Children and Computer Use: The Impact on Learning and Visual Development

■ **Edward C. Godnig, O.D.**

Abstract

Children starting as young as three years old are using computers for recreational game amusement and educational enrichment. This can result in less physical activity for the child. There is growing concern from educators and governmental agencies regarding the dangers of excessive computer use at young ages. These include developmental, physical and ergonomic considerations. Two optometric paradigms also stress the importance of physical activity in visual development. Thus, limiting physical movement through space during critical childhood developmental stages can alter general development and learning related visual abilities. Further, the American Optometric Association has defined a Computer Vision Syndrome. The role of optometrists in evaluating and providing therapeutic services for the pre-school child is discussed along with offering developmentally appropriate guidelines for computer use and activities that foster the acquisition of age appropriate visual-motor abilities. Suggestions for how optometrists can increase public awareness of the dangers of excessive computer use at young ages, along with pertinent research are made.

Key Words

computers, computer vision syndrome (CVS), child development, ergonomics, Getman, movement, pediatric optometry, Skeffington, visual development, visual-motor

INTRODUCTION

The use of computer software educational programs and computer generated games, have become commonplace in the United States. A high percentage of elementary schools introduce children to the basic skills of computing. Increasingly, schools are introducing computer- based curriculum as a component of the general education of elementary aged students. During the 1997-98 school year, there were 23,499,195 students enrolled in U.S. elementary public schools. The number of computers totaled 3,409,082, yielding a 6.9 ratio of elementary school students per computer.[1]

Software programs are now being used by elementary school teachers to teach skills related to reading and mathematics. These programs can reinforce and supplement traditional teaching methods for reading and mathematics. Teachers are becoming more adept in finding skillfully designed computer programs that have a positive effect on reinforcing well established teaching protocols of using books and hands-on learning methods. When used judiciously and as a supplemental tool, computer software programs can have a beneficial influence on early childhood education.

A high percentage of homes in the U.S. have computers that allow children access to their use. A comparison of the percentage of students using a computer at home or at school during 1984 as compared to 1996 illustrates a growing trend of children using computers. The percentage of grade four students in 1984 that used computers to play games was 71.8%; to learn things 67.9%; to write papers 23.4%. The percentage of grade four students in 1996 that used computers to play games was 89.7%; to learn things 87.5%; to write papers 79.2%. [2]

For those children without a personal home PC, friends often provide them with access to a computer, most commonly to play computer games. Today's youth learn to play computer games as an expected rite of development in our high tech society. These games help teach many of the basic skills necessary to use a computer, such as the use of the mouse and/or joystick, basic keyboard commands, starting and ending programs, and learning how to save and store files. Learning these basic skills enable youngsters to feel comfortable with computing and give them an ability to learn to use educational software more easily at school. The benefits of being familiar with computer technology will assist young students as they proceed through school.

And it can be argued that using a computer from an age as early as 3 years can have a positive impact on developing eye-hand coordination as when using the mouse to control the cursor. Additionally, most simple computer games require an ability to move eyes from one point of fixation to another as action proceeds on the computer screen. Basic eye movement skills can be trained while engaging in developmentally appropriate computer games. Of course, effective synchrony of the accommodative/convergence complex is necessary for the child to maintain clear and comfortable single vision on the monitor's visual display. These basic visual skills can be developed and improved to a certain extent while engaging in computer games.

However, I propose that caution must be exercised to avoid the overuse of computer programs as a learning and educational tool. Basic educational concepts and basic visual developmental skills can be reinforced while using computer programs. However, dynamic experiences while moving through and engaging the physical environment is of paramount importance for establishing the foundational abilities necessary for visually based learning aptitudes. Some educators report that children in our electronic society are becoming deficient in generating their own images and ideas.[3]

The National Science Board reported in 1998 that prolonged time with computer use may create "individuals incapable of dealing with the messiness of reality, the needs of community building, and the demands of personal commitments."[4] Youngsters need time and experience talking with parents and educators to develop language abilities that are built upon to later develop critical reading, writing and speaking skills. There is a calling by more and more early childhood educators to refocus attention in furthering the essentials of a healthy childhood to include nurturing strong bonds with caring adults, time for spontaneous and creative play, reading books aloud, storytelling, building things and spending more time in nature. All these activities require human interaction with children. Educational psychologist Jane Healy states that, "As a child learns to put movements in order, brain areas are primed to put words and ideas into a logical sequence."[3 (p. 122-3)]

There is a body of literature from a number of professions dealing with child development and education that indicate concern for computer overuse. These are discussed below.

