Using Nature and Outdoor Activity to Improve Children's Health

Leyla E. McCurdy, MPhil,[a] Kate E. Winterbottom, MPH,[a] Suril S. Mehta, MPH,[b] and James R. Roberts, MD, MPH[c]

Childhood obesity affects 17% or 12.5 million of America's children, contributing to the rise in children's health disparities. Type 2 diabetes, asthma, vitamin D deficiency, and attention-deficit/hyperactivity disorder have also increased over the past few decades. A shift toward a sedentary lifestyle is a major contributor to the decline in children's health. Children spend more time indoors using electronic media and less time engaged in outdoor unstructured play. This article reviews the current evidence of the mental and physical health benefits associated with unstructured, outdoor activities and time spent in a natural environment such as a park or other recreational area. Pediatric health care providers should recommend outdoor activities for children and refer families to safe and easily accessible outdoor areas. Pediatric health care providers can incorporate this simple, lifestyle-based intervention into anticipatory guidance.

Curr Probl Pediatr Adolesc Health Care 2010;5:102-117

Today's children may be the first generation at risk of having a shorter lifespan than their parents.[1] An increase in sedentary indoor lifestyles has contributed to childhood chronic conditions such as childhood obesity, asthma, attention-deficit/hyperactivity disorder (ADHD), and vitamin D deficiency, all of which have increased in prevalence in the US over the past few decades.[2,3] Such conditions may lead to pulmonary, cardiovascular, and mental health problems that can persist into adulthood. While myriad advances in pediatric health care have been made over the past few decades, they have been accompanied by vast increases in chronic health issues. The increase in chronic health conditions is disproportionately affecting children of minority and low-socioeconomic communities, creating increased disparities in children's health. More focus is needed on sustainable, long-term prevention methods that promote healthy lifestyle changes. More emphasis on promotion of outdoor activity in nature is needed in children's health care.

A critical dialogue has emerged in both the public health and the environmental education communities about the benefits of nature for children. Richard Louv, author of *Last Child in the Woods*,[4] coined the term "nature-deficit disorder" to describe children's lack of outdoor activity, replaced by electronic media and a demanding school schedule. These lifestyle changes have promoted physical inactivity, have social and psychological ramifications, and have aided in the increasing chronic disease trend. Meanwhile, a growing body of evidence has suggested that exposure to nature may directly benefit health. There is also a strong body of evidence attributing health to physical activity, and recent studies suggest that children who spend time outdoors are more active.[5-8] If integrated into pediatric care, outdoor activity in natural environments may have the potential to improve children's mental health and physical well-being. This article reviews the current evidence of the health benefits from outdoor physical activity and natural environments and proposes that providers do more to promote children's outdoor physical activity in natural settings.

From the [a]National Environmental Education Foundation, Washington, DC; [b]George Washington University School of Public Health and Health Services, Washington, DC; and [c]Medical University of South Carolina, Charleston, South Carolina.

Curr Probl Pediatr Adolesc Health Care 2010;40:102-117
1538-5442/$ - see front matter

doi:10.1016/j.cppeds.2010.02.003

Children's Health and Sedentary Lifestyle

In the US in recent decades there has been a nationwide shift to a sedentary lifestyle, leaving children vulnerable to the negative effects of inactivity. Physical activity is known to reduce the risk of premature mortality, coronary heart disease, hypertension, diabetes mellitus, osteoporosis, colon cancer, depression, and anxiety.[9] Nonetheless, in 2006, approximately 40% of US adults reported no participation in any leisure-time physical activity.[10] Adult inactivity is likely to become a family routine. Parental health status is a key factor in influencing the habits and behaviors of children. A 1997 cohort study examining parental and child health data determined that parental obesity more than doubled the risk of a child becoming an obese adult.[11] Inactivity has also been measured in children and adolescents. Fifty percent of fifth and seventh grade students in Georgia are below healthy levels for cardiovascular fitness.[12] While research shows that adolescents who are physically active are more likely to be active during adulthood,[13,14] only 35% of high school students met currently recommended levels of physical activity in 2005.[15]

Children's lack of physical activity and their growing disconnect with the natural environment have been influenced by the rise in electronic media, decreased time for unstructured free play, and environmental barriers. The rapid progress and integration of technology and electronic media[a] in our society has brought about innovative ways to entertain, communicate, and share information at our own convenience. Unfortunately, it has also become the dominant force detracting from physical activity and outdoor time. Per capita visits to US national parks have decreased since 1987, coincident with the rise in electronic entertainment media, video game, and Internet use.[16] With the introduction and growing popularity of online social networking, more youth are likely to be using computers. In 2006, 21% played video or computer games or used a computer for something that was not schoolwork for at least 3 hours every day.[15]

According to the American Academy of Pediatrics (AAP), the average child watches nearly 3 hours of television per day.[17] Young people spend roughly 7.5 hours a day consuming some form of electronic media—an hour more than was reported 5 years ago.[18] Exacerbating the issue, many children have television sets in their bedrooms: 32% of 2-7 year olds and 65% of 8-18 year olds.[19] Research has also suggested that excessive television viewing may negatively affect children's health. Increased television viewing has been linked to obesity, poor oral hygiene, and poor overall health. Additionally, each added hour of television significantly increases the odds of having social or emotional problems such as low self-esteem.[20] Toddler and preschool-aged children are also a major target group for electronic media companies. Television networks and computer software companies have been aggressively marketing to children as young as 9-12 months old.[21] The health implications of electronic media on toddlers need to be further researched, as this period of childhood is critical to social and cognitive development. An analysis of a national longitudinal sample of 1 to 3 year olds revealed that daily television watching was associated with developing attention problems by age 7.[22]

Free, unstructured play also affects the amount of physical activity children engage in each day. According to the AAP, play allows children to use their creativity and imaginations while building dexterity and physical strength. Unstructured play is also important for healthy brain development; children learn how to work in groups, share, negotiate, resolve conflicts, and learn self-advocacy skills.[23] Since the 1970s, children have lost roughly 12 hours a week of free time, including a 25% decrease in play and a 50% decrease in unstructured outdoor activities.[24] The No Child Left behind Act of 2001[25] prompted school districts nationwide to allocate more time and resources into reading and mathematics. As a result, school programs such as art, physical education, and recess suffered cutbacks.[26,27] Thirty percent of kindergarten classrooms are deprived of a recess period to account for increased academics.[28]

Furthermore, the built environment can affect the amount of opportunities available to children for outdoor activity. Certain factors in the built environment encourage active travel, such as connected streets, sidewalks, and access to recreational facilities. Conversely, the absence of community playgrounds and sidewalks, and overuse of cul-de-sacs, can discourage physical activity.[29] Children now spend more time in vehicles being transported from one indoor

[a] The term "media" refers to television, audio, computers, and video games, and now mobile media; including iPods/MP3 players, cell phones, and laptops.[18]

activity to another than outside in nature. Additionally, parents may keep their children indoors due to fears of crime, injury, insect bites and stings, and environmental health threats such as air pollution. Parents' encouragement and presence are actually key predictors of the amount of time children spend outdoors; authors of a 2009 ecological study observed that older children who had less adult supervision after school spent less time outside.[30]

Differences in the built environment also may contribute to racial and ethnic health disparities in the USA.[31] Minority children and those from lower socioeconomic classes generally have less access to recreational facilities, which is linked to decreased physical activity and overweight.[32] Access to healthy fresh foods is another factor contributing to health disparities. Neighborhoods with large minority populations, on average, have fewer supermarkets and produce stores.[33] Therefore, they must rely on convenience stores and fast food restaurants that carry food high in fat, sodium, and sugar that are also associated with a higher body mass index (BMI).[34,35] These factors have contributed to the rise in childhood obesity and chronic conditions, especially among disadvantaged children.

