Children Development and Screen Exposure Time Effects: A Review article

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Abstract

This review explores the impact of screen exposure on early childhood development, focusing on physical, cognitive, language, and socio-emotional domains. Early childhood, particularly the first five years, is critical for achieving developmental milestones, driven by complex neurodevelopmental processes such as synaptic pruning and myelination. Various biological, environmental, and psychosocial factors influence this developmental trajectory. Recently, increasing screen time due to digital media use has raised significant public health concerns. Although interactive and educational screen content can support certain cognitive and language functions, excessive or passive exposure is linked to developmental delays. Prolonged screen time is associated with reduced executive functioning, lower language acquisition, impaired social skills, and delayed motor coordination. The review highlights that passive screen use—especially before the age of two may interfere with essential face-to-face interactions needed for language and emotional development. Furthermore, excessive screen time is linked to reduced physical activity, negatively affecting gross and fine motor skills. Factors moderating these effects include the type and duration of content, parental engagement, and the quality of the home environment. Early developmental delays, especially in language, remain a significant global concern, particularly in low- and middle-income countries. Timely screening and parental awareness are essential to identify and mitigate risks. This review underscores the importance of balanced screen use, emphasizing quality content, parental involvement, and the promotion of traditional play and social interaction to foster healthy child development in the digital era.

Key words: Child development; Screen time; Developmental milestones; Early childhood; Cognitive development.

Introduction:

'Screen time' refers to time spent with any screen, including smartphones, tablets, televisions, video games and computers. Potential risks of screen exposure are categorized into developmental, psychosocial, and physical domains. Children younger than 5 years learn best from live, face-to-face interactions with family members and caregivers.

Developmental milestones in children

Developmental milestones are sequentially occurring behavioral and physical capabilities that provide a general framework for assessing child growth. These milestones progress in an orderly manner, from proximal to distal and cephalic to caudal, shifting from reflexive reactions to goal-oriented actions (1). They serve as indicators of typical versus delayed development and cover multiple domains, including

motor, cognitive, social-emotional, and language abilities (2,3). Although children develop at individual paces, these milestones provide a baseline for monitoring their progress (4).

The first five years are particularly critical as the brain undergoes extensive neurodevelopmental transformations. Processes such as neurogenesis, synaptic pruning, and myelination shape the brain's long-term structural and functional capabilities (5). Various biological and psychosocial factors influence this development, creating individualized trajectories (6,7).

Factors affecting children's development

Biological risk factors include genetic attributes, nutritional status, intrauterine growth, and exposure to infections. Genetic influences regulate key growth aspects, including predisposition to neurodevelopmental disorders like ASD and ADHD (8). Malnutrition, particularly iron and iodine deficiencies, significantly impacts cognitive outcomes, motor development, and educational attainment (7,9). Conditions such as intrauterine growth restriction (IUGR) can lead to reduced brain volume and cognitive impairments. Infections during early childhood further threaten neurodevelopment through direct central nervous system involvement or indirect nutritional depletion (10,11).

Environmental exposures including heavy metals and air pollution, are major concerns. Toxins such as lead, mercury, and bisphenol A disrupt cognitive and motor development, particularly during critical neurodevelopmental windows. Over 92% of the global population is exposed to harmful air pollutants, exacerbating developmental risks (12).

Psychosocial factors encompass early childhood adversities like violence, neglect, and parental mental health issues. These experiences can alter neurological pathways, leading to long-term cognitive and emotional consequences. Studies indicate that nearly 59% of children in developing nations have been exposed to abuse, significantly impacting developmental outcomes (13,14).

Domains of developmental milestones

Specific developmental milestones are categorized within larger domains. Developmental milestones have been settled in motor skills (gross and fine), cognitive, socio-emotional, and communication including receptive and expressive language domains (15).