MUSCULOSKELETAL INJURIES AND ERGONOMIC CONCERNS

Many schools and parents are allowing children to use computers in ways that increase the risk of stressing their bodies. Often the keyboard and monitor placements are higher than the ergonomic recommendations. A study of computer workstations at 11 elementary schools clearly demonstrated unhealthy typing postures. The researchers of this study concluded that up to 40% of the children using computers at these schools were at risk of serious injury.[5]

A high percentage of classrooms in the U.S. use fluorescent lighting to illuminate the room. This type of lighting is adequate for reading text and viewing written words on a board, but is much too bright for comfortable computer screen viewing. This mismatch of lighting creates an ergonomic design challenge that often is not addressed in most school settings.

Young children tend to work much closer to the computer monitor than the 18-28" working distance suggested by computer ergonomic specialists. Also, when the computer monitor is positioned too high, this can lead to an upward gaze while viewing the screen. These awkward viewing angles can lead to excessive amounts of superior gaze eye and head movement patterns. Forrest postulated a model that describes a relationship between changes in astigmatism and an observable triad consisting of head scan, head movement and head posture.[6] In this regard awkward computer related visual viewing angles could result in an increasing prevalence of astigmatism in upcoming generations.

LACK OF EXERCISE AND OBESITY

A national news magazine stated that children spend more time sitting in front of electronic media and less time actively playing at home and school. Because they consume so many high-fat, high-sugar foods, the chances of developing obesity has increased in recent years. Medical studies show that children who grow up obese also are at higher risk of becoming adults having diseases such as hypertension and heart disease.[7]

In the summer of 1999, former U.S. Surgeon General David Satcher is quoted as saying, "We have the most sedentary generation of young people in American history."[8]

A 1999 study by the Kaiser Family Foundation concluded that school-aged children spend on average some four hours and 45 minutes a day plugged into electronic media of all kinds.[9] If you assume that a typical child spends seven hours per day in school, one hour preparing for school and traveling to and from school, nine hours sleeping, and about five hours viewing electronic media, this leaves two hours per day available for free and spontaneous play time. Is this amount of free time adequate to allow children the experiences necessary to move through and explore their environments, as well as get adequate exercise to promote good health?

A possible further reduction in exercise time for children is highlighted by the fact that many schools have reduced or eliminated recess in a move to make more time for computer classes and deskwork. Yet this trend runs against other studies that show that children return from outdoor recess with a new surge of energy for paying attention to their studies.[10]

CHILDHOOD DEVELOPMENT AND LEARNING RESEARCH

There are consistent themes that permeate many early childhood development studies that investigate how children learn about themselves and their relationship to their environment.[11] Some studies indicate that early childhood learning primarily takes place through the use of the whole body in a truly "hands-on" approach to exploring the world. The dramatic changes in purposeful movement control, beginning from the relative immobility of a newborn to the crawling, grasping, walking and running of a maturing toddler, illustrate the paramount importance of allowing children ample opportunity to move their bodies through space.

Intellectual development (and some optometrists can argue, visual development) is rooted in childhood experiences that combine healthy emotional relationships, ample human touch, physical engagement with the real world, and using creativity and imagination during play. Overuse of computer time can hinder these types of primary learning experiences. As children move through space and time, feedback from muscle proprioception, as well as feedback from body and eye position kinesthetics, work in unison to assist children in learning about spatial localization abilities such as distance, size, shape and relative speed. These primary experiences lay the foundation for later abstract thinking abilities.