Overview of Children's Health

Childhood Obesity

Currently, obesity affects 17% or 12.5 million of America's children and adolescents aged 2-19 years.[36] According to the Institute of Medicine, the prevalence of obesity has doubled over the past 30 years for preschoolers and adolescents, and more than tripled for children aged 6-11.[37] Hospitalizations for obesity-related diseases have nearly doubled since 1999, which in turn has raised medical costs by $100 million.[38] Disparities in childhood obesity are also rising. While obesity prevalence increased by 10% for all US children from 2003 to 2007, children of lower socioeconomic status from high unemployment households saw a 23%-33% increase in obesity. Among Hispanic children, obesity prevalence increased by 24% from 2003 to 2007, and odds of obesity and overweight were twice as high for black and Hispanic children than white children.[39]

Obesity refers to the development of excess body fat, which occurs when energy intake is disproportionate to energy expenditure. Although definitions have changed over time, the Centers for Disease Control and Prevention (CDC) now uses the terms "overweight" to describe children aged 2-19 years old with BMI[b] at or above the 85th percentile and lower than the 95th percentile and "obese" for BMI at or above the 95th percentile for children of the same age and sex.[40] Obesity is a biological interaction involving multiple variables, including caloric intake, food choices, physical activity, hormone secretion, age and genetics, and psychological issues that may affect dietary behavior. Obesity and its comorbidities account for approximately 112,000 deaths per year,[41] and these comorbidities are now increasingly recognized in young children. Childhood obesity is associated with diseases in adulthood such as type 2 diabetes, hypertension, cardiovascular disease, nonalcoholic fatty liver disease, and obstructive sleep apnea.[42] The risk for metabolic syndrome, a combination of several of the above disorders, may be increasing in adolescents.[43] Developmental comorbidities of childhood obesity include early maturation and orthopedic issues.

Childhood obesity is also a predictor of adult morbidity and mortality.[42] Up to 80% of obese youth grow up to be obese adults.[11] Obese adults are susceptible to additional health consequences, including cancer, hypertension, stroke, liver and gallbladder disease, osteoarthritis, and gynecologic problems. Adults with obesity also have an increased risk of dementia and Alzheimer's disease.[44] Furthermore, obese children are more likely to grow up with a negative self-image, lower levels of advanced education, lower family income, and a lower rate of marriage as adults.[45]

Obesity-Related Diseases

Type 2 Diabetes. Type 2 diabetes is being diagnosed with increasing frequency in children. Due to the increase in prevalence over the past few decades, the definition has now changed from its previous title, "adult-onset" diabetes. Approximately 186,300 children had diabetes in 2007, and up to 3700 additional children are diagnosed with type 2 diabetes each year.[46] According to the CDC, 1 in 3 children born in 2000 will eventually develop diabetes mellitus if present rates of obesity continue.[47]

Obesity, a known risk factor for type 2 diabetes, can exacerbate insulin resistance and glucose tolerance, eventually leading to the disease.[48] Impaired glucose toler-

[b] BMI is calculated using the formula: weight (lb)/(height (in))^2 × 703.

ance was found to be prevalent in severely obese children and adolescents.[49] Other risk factors for childhood type 2 diabetes include age, race, and ethnicity.[46]

Children with type 2 diabetes are at risk for the comorbidities associated with insulin resistance. These include hyperlipidemia and hypertension. These diseases, in turn, place this group at greater risk for premature cardiovascular disease. However, physical activity and cardiorespiratory fitness are shown to improve insulin sensitivity in children with type 2 diabetes, and increased physical activity and healthy eating are at the core of recommendations for type 2 diabetes management.[50]

Hypertension. Hypertension in children has increased because of the childhood obesity epidemic, with 10% of obese children having elevated blood pressure.[51] Hypertension is a major risk factor for heart disease, stroke, congestive heart failure, and kidney disease. Lifestyle factors such as weight control, exercise, and healthy diet improve high blood pressure. Sedentary behavior, therefore, may influence the development of hypertension in children. For example, high blood pressure in children aged 3 through 8 years old has been associated with high periods of television viewing and screen time.[52] Possible explanations for this relationship include the effects of physical inactivity while watching television and the unhealthy behaviors associated with watching television, such as the increased consumption of foods high in fat, sugar, and salt.[53-55]

Cardiovascular Disease and Metabolic Syndrome. Overweight adolescents are at an increased risk of coronary heart disease and premature death. Most overweight and obese children have at least one risk factor for cardiovascular disease, including higher cholesterol levels, abnormal glucose tolerance, high blood pressure, and elevated triglycerides.[42] Cardiovascular disease is the leading cause of death and morbidity in the USA. In 2006, 630,000 or approximately 26% of all US deaths were attributable to heart disease.[56]

An analysis of the National Health and Nutrition Examination Survey (NHANES) from 1999 to 2006 revealed that 65% of 12-19 year olds were obese or overweight, and 20% had at least 1 abnormal lipid level.[57,c] Conversely, from 1988 to 1994, only 10% of 12-19 year olds surveyed had abnormal lipid and triglyceride levels.[58]

Physical activity and diet can alter the course of the disease process. Intervention strategies include lifestyle changes for children and adolescents at higher risk for cardiovascular disease. The AAP now recommends screening overweight or obese children for high cholesterol and prescribing cholesterol-lowering drugs, if needed.[59]

Metabolic syndrome is a collection of risk factors for cardiovascular disease and diabetes mellitus that includes insulin resistance, glucose intolerance, hyperlipidemia, obesity, and hypertension.[60] The prevalence of metabolic syndrome among the adolescent population is 910,000 (~4%); among overweight adolescents, 30% have metabolic syndrome.[43]

Nonalcoholic Fatty Liver Disease. Nonalcoholic fatty liver disease refers to the fatty infiltration of the liver without excessive alcohol consumption. It is closely related to obesity and insulin resistance. The degree of severity can range from fatty infiltration of the liver, or steatosis, to inflammation of the liver, or steatohepatitis. Nonalcoholic fatty liver disease is among the most common type of liver disease in the pediatric population.[61] A population-based study estimated that the prevalence of nonalcoholic fatty liver disease among children aged 2-19 at nearly 10%, and that the prevalence of fatty liver among obese children at 38%.[62]

Obstructive Sleep Apnea. Obesity is a well-documented risk factor for the development of obstructive sleep apnea in adults, and it may be a risk factor for sleep apnea in children as well.[63,64] This relationship is not entirely understood; however, it may be related to the deposition of adipose tissue within the muscles and soft tissues surrounding the upper airway.[65] Obesity may also increase a child's risk for the consequences of obstructive sleep apnea. For example, obstructive sleep apnea was found to be an independent predictor of nocturnal hypertension.[66] In addition, morbidly obese children with obstructive sleep apnea may experience neurocognitive deficits.[67]

Asthma. Approximately 7 million American children (9.4%) have asthma, a percentage that has doubled since the 1980s.[68] Children who are overweight or obese are more likely to have asthma symptoms.[69,70] Obesity is related to allergy symptoms and higher serum IgE levels, a biomarker of atopy among children aged 2-19 years.[71] In adults, a large waist size

[c] Determination of abnormal lipid level was based on cutoff points for high LDL-C (>130 mg/dL), low HDL-C (<35 mg/dL), and high triglyceride levels (>150 mg/dL).

is associated with increased asthma prevalence and severity, especially among women.[72]

Of the 7 million children reported to have asthma in 2003-2006, black and Puerto Rican children have the highest prevalence.[73,74] Asthma is more prevalent in urban environments; factors contributing to this disparity include indoor and outdoor air pollution, housing and neighborhood conditions, poverty, health care inequities, and social and psychosocial stressors.[75] Black children are 1.6 times more likely to be diagnosed with asthma when compared with white children. Puerto Rican children have the highest prevalence of asthma of all racial and ethnic groups; they are 2.4 times more likely than white children to have asthma.[76]

The relationship between asthma and obesity may also reflect sedentary lifestyle behaviors. For example, low physical fitness may be linked to the development of asthma. In a prospective, community-based study beginning in 1985, 757 children without asthma symptoms were followed for 10 years. Physical fitness was measured in 1985 and again in 1996 using a maximal progressive exercise test, which induced airway narrowing. Over the 10-year period, 6.7% of the previously asymptomatic children developed asthma. A weak correlation was observed between low physical fitness in 1985 and airway reactivity in 1996.[77] More research is needed to investigate the relationship between asthma and sedentary behavior.

