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Review Article

Epidemiology and etiology of fractures in children and adolescents

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ABSTRACT

Fractures in children and adolescents are a significant public health concern. The incidence of fractures varies based on age, sex, and anatomical site, with falls, sports-related injuries, motor vehicle accidents, child abuse, and pathological conditions identified as primary causes. Risk factors such as age, sex, physical activity, bone mineral density, body composition, and genetic factors contribute to fracture occurrence. Preventive measures targeting modifiable risk factors and promoting safety in physical activities are crucial for reducing the burden of fractures in children and adolescents. This review aims to provide a comprehensive understanding of the epidemiology and etiology of fractures in children and adolescents. Understanding the epidemiological patterns and etiological factors can guide the development of effective prevention strategies and optimize fracture management in this population.

Keywords: Fractures, Children, Adolescents, Epidemiology, Etiology

INTRODUCTION

Every year in the United States, approximately 25% of children experience accidental injuries that require urgent medical attention, resulting in an estimated annual treatment cost of around $350 billion.[1,2] Among pediatric inpatient surgeries, orthopedic surgery for fractures and musculoskeletal injuries is the second most common type.[3] Fractures are typically diagnosed definitively through radiographs and treated in fracture clinics. They are frequently observed in both young individuals and the elderly, during stages when the skeletal structure becomes porous and vulnerable at the physes and metaphyses, correspondingly.[4] Roughly one-third of children experience at least one fracture before reaching the age of 17, as reported by Cooper et al.[5] Additionally, fractures account for 9% of all injuries in children that require medical attention.[6]

Engaging in regular physical activity is crucial for promoting the healthy mental and physical development of children.[7] International guidelines recommend that children participate in at least sixty minutes of moderate or vigorous physical activity daily.[8] On the other hand, it

is important to note that physical activity comes with a risk of injury. There is a growing epidemic of preventable injuries among children and adolescents, with sport and recreational activities accounting for up to 39% of pediatric fractures.[9,10] To address this issue, various national initiatives, such as the sports trauma and overuse prevention (STOP) Sport Injuries campaign, have been established to promote effective preventive measures. In order to develop strategies that reduce the risk of injury while maintaining the recommended level of physical activity, it is essential to quantify the risk of injury associated with different childhood activities.[4]

The incidence of fractures in childhood varies, with reported rates ranging from 12.0 to 36.1 per 1,000 children per year.[11] The lifetime risk of sustaining a fracture for boys aged 0 to 16 years is estimated to be between 42% and 64%, while for girls, it ranges from 27% to 40%.[12] A study from Sweden found an overall annual incidence of 257 fractures per 10,000 boys, 165 fractures per 10,000 girls, and a combined incidence of 212 fractures per 10,000 children.[13] Although most fractures in children heal without long-term complications, fracture treatment and follow-up visits generate additional costs in healthcare systems. Reducing fracture risk would bring substantial benefits to both children and the healthcare system, alleviating the associated cost burden.

The cost of treating pediatric fractures varies, averaging about $7,000 for emergency department treatment and nearly $24,000 for operative treatment.[14] These costs have a significant impact on healthcare expenditures. Additionally, pediatric fractures impose non-monetary costs on children, such as missed school days and restricted activity, which range from 14 days for upper extremity fractures to 26 days for lower extremity fractures. Parents or guardians also bear the consequences, including missed work days, transportation expenses, and other related costs.[15]

In this review, we will discuss the epidemiology and etiology of fractures in children and adolescents that will help to understand the risk factors and reduce the occurrence of injuries.

LITERATURE SURVEY

For this particular study, an extensive search of the literature was carried out on June 7, 2023, using the Medline and Cochrane databases. The search involved employing medical topic headings (MeSH) and a combination of relevant terms found within the databases. The main focus was on articles published from 2000 to 2023, in order to gather the most up-to-date information available. To ensure a comprehensive review, a manual search was also conducted using Google Scholar, starting from the previously identified papers. The review encompassed papers that discussed topics such as epidemiology, etiology and risk factors of fractures in children and adolescents. In order to be inclusive, no restrictions were placed on the type of publication, participant age, language, or publication date.

DISCUSSION

Fractures are indeed significant burden in pediatric population, accounting for substantial number of emergency department visits and hospital admissions.[5] The incidence of fractures varies based on age, sex, and anatomical site, reflecting diverse nature of these injuries.

Younger children, particularly those aged 1-5 years, are more prone to fractures due to their increased vulnerability to falls. A study by Cooper et al utilizing the general practice research database in Britain found that children aged 1-4 years had the highest fracture incidence, with a rate of 62.7 per 10,000 person-years.[5] Similarly, Lyons et al conducted a population-based study and reported a peak incidence of fractures between the ages of 2 and 3 years.[11]

During adolescence, incidence of fractures remains substantial, especially among individuals engaged in sports and physical activities. Age group experiences growth spurt, rendering them susceptible to fractures. Goulding et al conducted study, found that adolescents aged 12-14 years had highest incidence of fore arm fractures, with rate of 52.3 per 10,000 person-years.[16]

The overall incidence of fractures in children and adolescents varies widely, ranging from 1% to 40%. A study by Clark et al followed a cohort of children aged 9-15 years and reported an overall incidence rate of 14.6 per 10,000 person-years for fractures.[17] However, it is essential to note that fracture rates can vary across different populations and geographical regions.