There is an emerging trend in the 21st century, involving a 'movement deficient style' of educating children. Some researchers claim that children of elementary-school age and younger are neither intellectually nor visually mature enough to benefit from using computer software programs beyond short periods of experimentation and exposure times. Researchers state time and again that computer technologies are advanced tools that do not fully engage young bodies and eyes in the experiential ways essential for optimal development. There is the risk that some computer programs can overwhelm young children with abstract information about adult realities. [12]

Kate Moody, a researcher on reading and electronic media at the University of Texas at Gainesville, reports that "experts now realize that creating things with your hands to develop the brain, music and songs cause the student to focus on sounds within words and spatial relationships, while body movement of all kinds produce physical, mental and cognitive benefits." [12]

Recently, an Indiana University research team concluded, "Visual-motor integration (VMI) skill appears to be one of the best cognitive information processing predictors of achievement during the first two years of school."[13]

Any discussion of childhood development and learning would be somewhat incomplete without a comment of how Piaget understood the importance of movement through space. He suggested that children up to about the age of seven are biologically ready to learn intuitively about the world through their senses, movement, and handling objects, especially through play and imitation. He theorized that through sensory and motor experiences in the world, children take their "first steps in numerical and spatial intuition", which prepares them for later logical and verbal abstractions.[14]

OPTOMETRIC MODELS OF VISION DEVELOPMENT

Skeffington

Optometry has a long and rich history of explaining the important role movement plays in developing vision. In the 1940s and 1950s, A.M. Skeffington built a model of how vision emerges out of four intersecting circles comprising the learning process of vision.[15] He named the interlocking circles Anti-gravity, Centering, Indentifications and Speech-Audition. A brief review of a few highlights within each circle process can better explain how the emergent, what can be defined as vision, involves various movement related learning elements.

Anti-gravity (or Locomotion) encompasses a set of abilities that allow a child to purposefully move through space. This segment of the model answers the question of "where am I?" in space. Visually directed movements allow a child to orient himself in space, and over time, project these internal coordinates such that relationships of objects relative to self can be judged. The ability to organize oneself with respect to gravity, and develop internal spatial coordinates and postural stability, is heavily influenced by how children move their bodies through space.

Centering (or Location) is the set of abilities that answer the question "where is the object of attention located in space?" It allows the child to direct his visual attention at a specific location in space. Kinesthetic and proprioceptive feedback is necessary to develop internal spatial coordinates that are used as the basis from which relative projections into space can be made. Movement is a necessary ingredient allowing for these types of feedback mechanisms to function. Centering skills are influenced by how well a child is developing the Anti-gravity skills, illustrating the importance of how each of the interlocking circles need to be integrated to develop optimal vision. In the early stages of this process, movement plays a critical as an integrating force in building a visual-motor based spatial solid.

The identification circle (or Labeling) answers the question of "what is it?" Determining the details of size, shape, color, texture, form, and contrast, and then piecing together the essence of an object of visual attention, requires many developmental learning processes. Early development of this identification process involves movement to within reach of the object of regard in order to manipulate it to gain touch and feel sensations used as integrating reinforcements of the visual image. Movements related to grasping and manipulating are the beginning movement processes used as building blocks for higher order visual discriminations and interpretations.

Skeffington's final circle, Speech-auditory (or Language), answers the question of "what can I tell you about it?" This circle is necessary so that humans can share visual experiences with others. Language allows children to share temporal and spatial understandings as they learn to express their newly learned visual experiences. The idea of relating directly with other human beings is what language skills offer developing young minds. Computer technology does not always allow a child to provide auditory responses to visual information.

The common intersection of the four L's of learning to see (Locomotion, Location, Labeling and Language) is where vision emerges. Skeffington's comprehensive model of vision development understood the importance of movement. This active, dynamic process can not be fully realized only using computer generated images for child to explore and manipulate.

Getman

Getman proposed a "visual-motor hierarchy" to further elaborate visual development from the standpoint of its relationship with movement. He postulated that in this relationship, motor behavior in early infancy is the child's primary method of dealing with the outside world (motor phase). At a second stage, vision becomes involved at the direction of motor (motor-visual) and still later this relationship reverses (visual-motor). In the last phase vision becomes dominant and motor behaviors act under the direction of vision (visual). [16]