Television viewing has also been associated with asthma. In a prospective longitudinal cohort study, authors investigated the association between duration of television viewing and the development of asthma in young children. The study followed children with no wheeze up to the age of 3.5 years and then gathered follow-up data for these children at 11.5 years. Television viewing was associated with increased prevalence of asthma at 11.5 years, and children who watched television for more than 2 hours a day were almost twice as likely to develop asthma compared with those who watched television for 1 to 2 hours a day.[78] Additionally, a population-based study investigated the relationship of BMI with wheezing and asthma in 20,016 children. The authors found that subjects who spent 5 or more hours a day watching television were more likely to experience wheeze and asthma in comparison with those who watched television less than 1 hour a day.[79]

Vitamin D Deficiency

Children continue to demonstrate evidence of vitamin D deficiency, as noted in an analysis of the 2001-2004 NHANES. It indicated that 9% of the pediatric population, or 7.6 million US children and adolescents, were vitamin D deficient. Additionally, 61% or 50.8 million children and adolescents had insufficient levels of vitamin D.[80,d] If the body becomes extremely deficient in vitamin D, only about 10%-15% of dietary calcium and 50%-60% of dietary phosphorus are absorbed. This can lead to skeletal abnormalities in children typically defined as rickets, which can inhibit growth, weaken the immune system, and cause seizures.[81] Medical centers have detected an increase in rickets.[82-85] Additionally, low levels of vitamin D may lead to osteoporosis,[86] cardiovascular disease, metabolic syndrome, hypertension, diabetes, myocardial infarctions, and peripheral arterial disease.[87,88]

Physical activity may be associated with vitamin D levels. In a cohort study conducted in Japan in 2003, authors evaluated the degree of association between vitamin D and lifestyle factors in Japanese women aged 19-25 years. Lifestyle factors included nutrient intake, physical activity, and duration of sunlight exposure. Two main findings of the study were that daily energy expenditure and numbers of steps taken per day were positively associated with vitamin D. Furthermore, the average amount of time per day spent in sedentary activity was negatively associated with vitamin D.[89]

Asthma may also be related to vitamin D deficiency. In a cross-sectional study of 616 Costa Rican children between the ages of 6 and 14 years, lower vitamin D levels were associated with increased markers of allergy and asthma severity. Twenty-eight percent of the children with asthma had insufficient levels of vitamin D.[90]

Historically, the main source of vitamin D comes from synthesis in the skin after exposure to UVB light. The AAP states that vitamin D deficiency among children and adolescents reflects modern-day lifestyle changes, and vitamin D supplements during infancy, childhood, and adolescence are now rec-

[d] 25-Hydroxyvitamin D (25[OH]D) levels are the most commonly measured indicator of vitamin D status. 25[OH]D levels below 15 ng/mL are considered deficient, and 25[OH]D levels 15-29 ng/mL are considered insufficient.

ommended.[91] According to the American Medical Association, the body needs 10-15 minutes of sun exposure at least twice a week to receive adequate amounts of vitamin D.[86]

Mental Health

Children and adolescents are increasingly being prescribed medication for depression, anxiety, or behavioral difficulties.[92] Six percent of adolescents 14-18 years old have been diagnosed with depressive disorders, as well as 3% of children younger than 13 years old.[93] Stress is also a top health concern for adolescents in the USA, according to a 2009 survey by the American Psychological Association. The survey found that nearly half of adolescents in the USA said that their level of stress had increased in the past year, and 14% of adolescents categorized their stress as extreme.[94]

The prevalence of ADHD has increased considerably in recent decades, labeled by the CDC as "a serious public health problem."[95] The results of the National Health Interview Survey showed that 9% of children have ADHD.[96] Another study in 2005 found that 5% of US children between the ages of 4 and 17 were prescribed medication for difficulties with emotions or behavior, and 90% of these were treatment for symptoms of ADHD.[97]

Health Benefits of Physical Activity and Natural Environments

Health and Physical Activity

The physical activity guidelines of the US Department of Health and Human Services (DHHS) state that regular physical activity helps build and maintain healthy bones and muscles, reduces the risk of obesity and chronic diseases such as diabetes and cardiovascular disease, reduces feelings of depression and anxiety, and promotes psychological well-being.[98] Numerous scientific studies provide additional evidence of the benefits of physical activity. In a prospective, randomized controlled study, physical activity was shown to reduce systolic and diastolic blood pressure in young children over an 8-month period.[99] An examination of 6 hypertensive adolescents revealed a significant reduction in blood pressure after 3 to 7 months of weight-lifting.[100]

Physical activity is particularly important in the treatment of type 2 diabetes in children because of its potential to improve insulin sensitivity and maintain both short- and long-term metabolic control.[101] Lack of physical activity may contribute to type 2 diabetes in children. A 2008 study assessed cardiorespiratory fitness in adolescent boys with previously diagnosed type 2 diabetes during a progressive exercise test. Cardiorespiratory fitness levels were 18% lower in adolescent males with type 2 diabetes compared with males of equal age and BMI. The youth with diabetes also spent about 60% less time per day in moderate to vigorous physical activities compared with the control group. Although childhood type 2 diabetes is caused by a complex interaction of genetic and environmental factors, physical inactivity may also contribute through a lack of stimulation of glucose uptake in skeletal muscle.[50]

The AAP recommends promoting lifelong habits of physical activity to achieve sustained weight loss rather than short bouts of aerobic exercise.[102] Long-term weight loss is facilitated by regular physical activity, which requires a change in mindset to achieve success.[103] Various programs around the country are striving to address childhood obesity and some have been effective in reducing children's BMI. For example, a program focusing on lifestyle-based activities such as outdoor games, household chores, gardening, beach hikes, and international children's games encouraged children to be more physically active. One- and 2-year evaluations of the program determined a significant decrease in BMI in the children who participated in the intervention group (95% CI: 0.01, 0.18; 95% CI: 0.21, 0.32). The program appears to have resulted in a sustained change because the children continued to have weight loss 2 years later.[104]

A decline in physical activity from childhood to adulthood is a strong predictor of adult obesity and insulin resistance.[105] Programs should be aimed at maintaining high physical activity levels from childhood into adulthood. To accomplish this, the AAP recommends that parents help their children be physically active in other ways than organized sports alone, and to plan outdoor activities for the entire family such as biking or playing outdoors. Additionally, AAP recommends that children spend as much time outdoors as possible.[102]

Physical Activity in Parks and Other Natural Environments

Research has indicated that time spent outdoors is associated with increased physical activity. Parents of

preschool children reported that physical activity usually occurs during outdoor playtime as opposed to during indoor activities.[106] One study among 10- to 12-year-old children found that for every additional hour spent outdoors, physical activity increased by 27 minutes a week and prevalence of overweight dropped from 41% to 27%.[5] Parks, schools, trails, and recreation facilities provide settings that can facilitate physical activity. However, due to increasing urbanization and population density, many people live in residential areas lacking vegetation, parks, and other natural environments, limiting the availability of easily accessible and safe outdoor play settings for children.

"Green" school grounds, which contain a greater diversity of environmental features such as trees, gardens, and nature trails, may affect the quantity and quality of physical activity among elementary schoolchildren. Asphalt and turf grounds are only conducive to certain activities, such as basketball, which not all children may be interested in or able to play. Offering a natural environment with which children can interact at school may stimulate physical activity in greater numbers. Recently, schools have engaged in efforts to emphasize these features in an effort to encourage children to be more active and imaginative. An evaluation of these initiatives was conducted at 59 schools across Canada by surveying teachers, parents, and administrators. The survey evaluated to what extent the "green" features in their school yards influenced physical activity of students. Seventy percent of respondents indicated that the initiative resulted in increased light to moderate physical activity, and 50% also reported that their "green" school ground promoted more vigorous activity. Respondents also indicated that their school grounds appealed to a greater breadth of student interests and support a wider variety of play activities.[6]

As residential areas become more populated and overdeveloped, "green space," which refers to areas of dense, healthy vegetation, becomes increasingly important as an outlet for physical activity and a means to sustain a healthy weight. A retrospective cohort study in 2008 followed low-income children aged 3-16 years old for 2 years. Authors calculated their change in BMI and measured the amount of vegetation in each child's neighborhood using satellite images. After adjusting for age and gender, increased vegetation was associated with lower odds of increased change in BMI, independent of residential density (OR: 0.87, 95% CI: 0.79, 0.97). Although physical activity was not directly measured, a change in BMI may imply increased physical activity. However, this study is limited by selection bias, as socioeconomic status may influence the choice of a home location with respect to natural surroundings.[7]

Proximity to parks may also influence children's weight. A Canadian study examined the association between healthy weight status among children and the availability of 13 specific park facilities within 1 km of their residences, which contained features such as paved and unpaved trails, playgrounds, meadows, wooded areas, and sports facilities. Logistic regression was used to analyze the relationship between the proximity of a particular park facility to childhood BMI, while controlling for neighborhood residence, age, gender, and parental BMI. Children who lived within a kilometer of a park facility that contained playground equipment were almost 5 times more likely to be classified at a healthier weight than children without accessible playgrounds. The association between playground availability and normal BMI suggested that children were getting the physical activity needed to maintain a normal BMI.[8]

