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Lower limb extensor moments in children with spastic diplegic cerebral palsy

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Abstract

In this retrospective study, we quantified the mean extensor moment at the ankle, knee and hip over the stance period in a group of independently ambulant children with spastic diplegia ($n = 90$; 167 limbs) and in a group of normally-developing (ND) children ($n = 22$; 22 limbs). The mean knee extensor moment and the mean support moment demonstrated greater variance in children with diplegia than in normally-developing children ($P < 0.0001$ and $P < 0.001$). This was explained by a strong relationship between the mean knee extensor moment and minimum knee flexion in stance ($r^2 = 0.615$; $P < 0.0001$) in the affected group with a positive mean knee extensor moment for all those children who walked in greater than 20° of knee flexion. We also found a linear relationship between the support moment and knee flexion ($r^2 = 0.805$; $P < 0.0001$). Our data supported the biomechanical analysis of Hof [Gait Posture, 12 (2000) 196] who suggested that his modified support moment should be a linear function with eccentricity at the knee. Extensor moments at the ankle ($r^2 = 0.001376$; $P = 0.641$) and hip ($r^2 = 0.0860$; $P = 0.000168$) bore weak relationships with increasing knee flexion even though there was a strong positive relationship between minimum knee flexion and minimum hip flexion ($r^2 = 0.316$; $P < 0.0001$). We conclude that children with spastic diplegic cerebral palsy (SDCP) who walk with a crouch gait rely on their knee extensors to prevent collapse of the lower limbs. Intervention directed at redistributing extensor moments between the joints of the lower limbs may slow the increase in knee flexion and prolong reasonable walking function in this group.

Keywords: Spastic cerebral palsy; Knee flexion; Support moment

1. Introduction

In the lower limbs, kinetic data describes the net moments and forces acting about the hip, knee and ankle. Increasing net joint moments indicate that greater muscle forces are required to stabilise or move the body segments. Kinetic patterns in the child with spastic diplegia have been evaluated [4,9], but their value is probably under exploited in the clinical setting.

Winter [19] proposed that the sum of the individual extensor moments at the joints of the lower limb must be positive to support the body in an upright posture. "the support moment" (Eq. (1)) was shown to be less variable than the individual net joint moments during walking and jogging. Further, it was asserted that the net moments around each of the joints are compensatory, such that a deficit in a knee extensor moment may be substituted by an increase in the plantarflexor moment or the hip extensor moment, or both. However, his hypothesis was not tested in a single well-defined pathological group.

$$M_s = M_h + M_k + M_a \quad (1)$$

where M_s is the support moment according to Winter [19], M_h the hip extensor moment, M_k the knee extensor moment and M_a the ankle plantarflexor moment.

Hof [6] re-formulated the support moment (Eq. (2)) and provided a biomechanical interpretation. In a 2D model, he showed that a modified sum of the net extensor moments was proportional to the projection of the ground reaction force vector on a line connecting the ankle and hip joint centres, and to the eccentricity of the knee (the ratio of the perpendicular distance between the knee joint centre and the line joining the hip and ankle joint centres to the distance between the hip and ankle joint centres). Hof [6] demonstrated

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