1. Gross motor development

Gross motor development involves the coordination and movement of large muscle groups, including the torso and limbs, and progresses from reflexive to goal-oriented actions. Newborns exhibit innate movements and reflexes that prepare them for more advanced motor skills, which become intentional as the central nervous system matures. As infants grow, they develop greater strength, balance, coordination, and speed, enabling independent mobility and exploration (16,17).

Factors such as prematurity, prolonged positioning in car seats or strollers, and excessive swaddling can contribute to motor skill delays (18). Movement patterns follow cephalocaudal (head-to-toe) and proximodistal (center-outward) principles, guiding the progression from instinctive reflexes to more controlled motor skills like grasping and responding to stimuli. Ensuring opportunities for movement and exploration is crucial for healthy motor development (16,17).

2. Fine motor development

Fine motor skills involve the coordination of small muscles, particularly in the fingers and wrists, requiring precise hand-eye coordination. The evolution of the thumb and its role in grasping has been

crucial in human functional development. These skills include gripping, drawing, cutting, folding, and manipulating objects, which are essential for daily tasks and cognitive engagement (19).

The upper extremities initially support balance and movement, aiding in gross motor functions like rolling, crawling, and standing. Infants begin using their hands to explore early on, and as gross motor skills advance, fine motor abilities develop further. Fine motor milestones are interconnected with cognitive, visual, and gross motor development, allowing for more refined and independent hand use as children grow (17,20).

3. Language development

Language is a fundamental trait that enables human communication and social interaction, fostering mutual understanding. It begins in early childhood through interactions with parents and caregivers, helping children grasp language structures and complexities.

Language development progresses from basic sound expressions and gestures to clear, structured speech. Around 18 months, children's vocabulary expands significantly, with receptive vocabulary—understanding words—developing alongside spoken language. Early exposure to rich language environments plays a crucial role in shaping linguistic abilities (21,22).

4. Cognitive development

Cognitive development refers to the maturation of various thinking processes, including perception, memory, problem-solving, and reasoning. It begins at birth as children explore and experiment with their surroundings, with curiosity driving their learning process (23).

Early childhood is a crucial period for cognitive growth, with rapid brain development occurring. During this stage, children refine their thinking skills, becoming more analytical and deliberate in decision-making. Parents play a key role in nurturing cognitive abilities and self-control, significantly shaping a child's intellectual development (24,25).

5. Social and emotional development

Social relationships, broadly known as connections with other individuals, can affect behavioral and health status. It is well established that social and relational contexts are crucial for both cognitive growth and emotional health. The development of solid relationships that children build between the ages of birth and five can be advantageous for the rest of their life (26,27).

Relationships between children and their caregivers are essential to early childhood development and play a significant socialization function. Early interactions and social environments are crucial for children's emotional, intellectual, and social development into adulthood and can have a substantial impact on the child's lifelong adaptation strategies (28).

Developmental milestones from birth to 24 months

From birth to 3 months, infants begin developing gross motor skills by lifting their heads while lying on their stomachs and kicking their legs when on their backs. Fine motor skills emerge as they grasp objects reflexively and briefly follow objects with their eyes. Cognitive development begins with basic visual tracking, while language development involves cooing and making vowel sounds. Socially, infants respond to caregivers' voices and touch.

Between 4 and 6 months, babies start rolling over from tummy to back and sitting with support. Their fine motor skills advance as they reach for and grasp objects, transferring them between hands.

Cognitively, they explore objects by mouthing and recognize familiar faces. Language skills progress with babbling sounds like "ma-ma" and "da-da," and socially, they smile and express joy.

At 7 to 9 months, babies sit without support and begin crawling. They develop a pincer grasp and start banging objects together. Cognitive skills improve with an understanding of simple gestures and object permanence. They imitate sounds and gestures, respond to their names, and show social-emotional attachments, including fear of strangers.

Between 10 and 12 months, babies stand with support and cruise along furniture. Fine motor skills become more refined as they frequently use a pincer grasp and place objects into containers. They begin understanding simple instructions, saying their first words, and pointing to objects or pictures. Socially, they show independence, preferences, and dislikes.