Finally, access to natural environments may reduce health inequalities by promoting physical activity and offering protection from the biological effects of poverty-related stress. To determine if exposure to "green space" such as parks, forests, rivers, creeks, and play fields was a determinant of good health, more than 40 million people from England were classified based on level of income and access to natural environments. Records for all causes of mortality, as well as circulatory, lung cancer, and intentional self-harm, were obtained from 2001 to 2005 to determine if there was an association with income deprivation and exposure to "green space." The major finding was that the group living in the areas with the most nature had the lowest level all-cause mortality and mortality due to circulatory diseases related to income deprivation. The authors suggested that exposure to natural environments could play a vital role in reducing health inequalities.[107]

Natural Environments and Mental Health

Exposure to a natural environment may have a beneficial effect on psychological health. One study investigated the relationship between morbidity and the amount of natural land around a residential environment, which excluded small-scale natural features

such as gardens and residential trees. Multivariate logistic regression was used to control for demographic factors, socioeconomic characteristics, and whether the surroundings were urban or rural. The authors found 24 clusters of disease and determined that the prevalence rates for 15 of these 24 clusters were lower in environments with more natural environments. This relation was apparent for all 7 disease categories, including cardiovascular, musculoskeletal, mental, respiratory, neurological, digestive, and miscellaneous. Depression and anxiety disorder showed the strongest association to the amount of nature in people's living environments, especially in children. Owing to its cross-sectional study design, it is difficult to determine whether the relationship between natural space and morbidity is causal. Authors also stressed the importance of natural environments close to home for both children and lower socioeconomic groups.[108]

Childhood stress has also become an increasing issue of concern for pediatric health care providers. The workload of school and extracurricular activities has the potential to create more stress on a child, thereby influencing cognitive development. Natural environments may moderate the impact of stressful life events for children. The psychological effects of stressful life events, such as family relocation, being picked on at school, and peer pressure, and the amount of "nature" in each child's environment were evaluated among 330 rural children in grades 3-5. In the study, "nature" meant the amount of trees and vegetation in the window view, the number of live plants indoors, and the outdoor landscape. Hierarchical regression analyses were used to examine the effects of nearby nature on stressful life events, while controlling for family income. The children felt less psychological distress if they lived in an area with more natural surroundings. Specifically, higher amounts of exposure to natural environments indicated lower levels of stress in a child. The authors postulated that nearby nature both provided social support in rural settings and restored children's capacity for attention that helps them to better think through problems.[109]

Physical activity in natural environments may benefit both physiological and psychological health. One study examined the health effects of physical activity while being exposed to various forms of nature. In this study, adult subjects in the intervention group ran on a treadmill while being shown 4 different themes of pictures: rural pleasant, urban pleasant, rural unpleasant, and urban unpleasant photographs. The researchers measured subjects' blood pressure, self-esteem, and mood. The pleasant rural and urban nature pictures were linked to a significant reduction in blood pressure and a more positive effect on mood. Furthermore, participants in the rural pleasant group had the largest reduction in blood pressure and the most significant increase in self-esteem. The authors suggested that "green exercise" not only has a greater effect on blood pressure than exercise alone, but also contains potential benefits for psychological health.[110]

Natural environments may improve attention, especially for children with ADHD. These studies are based on the idea that nature can restore the mental fatigue that occurs after prolonged concentration, which is characterized by having difficulty focusing on tasks, feeling irritable, and being easily distracted. Nature has been described to effortlessly engage the human mind away from daily stressors, offering an opportunity for reflection and escape.[111] Furthermore, mental fatigue and ADHD may be linked to the same underlying mechanism in the brain.[112-114] A number of studies have measured the benefits of natural environments on children's attention, especially among those with attention disorders.

In 2001, Taylor et al investigated whether time spent in natural settings affects the inattentive symptoms of attention deficit disorder, sometimes known as attention deficit disorder without hyperactivity. The authors surveyed parents to compare their child's symptoms when engaging in leisure activities in an indoor setting, such as a windowless room, and a natural outdoor setting, such as a park, farm, or neighborhood space. They identified 4 inattentive symptoms as outcome measures for this study: (1) inability to stay focused on unappealing tasks, (2) inability to complete tasks, (3) inability to listen and follow directions, and (4) being easily distracted. The results showed that activities taking place in natural settings were more likely to be nominated by survey participants as helpful in reducing inattentive symptoms. In addition, as tree cover within the settings increased, symptoms of attention deficit disorder decreased in severity.[115]

A nationwide study published in 2004 by the same authors examined if "green" settings reduced symptoms of ADHD. The authors surveyed parents of children who had been diagnosed with ADHD on the perceived effect of common after-school and weekend activities on their child's symptoms. Activities chosen by the authors represented a broad range of physical settings and social contexts. Parents were asked to

indicate whether each activity resulted in the child's symptoms being (a) worse than usual, (b) same as usual, (c) better than usual, or (d) much better than usual. Authors measured the distribution of after-school and weekend activities by conducting *t*-tests. A repeated analysis of variance examined the association between reported ADHD symptoms and natural outdoors vs. built indoor/outdoor activities. Natural outdoor activities significantly reduced symptoms and natural outdoor activities reduced ADHD symptoms significantly more than activities conducted in built outdoor settings or indoor settings. The limitations of the study included systematic error in parental perceptions of different settings, in part because "green" activities were not uniformly defined.[116]

Cognitive functioning was also examined in low-income urban children from 2 separate home environments. One environment consisted of fewer natural elements, and the other environment contained plants and views of nature. Children's cognitive functioning was measured in each home environment using the Attention-Deficit Disorders Evaluation Scale. Children who experienced the greatest increase in natural elements in the home had the greatest ability to focus attention a few months later.[117] ADHD-diagnosed children from another recent study were guided through a 20-minute walk in 3 different environments: a city park, an urban area, and a residential area. The guided walks were single-blinded controlled trials. Prior to each of the walks, children completed a series of puzzles that were selected to cause a degree of mental fatigue. After the walks, children completed tests of concentration and impulse control. Concentration was significantly better after a walk in a city park than the other 2 settings.[118] Limitations included low external validity due to small sample size. However, these findings add to the body of evidence of nature's effect on attention in children.

Human evolutionary history may be related to nature's potential ability to restore mental health. Humans have evolved living close to the land as hunter-gatherers, and it is only recently that we have congregated into densely populated cities.[119] A sense of spending time in the natural world may bring about a positive effect on mood. Factors that lead to attention restoration may also increase a person's experiential sense of feeling connected to nature. Participants who spent 15 minutes walking in a natural setting or urban settings, or by watching a video of 1 of these settings, reported increased feelings of connectedness to nature, improved attention, positive emotional well-being, and an increased ability to reflect on a life problem.[120]

Researchers have offered multiple reasons to why nature may be benefiting children with attention disorders. Children with ADHD may benefit from time spent outdoors in nature, whether during a break in the school day, an after-school trip to the park, or a weekend outing to a nature center. Simply observing various forms of nature has been shown to provide restorative benefits and enhance a sense of well-being in children. Evidence suggests that natural-environment interventions may be a beneficial component of cognitive behavioral therapy; however, more research is needed.[121]

Additional Potential Health Benefits of Nature

Outdoor activity in nature may also benefit children's health by improving asthma, myopia, chronic pain issues, and childhood development. For example, a recent ecological study conducted in New York City suggested that being exposed to a natural environment may be correlated with less childhood asthma. Authors collected both tree density information and asthma prevalence data on 4- and 5-year-old children living in the city. The authors also measured the proximity to pollution sources that have previously been associated with asthma. Results revealed that tree density was correlated with a lower prevalence of childhood asthma, after controlling for potential confounding factors including sociodemographic characteristics, population density, and proximity to pollution sources. Due to the design of the study, the results of the analysis merely serve to generate hypotheses surrounding tree density and asthma. The extent to which trees and vegetation play a role in the control of pediatric asthma remains unknown.[122]

Myopia, or nearsightedness, has been acknowledged by the World Health Organization as one of its top priorities to control in preventing avoidable blindness in the world by 2020. In the USA, the prevalence rate of myopia has substantially risen in the past 30 years.[123] Roughly 9.2% of children in America are myopic.[124] Profound increases in myopia prevalence may potentially be exacerbated by external factors such as increased illuminated screen viewing and reading time. Time spent outdoors may reduce a child's risk of myopia. A recent cross-sectional study among 12-year-old participants found that higher levels of outdoor time were associated with less myopia and higher hyperopic mean refraction. Outdoor activ-

ity should be promoted by the public health community and included in school curricula.[125] Additionally, a 2009 cohort study of 1249 teenage students in Singapore revealed significantly less myopia in adolescents who spent more time outdoors (OR: 0.90; 95% CI: 0.84, 0.96; $P = 0.004$).[126] Further research is currently being conducted on the protective effects of outdoor activities on myopia.