Thus, according to this model, a child learns about the world by initially using the hands as the primary investigation tool for spatial exploration. Over time the hands and the eyes begin to work as a team as the hand movements lead the eye movements. Finally movement through space leads vision exploration. Eventually the eyes begin to lead the hands. As the child matures, actions become progressively more visually based and less motor based. More and more learning opportunities become visually dominated, as movement and motor integration and reinforcement becomes less necessary. The ultimate stage of development within this model is visualization, the ability to use pure visual imagery without the need for motor reinforcement. Interestingly, however, the highest developmental ability of visualization helps to initiate motor responses if what one is visualizing involves a movement action, as in sports. Thus, visualization still has a primary linkage to movement

COMPUTER VISION SYNDROME (CVS)

CVS is defined by the American Optometric Association as "the complex of eye and vision problems related to near work which are experienced during or related to computer use. CVS is characterized by visual symptoms which result from interaction with a computer display or its environment. In most cases, symptoms occur because the visual demands of the task exceed the visual abilities of the individual to comfortably perform the task."[17]

I propose that CVS can be included as one of the "nearpoint visual stress" models. Other nearpoint stress models include a behavioral model of visual stress, which Forrest proposed as; "The initial visual response to a stressor is a sympathetic nervous system reaction. The tendency to posture accommodation outward in space in relation to both the identification process of which it is a part, and to the centering process creates an internal dissonance that the organism attempts to resolve in some way. They function together best with the least amount of dissonance and, therefore, there is an organismic advantage toward minimizing all forms of imbalance whenever possible."[18]

Generally these models have a common element by proposing that the immobility that often accompanies persistent near use of the eyes (most commonly seen during reading and computer work) is biologically unacceptable to humans. These models suggest that prolonged and persistent near point viewing tasks have the potential to lead to "visual stress." Visual stress if often defined as an imbalance between accommodation and convergence. When accommodation and vergence cannot be brought into balance, various adaptive behaviors are utilized to regain accommodation and vergence coordination and balance. It is hypothesized that some of the more common adaptations to visual stress include myopia, symptoms such as brow ache, or avoidance of near point tasks that cause discomfort.[15]

The public health issue that Skeffington, Getman and CVS models have in common is the potential risk that relative immobility has on early childhood development. It seems clear that the optometric models of vision development, along with other child development learning models, emphasize the need for dynamic, active, attentive and purposeful body and mind movement through space for normal general and visual development to optimally occur.

OPTOMETRY'S ROLE IN RAISING THE PUBLIC HEALTH ISSUES RELATED TO CVS

Clinical Interventions

While comprehensive optometric evaluations are necessary for all children, those from 3 to 6 years of age often require special considerations. Protocols that include developmentally based expecteds for this age group have been described in detail.[16, 19-21] In addition to the basic optometric battery of ocular health, refractive, oculo-motor, binocular and accommodative-convergence testing, assessments of general development, fine motor, gross motor and visual-motor development are included. It is important that the optometrist be cognizant of the developmental progression of these visual areas both in the testing and interpretation of the findings. I recommend that in addition, the usual history should include questions regarding the time the child reached developmental milestones, e.g., walking, talking, and the amount of time spent at the computer along with the ergonomics of the workstation. When visual functional and/or developmental problems are diagnosed, the usual optometric interventions should be instituted.

Provide Information

Another important contribution optometrists can make is to inform and educate parents, teachers and other child health professionals of the prerequisites for normal visual development and recommendations in this regard to attain healthy and productive use of computers by children. I have found it beneficial to discuss in detail child based computer ergonomic issues such as: proper chair design (adjust chair to fit body, keep back supported, both feet flat on floor or footrest); monitor screen location (top of screen slightly below eye level, eyes 18 to 28 inches from screen); keyboard and mouse placement (so that arms hang loosely and forearms are parallel to floor, and wrists maintain a neutral position); breaks (take a walk away from computer workstation every 15 minutes; room lighting (insure that there is no glare on screen and overhead lighting is relatively dim).

Optometrists can recommend guidelines for daily amounts of time children spend on the computer. I have intuitively developed the following schedule for children 3-12 years: At age 3, the maximum recommended time per day using a computer is 30 minutes. For every year add five minutes per day to the 30-minute baseline. By age 12, the daily time is 75 minutes per day.

Optometrists should be willing and able to inform the general public of the importance visual development, including the role that movement plays in the early stages of its development. Clinicians should make it well known that there exists methods of assessing and ameliorating visual development and visual stress anomalies, and that effective treatments are available for visually related learning problems.