From 13 to 18 months, toddlers walk independently and climb stairs with help. They start scribbling with crayons and building block towers. Cognitive abilities develop as they begin solving simple problems and recognizing body parts. Language expands with simple phrases, and they display empathy and affection, engaging in basic pretend play.

By 19 to 24 months, children run and jump, turn pages in books, and stack blocks into towers. They start sorting shapes and colors while understanding simple concepts. Language skills grow with 2–3-word sentences and the ability to follow simple directions. Socially, they express independence, defiance, and an increased desire for autonomy (4).

Developmental delays

Delays in achieving these milestones indicate potential developmental concerns, which may manifest as isolated, multiple, or global developmental delays. Global developmental delay (GDD) affects multiple domains, leading to significant functional impairments. Early detection is critical, as interventions initiated during early childhood yield better long-term outcomes. An estimated 52.9 million children worldwide experience developmental delays, with higher prevalence in low- and middle-income countries (29,30). In Egypt, 6.7% of children present developmental delays, with language deficits being most common (31).

Early surveillance and screening play a crucial role in identifying developmental delays. Pediatricians and caregivers employ standardized screening tools, such as the Ages and Stages Questionnaire (ASQ), to assess children across developmental domains (Squires et al., 2009; Singh et al., 2017). Routine screenings at 9, 18, and 30 months, as recommended by the AAP, enhance early identification and intervention efforts (32,33).

There are several developmental screening instruments, either administered by a health care provider or completed by caregivers, have been validated, and can assist the process of early detection along the path to early interventions. The ASQ, now in its third edition, is a widely used developmental screening tool designed to assess the developmental progress of children from birth to 5 years of age.

The ASQ is widely recognized for its reliability in early developmental assessments. It evaluates communication, motor, cognitive, and personal-social skills through parent-reported responses, categorizing children as "on schedule," "monitor," or "refer" for further evaluation. Although it does not provide a clinical diagnosis, it serves as a valuable tool for early intervention planning (34,35).

Screen exposure and developmental outcomes

In the digital age, children's daily experiences have significantly changed due to the widespread use of screens, raising concerns about their developmental milestones. Developmental milestones include cognitive, motor, language, and socio-emotional domains. According to recommendations by the American Academy of Pediatrics (AAP), screen time should be limited for children aged 0 to 2 years old (except for video chatting), and no more than 1 hour per day of highly educational content for children aged between 2 and 5 years (36)**.** Additionally, several international health organizations advise parents to limit screen time for kids under the age of five (e.g., German Federal Ministry of Health, 2016; Australian Department of Health, 2017; Canadian Pediatrics Society, 2017).

Studies indicate that higher screen time exposure (≥4 h/day) at one year of age is linked to developmental delays at two years and persists up to four years. The term "glow kids" has emerged, reflecting concerns regarding excessive screen exposure. Given the increasing integration of digital media into children's lives, it is crucial to understand both the benefits and risks associated with prolonged screen use (37,38).

Cognitive Development

Screen media has both beneficial and detrimental effects on cognition. While educational content can enhance early reading skills, problem-solving, and vocabulary development, prolonged exposure can negatively impact executive functioning, self-regulation, and academic outcomes (39,40). Excessive screen use in early childhood is linked to decreased attention span, poor working memory, and reduced inhibitory control, potentially affecting classroom participation and cognitive flexibility. Additionally, rapid scene changes in digital content may overstimulate young minds, leading to difficulties in sustained focus and delayed cognitive processing skills (41).

While interactive media can support cognitive growth, passive screen exposure, such as watching non-educational programs for extended periods, has been associated with lower language and numeracy skills in preschool-aged children. Studies suggest that personalized, interactive content that encourages problem-solving and parental engagement can mitigate some of the negative impacts of screen exposure (42,43).

Language and Communication Development

Language development relies on rich, interactive experiences. Passive screen exposure before age two is associated with reduced vocabulary acquisition and delayed syntax and grammar skills. Excessive screen use can limit face-to-face interactions, affecting essential communication skills like turn-taking and active listening. Research suggests that children exposed to prolonged passive screen time may struggle with expressive language skills, which are crucial for social integration and academic success (44,45).