Although currently studies examining pain reduction and the restorative effects of nature for children are not available, studies on adult pain management may form a basis for further research. In a 1984 study, patients with a view of deciduous trees took fewer doses of strong pain medication than a group viewing a brown brick wall, had shorter postoperative hospital stays, and fewer postsurgical complications.[127] Another study examined a group of patients during flexible bronchoscopy. Nature scene murals were placed at patients' bedsides, and they were provided with a tape of nature sounds to listen to before, during, and after the procedure. The patients with views and sounds of nature were more likely to report better pain control during the procedure.[128]

Because evidence suggests that natural environments encourage physical activity, increasing the amount of time children spend playing outside in natural environments has the potential to decrease the risk of childhood obesity. In addition, outdoor time in nature may decrease stress in children, instill a sense of well-being, and improve capacity for attention in children with ADHD. Natural environments may also reduce children's susceptibility to other diseases, although much more research needs to be conducted.

Pediatric Care

Pediatric health care providers have an important role to play in the management of childhood obesity, its comorbidities, and other chronic problems in childhood including vitamin D deficiency and ADHD. Although children's health care providers play an important role, they cannot manage the intricacies of childhood obesity on their own. A cooperative effort between parents, health care providers, schools, government agencies, and nongovernmental organizations, as well as the children themselves, is crucial to the success of any program. Interventions should be scientifically based, yet balanced with the practical needs of the patient.

Pediatric health care providers have a unique presence in the lives of children and their parents. Too often, however, parents rely on the Internet, friends, or other nonprofessionals for medical advice, which may not be scientifically sound. Pediatric health care providers should recognize that they are, and should be, a key link between children, their parents, and optimal health. They are clinicians and leaders and should be trusted sources of new information. Pediatric health care providers interact with children and their parents on a level that transcends daily public interactions and media messages. Therefore, they are in a position to provide parents with an understanding of the causes of childhood obesity and empowering them to make lifestyle changes to protect their children. An additional part of this educational responsibility is to direct patients to appropriate, evidence-based Internet sites for information.

The AAP has provided a blueprint for pediatricians to educate and advise families about ways to prevent childhood obesity. The AAP's Committee on Nutrition recently completed the 5th edition of the *Pediatric Nutrition Handbook*, which is a comprehensive reference designed for the clinician.[129] It provides advice on all aspects of nutrition, from the premature infant up to the adolescent. Another source that the AAP has developed is *A Parent's Guide to Childhood Obesity: A Road Map to Health*,[130] a resource developed for the parent. Further information about these and other nutritional related resources can be found at the AAP Nutrition web site.[131] Other AAP recommendations to the pediatric health care community include promoting healthy eating, and monitoring children's nutritional intake and BMI.

The AAP also has resources and advice about another equally important component of any strategy to treat and prevent childhood obesity: the promotion of an appropriate amount of physical activity. This should be a combination of more outdoor play, and less indoor "screen time," which has been shown to replace physical activity.[132] The AAP recommends that children older than 2 years old watch no more than 1-2 hours per day of television and that television sets should not be in children's sleeping rooms.[17] A policy statement was released by the AAP in 2006 by the Council on Sports Medicine that goes into greater detail about the level of physical activity children should achieve. In summary, the AAP recommends age-appropriate outdoor physical activity while recognizing the role of the cultural environment for the

child, where work, education, family life, and leisure time all impact the process. Clinicians should (1) adopt a healthy lifestyle as a role model, (2) limit screen time, (3) measure the number of times per week spent in 30 minutes of outdoor play, (4) encourage at least 60 minutes per day of physical activity (includes accumulated activity from multiple, shorter periods), and (5) encourage the parents of overweight children to have a participatory role in the activity process.[102]

Natural environments may reduce stress and improve attention. The natural outdoor environment is an ideal way of increasing physical activity. Activities that family members can participate in together enhance the social and supportive benefits of physical activity, which is taken advantage of in outdoor, natural environments. Nurturing a love of nature in children cannot only inspire them to protect the environment, it can also instill lifelong behaviors of an active lifestyle. This should be a lifestyle change and there is no better person to recommend that change than the child's primary health care provider.

Children and Nature Initiative

The National Environmental Education Foundation has launched an initiative that links 2 issues—rising childhood health concerns and the need to reconnect children to nature. The Children and Nature Initiative works with pediatric health care providers to encourage children to spend more time outdoors and connects children and their families to parks and other natural environments that are easily accessible to diverse populations.

The idea to prescribe nature to children to increase physical activity and improve health is similar to a new strategy that has emerged in adult health care. The American Medical Association and the American College of Sports Medicine have launched the Exercise is Medicine program, which encourages health professionals to include exercise when designing treatment plans for their patients, providing physical activity prescriptions and referrals.[133] This approach has been shown to be effective in increasing physical activity levels and is more cost-effective than other interventions because it mainly uses existing infrastructure.[134] A study conducted in Sweden during a 2-year period measured the effectiveness of issuing 6300 physical activity referrals. Half of the patients reached reported increased physical activity both at 3 months and at 12 months. In addition, the proportion of inactive patients decreased from 33% at baseline to 17% at 3 months and 20% at 12 months.[135] A program in Spain from 2003 to 2004 recruited around 4000 physically inactive patients and provided physical activity referrals to approximately half of them. Six months later, the patients who had received the referrals were more active.[136]

The Children and Nature Initiative is applying this approach to children's health care not only to increase physical activity, but also to get children to spend more time outside. The initiative, which is guided by an advisory committee of experts and stakeholders including members from leading health care organizations, educates pediatric health care providers about prescribing outside activities to children. The program also connects health care providers with local parks and nature centers, so that they can refer families to safe and easily accessible outdoor areas. The Children and Nature Initiative employs the highly successful Faculty Champions model, which has trained thousands of health care providers on environmental health issues to date.[137] Pediatric health care providers participate in a train-the-trainer workshop, which prepares them to serve as Nature Champions in their communities. These Nature Champions in turn train other providers in their local communities. The National Environmental Education Foundation provides them with the tools and resources they need to be effective, including the Children's Health and Nature Fact Sheet, which highlights the scientific basis for the health benefits of nature, and the Pediatric Environmental History Form, which includes questions for pediatric health care providers to encourage outdoor time for children.[138]

Through the Children and Nature Initiative, health care providers, parents, outdoor organizations, schools, federal, state, and local agencies, community groups, and other institutions can work together to encourage children to spend more time outdoors and teach them how to protect their health and the environment.[139]

Conclusions

Physical activity is shown to improve children's health, and a growing body of evidence suggests that exposure to natural environments can improve attention and decrease stress in children. Advising outdoor play in nature is a practical method for pediatric health care providers to address chronic conditions such as

childhood obesity, as well as mental health; and one that is cost-effective and easily sustainable. The DHHS and AAP recommend physical activity for children for at least 60 minutes a day.[96,102] The CDC stresses the important role of communities, schools, and families in promoting physical activity for youth[140] and encourages children to engage in healthy outdoor activities in nature and parks.[141] The DHHS advises physical activity through age-appropriate, enjoyable activities such as hiking or going to the park[96] and the AAP recommends that pediatricians promote free, unstructured play.[23]

Pediatric health care providers should promote increased physical activity for their patients and consider encouraging outdoor activities in natural environments as a physical activity routine.