Institute Research

Long standing and newly emerging questions related to optometric diagnosis and treatment of CVS in the pediatric population, remain to be answered. Topics that require further elaboration include determining:

- how much spontaneous play and movement activities are necessary for different aged children such that optimal eye-hand-body and visual development occurs.
- whether there is a relationship between the amounts of time spent on computer viewing and the prevalence of myopia or other refractive errors.
- the most effective way that optometry can inform the public of the potential

negative consequences to children's general and visual development.

the efficacy of "stress relieving lenses" or "computer lenses" on the symptoms and visual dysfunctions associated with CVS.

SUMMARY

Designing research projects that answer these challenging questions will provide optometry with additional strength to actively advocate for responsible use of computer technology for children. Optometry already possesses ample information that can be shared with the public to begin to illuminate the need to pay close attention to how our children are interacting with computers. Optometrists have a responsibility to help insure that the present and future generations of children are given ample opportunities to develop optimal learning related visual abilities. Establishing guidelines on recommended pediatric use of computers in relation to visual development, can serve as a valuable tool for helping children learn to benefit from using computer technology.

References

1. Market Date Retrieval, Shelton, CT, unpublished data (copyrighted), 1999.
2. Department of Education, National Center for Education Statistics, NAEP (US). Trends in Academic Progress (NCES 97-985). Washington, DC, 1996.
3. Healy J. Failure to Connect: How Computers Affect Our Children's Minds. New York: Simon and Schuster, 1998.
4. National Science Board. Children, Computers, and Cyberspace. Washington, DC: Science and Engineering Indicators, 1998:8-23.
5. Oates S, Evans G, Hedge A. A preliminary ergonomic postural assessment of computer work settings in American elementary schools. Computers in the Schools 1998.
6. Forrest E. Astigmatism as a function of visual scan, head scan, and head posture. Am J Optom & Physiol Optics 1980;57:844-860.
7. Lee M, Weiss J. Generation XXL: childhood obesity now threatens one in three kids with long-term health problems, and the crisis is growing. Newsweek, July 3, 2000; 40-44.
8. Lebalme, H. Surgeon General's Warning: Watch Less TV. The TV-Free American. Washington, D.C.; TV-Free America, Summer 1999;1-2
9. Kelly K. Get that TV out of your children's bedroom. U.S. News and World Report, Nov. 29, 1999:79.
10. Hughes F. Children, Play and Development. Boston: Allyn and Bacon, 1995;1-255.
11. Sherman T. Another danger for children? Education Week 1996;30-32.
12. Moody K. Cutting school 'frills' puts our young readers at real risk. Houston Chronicle, Oct. 3, 1999, Section C.
13. Visual-motor integration may predict early academic achievement. Am Optom Assn News, January 1,2001:6
14. Singer D, Revenson T. A Piaget Primer: How a Child Thinks. Rev. Ed. CT: International Universities Press, 1997.
15. Skeffington, AM, Lesser SK, Barstow R. Nearpoint Optometry. Curriculum II. Santa Ana, CA: Optom Extension Prog, 1947-48, 1948-49, 1949-50.
16. Getman GM. How to develop your child's intelligence. Santa Ana,CA:Optom Exten Prog Foundation,1993:39.
17. American Optometric Association. Guide to the Clinical Aspects of Computer Vision Syndrome. St. Louis: Am Optom Assn, 1995:1.
18. Forrest E, Stress and Vision. Santa Ana: Optom Extension Prog Foundation, 1988:182-183.
19. Pediatric Eye and Vision Examination, Reference Guide for Clinicians. St. Louis: American Optometric Association, 1994.
20. Press LJ. Examination of the preschool child. In: Press LJ, Moore BD, eds. Clinical Pediatric Optometry. Boston: Butterworth-Heineman, 1993:47-62
21. Apell R, Lowry RW. Preschool Vision. St. Louis: American Optometric Association, 1959.

Corresponding author:
Edward C. Godnig, O.D., FCOVD
36 Rogers Road
Kittery, ME 03904
godig@attbi.com

Date accepted for publication:
July 19, 2002