However, structured digital tools, such as interactive storybooks and language learning apps, may enhance vocabulary development when combined with active parental involvement. The quality of screen interactions is key, as children who watch educational programs alongside caregivers often exhibit better comprehension and language retention than those left to watch independently.

The impact of screen exposure on literacy development is also noteworthy. While screens can offer educational content that supports literacy skills, excessive or inappropriate screen exposure might interfere with the acquisition of pre-literacy skills, such as phonological awareness and print recognition. These foundational skills are critical for later reading and writing abilities, making it important to balance screen use with traditional literacy-promoting activities (40).

Socio-Emotional Development

Screen time affects social interactions, with both positive and negative outcomes. Digital platforms can foster social connections, yet excessive screen use may lead to social isolation, reducing real-world interpersonal skills. Overuse of digital media can limit direct human interactions, impacting the development of empathy, emotional intelligence, and self-regulation (47).

Prolonged exposure to violent and fast-paced content is associated with increased ADHD-like behaviors and antisocial tendencies. Studies have found that children frequently exposed to high-action or aggressive digital content tend to exhibit increased impulsivity and difficulty in emotional regulation. Additionally, screen addiction may result in neurological changes affecting emotional regulation, leading to symptoms similar to those seen in behavioral disorders(48,49).

On the positive side, structured social media use and interactive video communication platforms can support social development, especially in fostering peer relationships in a controlled environment. The key determinant is the type of content and parental guidance in ensuring balanced digital interactions.

Motor Development

Gross Motor Development

Excessive screen time is linked to decreased physical activity, hindering gross motor skills such as balance and coordination. Studies show that screen use alters brain white matter integrity, which is essential for motor functions. Reduced engagement in physical play can negatively impact spatial awareness and movement control. Additionally, children who spend prolonged periods sitting and engaging in screen activities may develop poor posture and weaker core muscles, affecting overall motor coordination (50).

Reduced engagement in physical activities due to excessive screen time might affect a child's sense of balance and coordination. Developing these skills typically involves practice and engagement in various physical activities that challenge the body's movement, spatial awareness, and control. Lack of diverse movement experiences due to increased screen exposure might hinder the refinement of these skills (50).

Fine Motor Development

Fine motor skills, involving coordination and dexterity, may be influenced by touchscreen interactions. While touchscreen use can enhance hand-eye coordination, it lacks the complexity of traditional activities like writing or manipulating objects, leading to lower muscle strength and coordination (51). However, moderate touchscreen use within recommended durations does not negatively impact fine motor skills (52,53).

Fine motor skill development is particularly essential for early childhood education. Traditional activities such as cutting with scissors, assembling puzzles, and drawing support the development of dexterity and coordination. While touchscreen activities involve finger movements, they often do not provide the resistance and precision necessary for refining fine motor control. Educators and caregivers should encourage a balance between digital and hands-on activities to ensure comprehensive motor development (54).

Factors Moderating Screen Exposure Effects

1. Duration and Type of Screen Time

The amount and nature of screen content determine its impact. While excessive use may be detrimental, educational and interactive content can have positive effects. Guidelines emphasize the importance of limiting passive screen exposure and ensuring that children are exposed to high-quality, age-appropriate material (55).

2. Parental Involvement and Screen Time Rules

Parental engagement is crucial in mitigating negative effects. Setting boundaries, co-viewing content, and modeling responsible screen habits improve outcomes. Studies suggest that children whose parents actively participate in their screen experiences develop stronger language skills and better emotional regulation (56,57).

3. Home Environment

A stimulating home environment supports cognitive and language development. Independent of socio-economic status, a well-structured home setting enhances school readiness and social functioning. Providing children with diverse learning experiences, including reading, outdoor play, and creative activities, can counterbalance the negative effects of excessive screen exposure (58,59)

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