References

1. Olshansky SJ, Douglas JP, Hershow RC, Layden J, Carnes BA, Brody J, et al. A potential decline in life expectancy in the United States in the 21st century. N Engl J Med 2005;352:1138-45.
2. Perrin JM, Bloom SR, Gortmaker SL. The increase of childhood chronic conditions in the United States. J Am Med Assoc 2007;297:2755-9.
3. Mithal DA, Wahl DA, Bonjour JP, Burckhardt P, Dawson-Hughes B, Eisman JA, et al. Global vitamin D status and determinants of hypovitaminosis D. Osteoporos Int 2009;20: 1807-20.
4. Louv R. Last child in the woods. Chapel Hill (NC): Algonquin Press; 2005.
5. Cleland V, Crawford D, Baur LA, Hume C, Timperio A, Salmon J. A prospective examination of children's time spent outdoors, objectively measured physical activity and overweight. Int J Obes 2008;32:1685-93.
6. Dyment JE, Bell AC. Grounds for movement: Green school grounds as sites for promoting physical activity. Health Educ Res 2008;23:952-62.
7. Bell JF, Wilson JS, Liu GC. Neighborhood greenness and 2-year changes in body mass index of children and youth. Am J Prev Med 2008;35:547-53.
8. Potwarka LR, Kaczynski AT, Flack AL. Places to play: Association of park space and facilities with healthy weight status among children. J Community Health 2008;33:344-50.
9. Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of sports medicine. J Am Med Assoc 1995;273:402-7.
10. National Center for Health Statistics. Health, United States, 2007 with Chartbook on Trends in the Health of Americans. Hyattsville, MD, 2007.
11. Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. N Engl J Med 1997;337:869-73.
12. Powell KE, Roberts AM, Ross JG, Phillips MAC, Ujamaa DA, Zhou M. Low physical fitness among fifth- and seventh-grade students, Georgia, 2006. Am J Prev Med 2009;36: 304-10.
13. Telama R, Yang X, Viikari J, Valimaki I, Wanne O, Raitakari O. Physical activity from childhood to adulthood: a 21-year tracking study. Am J Prev Med 2005;28:267-73.
14. Conroy MB, Cook NR, Manson JE, Buring JE, Lee IM. Past Physical Activity, Current Physical Activity, and the Risk of Coronary Heart Disease. Med Sci Exer Sports 2005;37: 1251-6.
15. Centers for Disease Control and Prevention. Youth risk behavior surveillance—United States, 2005. Morb Mortal Wkly Rep 2006;55:SS-5.
16. Pergams ORW, Zardiac PA. Evidence for a fundamental and pervasive shift away from nature-based recreation. Proc Natl Acad Sci USA 2008;105:2295-300.
17. American Academy of Pediatrics, Committee of Public Education. Children, adolescents, and television. Pediatrics 2001;107:423-6.
18. Rideout VJ, Foehr UG, Roberts DF. Generation M^2: media in the lives of 8-18-year olds. Menlo Park (CA): The Henry J Kaiser Family Foundation Report, 2010. Available at: http://www.kff.org/entmedia/8010.cfm.
19. Roberts DF, Foehr UG, Rideout VJ, Brodie M. Kids and media at the new millennium: a comprehensive national analysis of children's media use. Menlo Park (CA): The Henry J Kaiser Family Foundation Report, 1999.
20. Russ SA, Larson KL, Franke TM, Halfon N. Associations between media use and health in US children. Acad Pediatr 2009;9:300-6.
21. Vandewater EA, Rideout VJ, Wartella EA, Huang X, Lee JH, Shim M. Digital childhood: electronic media and technology use among infants, toddlers, and preschoolers. Pediatrics 2007;119:e1006-15.
22. Christakis D, Zimmerman FJ, DiGiuseppe DL, McCarty CA. Early television exposure and subsequent attentional problems in children. Pediatrics 2004;113:708-13.
23. Ginsberg KR, American Academy of Pediatrics, Committee on Communications, Committee on Psychological Aspects of Child and Family Health. The importance of play in promoting healthy child development and maintaining strong parent–child bonds. Pediatrics 2007;119:182-91.
24. Juster FT, Stafford F, Ono H. Changing Times of American Youth: 1981-2003. Ann Arbor, MI: Institute for Social Research, University of Michigan, 2004. Available at: http://www.ns.umich.edu/Releases/2004/Nov04/teen_time_report.pdf. Accessed January 15, 2010.
25. The no child left behind Act of 2001: executive summary. Available at: http://www.ed.gov/nclb/overview/intro/execsumm.pdf. Accessed January 25, 2010.
26. Dillon S. Schools cut back subjects to push reading and math. New York Times March 26;2006:1:1.
27. National PTA. Recess is at risk, new campaign comes to the rescue. Available at: http://www.pta.org/ne_press_release_detail_1142028998890.html. Accessed January 25, 2010.
28. Pellegrini AD. Recess: its role in education and development. Mahwah, NJ: Erlbaum, 2005.
29. American Academy of Pediatrics, Committee on Environ-

mental Health. The built environment: designing communities to promote physical activity in children. Pediatrics 2009;123:1591-8.
30. Cleland V, Timperio A, Salmon J, Hume C, Baur LA, Crawford D. Predictors of time spent outdoors among children: 5-year longitudinal findings. J Epidemiol Community Health 2009 [epub ahead of print].
31. Haas JS, Lee LB, Kaplan CB, Sonneborn D, Phillips KA, Liang S. The association of race, socioeconomic status, and health insurance status with the prevalence of overweight among children and adolescents. Am J Public Health 2003; 93:2105-10.
32. Gordon-Larsen P, Nelson MC, Page P, Popkin BM. Inequality in the built environment underlies key health disparities in physical activity and obesity. Pediatrics 2006;117:417-24.
33. Adler NE, Steward J. Reducing obesity: Motivating action while not blaming the victim. Milbank Q 2009;87:49-70.
34. Galves MP, Hong LU, Choi EC, Liao L, Godbold J, Brenner B. Childhood obesity and neighborhood food-store availability in an inner-city community. Acad Pediatr 2009;9:339-43.
35. Oreskovic NM, Kuhltau KA, Romm D, Perrin JM. Built environment and weight disparities among children in high- and low-income towns. Acad Pediatr 2009;9:315-21.
36. National Center for Health Statistics. Prevalence of overweight among children and adolescents: United States, 2003-04. Hyattsville, MD, 2006.
37. Koplan JP, Liverman CT, Kraak VI, editors. Preventing childhood obesity: health in the balance. Washington, DC: Institute of Medicine, 2005.
38. Trasande L, Liu Y, Fryer G, Weitzman M. Effects of childhood obesity on hospital care and costs, 1999-2005. Health Aff 2009;2:w751-60.
39. Singh GK, Siahpush M, Kogan MD. Rising social inequalities in US childhood obesity, 2003-07. Ann Epidemiol 2010;20:40-52.
40. Barlow SE. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. Pediatrics 2007;120:S164-92.
41. Flegal KM, Graubard BI, Williamson DF, Gail MH. Excess deaths associated with underweight, overweight, and obesity. J Am Med Assoc 2005;293:1861-7.
42. Dietz WH. Health consequences of obesity in youth: childhood predictors of adult disease. Pediatrics 1998;101:518-25.
43. Cook S, Weitzman M, Auinger P, Nguyen M, Dietz WH. Prevalence of a metabolic syndrome phenotype in adolescents. Arch Pediatr Adolesc Med 2009;157:821-7.
44. Kivipelto M, Ngandu T, Fratiglioni L, Viitanen M, Kareholt I, Winblad B, et al. Obesity and the vascular risk factors at midlife and the risk of dementia and Alzheimer's disease. Arch Neurol 2005;62:1556-60.
45. Gortmaker SL, Must A, Perrin JM, Sobol AM, Dietz WH. Social and economic consequences of overweight in adolescence and young adulthood. N Engl J Med 1993;329: 1008-12.
46. Centers for Disease Control and Prevention. National diabetes fact sheet: general information and national estimates on diabetes in the United States, 2007. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2008.
47. Narayan KN, Boyle JP, Thompson TJ, Sorenson SW, Williamson DF. Lifetime risk for diabetes mellitus in the United States. J Am Med Assoc 2003;290:1884-90.
48. Weiss R, Caprio S. The metabolic consequences of childhood obesity. Best Pract Res Clin Endocrinol Metab 2005;9:405-19.
49. Sinha R, Fisch G, Teague B, Tamborlane WV, Banyas B, Allen K, et al. Prevalence of impaired glucose tolerance among children and adolescents with marked obesity. N Engl J Med 2002;347:802-10.
50. Shaibi GQ, Faulkner MS, Weigensberg MJ, Fritschi C, Goran MI. Cardiorespiratory fitness and physical activity in youth with type 2 diabetes. Pediatr Diabetes 2008;9:460-3.
51. Sorof JM, Lai D, Turner J, Poffenbarger T, Portman RJ. Overweight, ethnicity, and the prevalence of hypertension in school-aged children. Pediatrics 2004;113:475-82.
52. Martinez-Gomez D, Tucker J, Heelan KA, Welk GJ, Eisenmann JC. Associations between sedentary behavior and blood pressure in young children. Arch Pediatr Adolesc Med 2009;163:725-30.
53. Temple JL, Giacomelli AM, Kent KM, Roemmich JN, Epstein LH. Television watching increases motivated responding for food and energy intake in children. Am J Clin Nutr 2007;85:355-61.
54. Taveras EM, Sandora TJ, Shih MC, Ross-Degnan D, Goldmann DA, Gillman MW. The association of television and video viewing with fast food intake by preschool-age children. Obesity 2006;14:2034-41.
55. Matheson DM, Killen JD, Wange Y, Varady A, Robinson TN. Children's food consumption during television viewing. Am J Clin Nutr 2004;79:1088-94.
56. Heron M, Hoyert DL, Murphy SL, Xu J, Kochanek K, Tejada B. Deaths: final data for 2006. Natl Vital Stat Rep 2009;57:33.
57. Centers for Disease Control and Prevention. Prevalence of abnormal lipid levels among youths–United States, 1999-2006. Morb Mortal Wkly Rep 2010;59:29-33.
58. Hickman TB, Briefel RR, Carroll MD, Rifkind BM, Cleeman JI, Maurer KR, et al. Distributions and trends of serum lipid levels among United States children and adolescents ages 4-19 years: data from the Third National Health and Nutrition Examination Survey. Prev Med 1998;27:879-90.
59. Daniels SR, Greer FR, American Academy of Pediatrics, Committee on Nutrition. Lipid screening and cardiovascular health in childhood. Pediatrics 2008;122:198-208.
60. Weiss R, Dziura J, Burgert TS, Tamborlane WV, Taksali SE, Yeckel CW, et al. Obesity and the metabolic syndrome in children and adolescents. N Engl J Med 2004;350:2362-74.
61. Papandreou D, Rousso I, Mavromichalis I. Update on non-alcoholic fatty liver disease in children. Clin Nutr 2007;26: 409-15.
62. Schwimmer BJ, Deutsch R, Kahen T, Lavine EJ, Stanley C, Behling C. Prevalence of fatty liver in children and adolescents. Pediatrics 2006;118:1388-93.
63. Redline S, Tishler PV, Schluchter M, Aylor J, Clark K, Graham G. Risk factors for sleep-disordered breathing in

