

Review Paper
The development of mature gait

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Abstract

We must understand the natural history of immature walking in order to define and interpret pathological gait in young children. Step length, cadence and walking velocity show evidence of both central nervous system maturation and growth until approximately 4 years of age. Until 4 years-of-age the step factor (step length divided by leg length) increases, but thereafter the step factor remains constant and adult-like. After 4 years-of-age the changes in velocity, cadence, step length in normal children are appropriately attributed to changes in limb length. Dynamic joint angle measurements indicate stabilization of gait by 3½ to 4 years-of-age. However, there is greater inter-subject and intra-subject variability of gait in children of all ages than of adults. Force plate measurements of subjects 2 to 7 years-of-age show an increasing definition of the mid-stance trough in the vertical force curve. The second peak of the vertical force curve is deficient, by adult standards, particularly in the younger age groups. Moment and power curves of hip, knee and ankle in subjects 4 years and older show patterns not unlike those of adult subjects. There are differences in magnitude, suggesting that the youngest children use their hip flexor and extensor muscles more than their ankle plantar flexors for power generation. A study from another center shows no age-related differences in hip, knee and ankle powers in children 5–16 years of age. All of the studies reported are very helpful in understanding gait maturation but researchers are needed to address remaining questions. © 1997 Elsevier Science B.V.

Keywords: Pathological gait; Step length; Cadence; Walking velocity

1. Introduction

We all can agree that the walking patterns of very small children differ from those of adults, but why is this important and why present childrens' gait data? The answer is that one must understand the normal or natural history of a studied phenomenon before attempting to describe and study the pathological or abnormal. It follows that there are three important questions to ask: (1) How does the gait of children differ from that of adults? (2) When do children achieve an adult-like gait pattern? (3) What are the factors controlling the maturation of gait? Much has been written on this subject, but only questions (1) and (2)

are beginning to come clearly into focus. The question of what factors control the maturation of gait will be a research focus for physiologists, neuro-scientists, developmental pediatricians, physical therapists, and gait laboratory teams for many years ahead. It has only been in the past 2 or 3 decades that the tools for dynamic investigation of gait have become both available and sufficiently well developed to permit serious studies of gait maturation in children.

From an observational standpoint, the general sequence of the early development of human mobility following birth is well known. The newborn infant is helpless and fully dependent. The infant is able to sit upright at about 6 months after birth, begins to crawl around 9 months, and walks without support at around 1 year of age [1]. There is evidence that the control

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