress, poor emotional well-being, and a higher risk of neck and back pain<sup>32,53,65</sup>. Parents and caregivers should monitor digital media use to support both mental and physical health.

Vision also plays an important role in posture. When children experience difficulty seeing clearly, they may adopt awkward positions while reading or using screens, which can lead to neck, shoulder, or back pain<sup>9,85</sup>. Encouraging proper reading posture, screen adjustments, and the use of prescribed eyewear when needed can help reduce this strain<sup>9,64,85</sup>.

Psychosocial stress, anxiety, and poor general well-being have also been associated with spinal pain and musculoskeletal discomfort in children<sup>32,53</sup>.

In addition, excessive homework—especially when done without proper posture—has been linked to



shoulder pain<sup>32</sup>.

Addressing these emotional, behavioral, and visual factors is essential to creating a well-rounded approach to musculoskeletal health in school-aged children.

## Conclusion:

The increasing use of cellphones and the daily burden of carrying backpacks have played a major role in the rising rates of musculoskeletal disorders (MSDs) among schoolchildren. Factors such as prolonged screen time, poor posture, heavy backpack loads, and inactive lifestyles place children at risk for conditions like text neck syndrome, back and shoulder pain, pinky deformity, headaches, and eye strain. These physical symptoms can also affect cognitive function, emotional health, and overall quality of life.

Addressing these issues requires a multi-layered approach that combines ergonomic education, supportive school environments, and healthier lifestyle habits. Parents, teachers, and healthcare providers each play a key role in prevention—from encouraging proper posture and regulating screen time to promoting physical activity, monitoring backpack use, and supporting the use of ergonomic classroom furniture. It's also important to help children develop healthier technology habits and provide emotional support to manage stress, as both can lower the risk of musculoskeletal problems.

As digital habits continue to evolve, future research should explore the long-term effects of smartphone use and backpack load on musculoskeletal health in children. Longitudinal studies can help evaluate the effectiveness of preventive strategies over time. Exploring the link between physical discomfort and mental health can also provide valuable insight into more complete approaches to care.

Schools and policymakers must work together to integrate ergonomic principles into education systems and promote early, proactive health

behaviors. Taking action now can help reduce the long-term burden of musculoskeletal disorders and support the well-being of a healthier, more active generation. Moving forward, it will be essential to continue evaluating and refining these strategies to meet the physical and psychological needs of children in a digital world.

Above all, the most urgent step is for schools and families to recognize musculoskeletal health as part of children's overall development—and to treat posture, movement, and screen habits with the same priority as nutrition and learning.

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