children: associations with obesity, race, and respiratory problems. Am J Respir Crit Care Med 1999;159:1527-32.
64. Brooks LJ, Stephens BM, Bacevice AM. Adenoid size is related to severity but not the number of episodes of obstructive apnea in children. J Pediatr Pulmonol 1993;16: 124-9.
65. Fiorino EK, Brooks LJ. Obesity and respiratory diseases in childhood. Clin Chest Med 2009;30:601-8.
66. Li AM, Au CT, Sung RY, Ho C, Ng PC, Fok TF, et al. Ambulatory blood pressure in children with obstructive sleep apnoea: a community based study. Thorax 2008;63:803-9.
67. Rhodes SK, Shimoda KC, Waid LR, Oapos P, Oexmann M, Collop N, et al. Neurocognitive deficits in morbidly obese children with obstructive sleep apnea. J Pediatr 1995;127: 741-4.
68. National Center for Health Statistics. Asthma. Hyattsville, MD, 2009.
69. Schachter LM, Salome CM, Peat JK, Woolcock AJ. Obesity is a risk for asthma and wheeze but not airway hyperresponsiveness. Thorax 2001;56:4-8.
70. Scholtens S, Wijga AH, Seidell JC, Brunekreef B, Jongste JC, Gehring U. Overweight and changes in weight status during childhood in relation to asthma symptoms at 8 years of age. J Allergy Clin Immunol 2009;123:1312-8.
71. Visness CM, London SJ, Daniels JL, Kaufman JS, Yeatts KB, Siega-Riz A. Association of obesity with IgE levels and allergy symptoms in children and adolescents: results from the National Health and Nutrition Examination Survey 2005-06. J Allergy Clin Immunol 2009;123:1163-9.
72. Von Behren J, Lipsett M, Horn-Ross PL, Delfino RJ, Gillilan F, McConnell R. Obesity, waist size, and prevalence of current asthma in the California teachers study cohort. Thorax 2009;64:889-93.
73. Environmental Protection Agency. Measure D2: Percentage of children reported to have ever been diagnosed with asthma. America's children and the environment. Available at: http://www.epa.gov/envirohealth/children/child_illness/d2-graph.htm. Accessed July 10, 2009.
74. National Center for Health Statistics. National Health Interview Survey 2003-06 [data file]. Available at: http://www.cdc.gov/nchs/nhis.htm. Accessed July 10, 2009.
75. Bryant-Stephens T. Asthma disparities in urban environments. J Allergy Clin Immunol 2009;123:1199-206.
76. Akinbami LJ, Moorman JE, Garbe PL, Sondik EJ. Status of childhood asthma in the United States, 1980-2007. Pediatrics 2009;123:S131-45.
77. Rasmussen F, Lambrechtsen J, Siersted HC, Hansen HS, Hansen NCG. Low physical fitness in childhood is associated with the development of asthma in young adulthood: the Odense schoolchild study. Eur Respir J 2000;16:866-70.
78. Sheriff A, Maitra A, Ness AR, Mattocks C, Riddoch C, Reilly JJ. Association of duration of television viewing in early childhood with the subsequent development of asthma. Thorax 2009;64:321-5.
79. Corbo GM, Forastiere F, De Sario M, Brunetti L, Bonci E, Bugiani M, et al. Wheeze and asthma in children: associations with body mass index, sports, television viewing, and diet. Epidemiology 2008;19:747-55.
80. Kumar J, Muntner P, Kaskel FJ, Hailpern SM, Melamed ML. Prevalence and associations of 25-hydroxyvitamin D deficiency in US children: NHANES 2001-04. Pediatrics 2009;124:e362-70.
81. Holick MF. Resurrection of vitamin D deficiency and rickets. J Clin Invest 2006;116:2062-72.
82. Kreiter SR, Schwartz RP, Kirkman HN, Charlton PA, Calikoglu AS, Davenport ML. Nutritional rickets in African American breast-fed infants. J Pediatr 2000;137:153-7.
83. Rudolf M, Arulanantham K, Greenstein RM. Unsuspected nutritional rickets. Pediatrics 1980;66:72-6.
84. Edidin DV, Levitsky LL, Schey W, Dumbovic N, Campos A. Resurgence of nutritional rickets associated with breast-feeding and special dietary practices. Pediatrics 1980;65: 232-5.
85. Sills IN, Skuza KA, Horlick MNB, Schwartz MS, Rapaport R. Vitamin D deficiency rickets: reports of its demise are exaggerated. Clin Pediatr 1994;33:491-3.
86. Brender E, Burke A, Glass RM. Vitamin D. J Am Med Assoc 2005;294:2386.
87. Reis JP, Mulen DV, Miller ER, Michos ED, Appel LJ. Vitamin D status and cardiometabolic risk factors in the United States adolescent population. Pediatrics 2009;124: e371-9.
88. Maki KC, Rubin MR, Wong LG, McManus JF, Jensen CD, Marshall JW, et al. Serum 25-hydroxyvitamin D is independently associated with high-density lipoprotein cholesterol and the metabolic syndrome in men and women. J Clin Lipidol 2009;3:289-96.
89. Ohta H, Kuroda T, Onoe Y, Orito S, Ohara M, Kume M, et al. The impact of lifestyle factors on serum 25-hydroxyvitamin D levels: a cross-sectional study in Japanese women aged 19-25 years. J Bone Miner Metab 2009;27:682-8.
90. Brehm JM, Celedon JC, Soto-Quiros ME, Avila L, Hunninghake GM, Forno E, et al. Serum vitamin D levels and markers of severity of childhood asthma in Costa Rica. Am J Respir Crit Care Med 2009;179:765-71.
91. Wagner CL, Greer FR, American Academy of Pediatrics, Section on Breastfeeding, American Academy of Pediatrics Committee on Nutrition. Prevention of rickets and vitamin D deficiency in infants, children, and adolescents. Pediatrics 2008;122:1142-52.
92. Thomas CP, Conrad P, Casler R, Goodman E. Trends in the use of psychotropic medications among adolescents, 1994-2001. Psychiatr Serv 2006;57:63-9.
93. Costello EJ, Erkanli A, Angold A. Is there an epidemic of child or adolescent depression? J Child Psych Psychiatry 2006;47:1263-71.
94. American Psychological Association. Stress in America. American Psychological Association, 2009.
95. Centers for Disease Control and Prevention. Attention deficit/hyperactivity disorder (ADHD). Available at: http://www.cdc.gov/ncbddd/adhd/research.html. Accessed December 1, 2009.
96. Pastor PN, Reuben CA. Diagnosed attention deficit hyperactivity disorder and learning disability: United States, 2004-06. In: National Center for Health Statistics. Vital Health Stat 2008;10:237.
97. Simpson GA, Cohen RA, Pastor PN, Reuben CA. Use of