Sex differences in fracture incidence have also been observed. Males tend to exhibit a higher fracture incidence compared to females. This disparity may be attributed to differences in physical activity patterns and skeletal development. Nieves et al conducted a study comparing bone mass between males and females and found that males had larger skeletal size and bone mass despite comparable body size, which could contribute to their higher fracture incidence.[18]

Regarding anatomical sites, fractures most commonly occur in the upper extremities. The distal radius and ulna are frequently affected, followed by the clavicle, humerus, and fingers. Lower extremity fractures involve the tibia, fibula, and ankle, while fractures in the femur and hip are less frequent. Vertebral compression fractures, although relatively rare, can have significant long-term implications for spinal health.[17]

Risk factors play a significant role in the occurrence of fractures in children and adolescents. Understanding these factors is crucial for implementing targeted prevention

strategies. To begin with, younger age groups, particularly toddlers and preschoolers, are at a heightened risk of fractures due to their limited motor skills, exploration of the environment, and a higher tendency to fall. This vulnerable age group often lacks coordination and balance, increasing their susceptibility to fractures.[5]

Males exhibit a higher incidence of fractures compared to females. This difference may be influenced by variations in physical activity levels and patterns between the sexes. Males tend to engage in more vigorous physical activities, including sports and rough play, which may increase their risk of fractures.[16]

Participation in sports and activities involving high-impact movements and contact can significantly increase the risk of fractures. Competitive athletes, especially those involved in contact sports such as football, soccer, and gymnastics, are at an elevated risk due to the potential for falls, collisions, and repetitive stresses.[19]

Lower bone mineral density, influenced by both genetic and environmental factors, contributes to increased fracture susceptibility. Conditions affecting bone health, such as osteogenesis imperfecta or vitamin D deficiency, are associated with a higher risk of fractures. Decreased BMD weakens the structural integrity of the bones, making them more prone to fractures.[17]

Obesity has been linked to an increased risk of fractures in children and adolescents. Mechanical stress exerted on bones due to excessive body weight, coupled with altered bone geometry, may contribute to this association. Obesity-related factors, including reduced physical activity, may also play a role in increasing fracture risk.[20]

Certain genetic conditions predispose individuals to bone fragility and an elevated risk of fractures. For example, osteogenesis imperfecta is a genetic disorder characterized by brittle bones, making affected individuals more susceptible to fractures. Marfan syndrome, another genetic condition, can affect the connective tissues in the body, including the skeletal system, increasing the risk of fractures.[21]

Understanding these risk factors can aid in identifying high-risk individuals and implementing appropriate preventive measures, such as safety education, modification of physical activity programs, and targeted interventions for underlying genetic conditions.

Fractures in children and adolescents have a multifactorial etiology, involving a combination of mechanical forces applied to the bone and the bone's ability to withstand these forces. Falls are the primary cause of fractures in children and adolescents. Whether from a height or on the same level, falls can result in fractures. Upper extremity fractures, particularly of the distal radius, are commonly observed as children instinctively extend their hands to break the fall.[22]

Participation in sports and recreational activities exposes children and adolescents to an increased risk of fractures. High-impact sports involving collisions, falls, and repetitive stresses, such as football, basketball, and skateboarding, carry a higher risk of fractures. The nature of these activities can place significant forces on the bones, leading to fractures.[7]

Motor vehicle accidents, including pedestrian and bicycle accidents, can result in severe fractures in children and adolescents. The lower extremities and pelvis are particularly vulnerable in such accidents. The impact forces generated during these incidents can exceed the bone's tolerance, leading to fractures.[23]

Non-accidental trauma, including physical abuse, can cause fractures in children. Suspicion of child abuse should be raised if there is an inconsistent injury pattern or explanation provided. Fractures associated with child abuse may exhibit specific characteristics, such as multiple fractures at different stages of healing or fractures in non-mobile infants.[24]

Underlying medical conditions affecting bone health can weaken the bone structure and increase the risk of fractures in children and adolescents. Conditions such as osteoporosis, osteogenesis imperfecta, or bone tumors compromise the integrity and strength of the bones, making them more susceptible to fractures.[17]

Understanding the etiology of fractures in children and adolescents helps in identifying the primary causes and implementing appropriate preventive strategies. It also underscores the importance of considering non-accidental trauma, such as child abuse, in cases where the injury pattern is inconsistent with the explanation provided.

CONCLUSION

Fractures in children and adolescents pose significant public health concern. Understanding their epidemiology and etiology is vital for developing prevention strategies. Incidence varies by age, sex, and anatomical site, with falls, sports-related injuries, motor vehicle accidents, child abuse, and pathological conditions as primary causes. Identifying modifiable risk factors, promoting physical activity safety, and raising awareness about child abuse are key for reducing fracture burden in this population.

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