mental health services in the past 12 months by children aged 4-17 years: United States, 2005-06. NCHS Data Brief 2008;8:1-8.
98. US Department of Health and Human Services. Physical Activity Guidelines Advisory Committee Report. Washington, DC: US Department of Health and Human Services, 2008.
99. Hansen HS, Froberg K, Hyldebrandt N, Nielsen JR. A controlled study of eight months of physical training and reduction of blood pressure in children: the Odense schoolchild study. BMJ 1991;303:682-5.
100. Hagberg JM, Ehsani AA, Goldring D, Hernandez A, Sinacore DR, Hollozy JO. Effect of weight training on blood pressure and hemodynamics in hypertensive adolescents. J Pediatr 1984;104:147-51.
101. Gahagan S, Silverstein J, American Academy of Pediatrics, Committee on Native American Child Health and Section on Endocrinology. Prevention and treatment of type 2 diabetes mellitus in children, with special emphasis on American Indian and Alaska native children. Pediatrics 2003;112:e328-47.
102. American Academy of Pediatrics, Council on Sports Medicine and Fitness and Council on School Health. Active healthy living: prevention of childhood obesity through increased physical activity. Pediatrics 2006;117:1834-42.
103. Okay DM, Jackson PV, Marcinkiewicz M, Papino MN. Exercise and obesity. Prim Care Clin Off Pract 2009;36: 379-93.
104. Taylor RW, McAuley KA, Barbezat W, Strong A, Williams SM, Mann JI. APPLE project: 2-y findings of a community-based obesity prevention program in primary school age children. Am J Clin Nutr 2007;86:735-42.
105. Dwyer T, Magnussen CG, Schmidt MD, Ukoumunne OC, Ponsonby AL, Raitakari OT, et al. Decline in physical fitness from childhood to adulthood associated with increased obesity and insulin resistance in adults. Diabetes Care 2009; 32:683-7.
106. Burdette HL, Whitaker RC. Parental report of outdoor playtime as a measure of physical activity in preschool-aged children. Arch Pediatr Adolesc Med 2004;159:46-50.
107. Mitchell R, Popham F. Effect of exposure to natural environment on health inequalities: an observational population study. Lancet 2008;372:1655-60.
108. Maas JM, Verheij RA, Vries SD, Spreeuwenberg P, Schellevis FG, Groenewegen PP. Morbidity is related to a green living environment. J Epidemiol Community Health 2009; 63:967-73.
109. Wells NM, Evans GW. Nearby nature: a buffer of life stress among rural children. Environ Behav 2003;35:311-30.
110. Pretty J, Peacock J, Sellens M, Griffin M. The mental and physical health outcomes of green exercise. Int J Environ Health Res 2005;15:319-37.
111. Kaplan S. The restorative benefits of nature: toward an integrative framework. J Environ Psychol 1995;15:169-82.
112. Mole M, Marshall L, Pietrowsky R, Lutzenberger W. Dimensional complexity of the EEG indicates a right frontocortical locus of attentional control. Psychophysiology 1995;9:45-55.
113. Coull JT, Frackowiak RSJ, Frith CD. Monitoring for target objects: activation of right frontal and parietal cortices with increasing time on task. Neuropsychologia 1998;36:1325-34.
114. Glosser G, Goodglass H. Disorders in executive control functions among aphasic and other brain damaged patients. J Clin Exp Neuropsychol 1990;12:485-501.
115. Taylor AF, Kuo FE, Sullivan WC. Coping with ADD: The surprising connection to green play settings. Environ Behav 2001;33:54-77.
116. Kuo FE, Taylor AF. A potential natural treatment for attention-deficit/hyperactivity disorder: evidence from a national study. Am J Public Health 2004;94:1580-6.
117. Wells NM. At home with nature: effects of "greenness" on children's cognitive functioning. Environ Behav 2000;32: 775-95.
118. Taylor AF, Kuo FE. Children with attention deficits concentrate better after walk in the park. J Atten Disord 2009;12:402.
119. Frumkin H. Beyond toxicity: human health and the natural environment. Am J Public Health 2001;20:234-40.
120. Mayer FS, Frantz CM, Bruehlman-Senecal E, Dolliver K. Why is nature beneficial?: the role of connectedness to nature. Environ Behav 2009;41:607-43.
121. Kaplan R. The nature of the view from home: psychological benefits. Environ Behav 2001;33:507-41.
122. Lovasi GS, Quinn JW, Neckerman KM, Perzanowski MS, Rundle A. Children living in areas with more street trees have lower prevalence of asthma. J Epidemiol Community Health 2008;62:647-9.
123. Vitale S, Sperduto RD, Ferris FL. Increased prevalence of myopia in the United States between 1971-1972 and 1999-2004. Arch Ophthalmol 2009;127:1632-9.
124. Kleinstein RN, Jones LA, Hullet S, Kwon S, Lee RJ, Friedman NE, et al. Refractive error and ethnicity in children. Arch Ophthalmol 2003;121:1141-7.
125. Rose KA, Morgan IG, Ip J, Kifley A, Huynh S, Smith W, et al. Outdoor activity reduces the prevalence of myopia in children. Am Acad Ophthalmol 2008;115:1279-85.
126. Dirani M, Tong L, Zhang X, Chia A, Young TL, Rose KA, et al. Outdoor activity and myopia in Singapore teenage children. Br J Ophthalmol 2009;93:997-1000.
127. American Academy of Pediatrics, Committee on Nutrition. Kleinman, RE, editor. Pediatric nutrition handbook. Elk Grove Village (IL): American Academy of Pediatrics; 2004.
128. Ulrich RS. View through a window may influence recovery from surgery. Science 1984;224:420-1.
129. Diette GB, Lechtzin N, Haponik E, Devrotes A, Rubin HR. Distraction therapy with nature sights and sounds reduces pain during flexible bronchoscopy. Chest 2003;123:941-8.
130. American Academy of Pediatrics. A parent's guide to childhood obesity: a road map to health. In: Hassink EG, editor. Elk Grove Village (IL): American Academy of Pediatrics, 2006.
131. American Academy of Pediatrics. Nutrition. Available at: http://www.aap.org/healthtopics/nutrition.cfm. Accessed January 25, 2010.
132. Andersen RE, Crespo CJ, Bartlett SJ, Cheskin LJ, Pratt M. Relationship of physical activity and television watching with body weight and level of fatness among children: results from the Third National Health and Nutrition Examination Survey. J Am Med Assoc 1998;279:938-42.
133. Exercise is medicine: physicians and health care providers.

Available at: http://www.exerciseismedicine.org/physicians.htm. Accessed January 13, 2010.
134. Morgan O. Approaches to increase physical activity: reviewing the evidence for exercise-referral schemes. Public Health 2005;119:361-70.
135. Leijon ME, Bendtsen P, Nilsen P, Festin K, Stahle A. Does a physical activity referral scheme improve the physical activity among routine primary health care patients? Scand J Med Sci Sports 2009;19:627-36.
136. Grandes G, Sanchez A, Sanchez-Pinilla RO, Torcal J, Montoya I, Lizarraga K, et al. Effectiveness of physical activity advice and prescription by physicians in routine primary care. Arch Intern Med 2009;169:694-701.
137. Rogers B, McCurdy LE, Slavin K, Grubb K, Roberts JR. Children's environmental Health Faculty Champions Initiative: a successful model for integrating environmental health into pediatric healthcare. Environ Health Perspect 2009;117:850-5.
138. Children and nature initiative: resources. Available at: http://www.neefusa.org/health/children_nature/resources.htm. Accessed January 13, 2010.
139. Kruger J, Nelson K, Klein P, McCurdy LE, Pride P, Ady JC. Building on partnerships: reconnecting kids with nature for health benefits. Health Promot Pract 2009 (Epub ahead of print).
140. Centers for Disease Control and Prevention. Physical activity guidelines for Americans: Children and adolescents. Available at: http://www.cdc.gov/healthyyouth/physicalactivity/guidelines.htm. Accessed January 25, 2010.
141. Centers for Disease Control and Prevention. Available at: http://www.cdc.gov/Features/ParksandTrails/. Accessed January 13, 2010.