Comparing Manual Muscle Strength Measurements with Joint Moments

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Introduction

The importance of muscle weakness in limiting walking ability in children with cerebral palsy has been increasingly acknowledged over the last decade (Wiley and Damiano, 1998). It has been established that it is possible to make measurements of strength in such children (evidence summarized in Damiano et al., 2002). Although these measurements are, essentially, of the moments muscle groups are capable of exerting during the clinical examination, no attempt has been made to compare these with the joint moments now routinely recorded as part of clinical gait analysis. This study aims to establish a framework for making such a comparison and to compare these two types of data for able-bodied children.

Statement of Clinical Significance

This approach will allow the comparison of measures of moment generating capacity ("muscle strength") made during the clinical examination with those measured during walking. This will allow a qualitative assessment of the impact of muscle weakness on walking ability. The present study, of able-bodied children, will provide normative reference data. The overall approach, however, is equally applicable for use with individual patients. The strength profile produced can serve as a tool for targeting strengthening programmes at specific muscle groups.

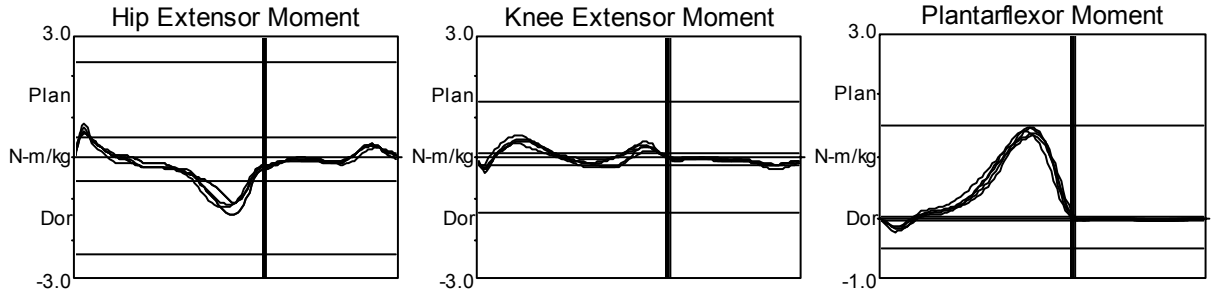

Figure 1. Sample data for one subject. Continuous line = gait kinetics from five separate walks. Dashed line = moment equivalent to maximum (grade 5) muscle strength (measured). Dotted line = moment equivalent to grade 3 muscle strength (calculated).

Methodology

11 able-bodied children with ages ranging from 6-11 were recruited from amongst friends and family of staff of the Gait Analysis Laboratory. Maximum isometric strength of seven lower limb muscle groups were recorded using a hand held dynamometer; the Lafayette Manual Muscle Test System (model 01163). Specific protocols were used to ensure that the positions of the limb segments distal to the tested joint were known. The effects of gravity on the distal limb segments were removed from the measurements using a simple biomechanical model

based on the anthropometric data of Jensen (1986) and were recorded in Newton-metres per kilogram to be consistent with joint moments from gait analysis data. The same model was used to calculate estimates of the joint moment equating to Grade 3 muscle strength – the ability to just overcome the effect of gravity on the distal segments.

The subjects then had markers applied to facilitate data capture with a 6 camera VICON 512 gait analysis system incorporating two AMTI force plates. Plug In Gait was used to generate joint moments for walking and the muscle strength measurements were superimposed on the graphs as horizontal lines. Descriptive statistics were calculated for all measurements.

Results

Muscle Group	Gait N-m/kg		Grade 5 N-m/kg		Grade 3 N-m/kg	
	mean	s.d.	mean	s.d.	mean	s.d.
Hip extensors	0.59	0.11	1.92	0.50	0.50	0.05
Hip flexors	0.85	0.27	2.05	0.43	0.50	0.05
Hip abductors	0.58	0.13	1.28	0.25	0.50	0.05
Knee extensors	0.47	0.20	1.17	0.27	0.13	0.01
Knee flexors	0.24	0.06	1.28	0.24	0.13	0.01
Ankle Plantarflexors	1.11	0.41	1.23	0.28	0.02	0.00
Dorsiflexors	0.11	0.07	0.49	0.11	0.02	0.00

Table 1 Maximum gait moments and moments equivalent to grade 5 and grade 3 muscle strength averaged over all subjects.

Discussion

Figure 1 clearly shows the ease of interpretation of data presented in this manner. The extension of such techniques to identify specific functional weakness in children with pathology is obvious.

For normal children the moments generated during walking are clearly well within the moments they are capable of generating during the clinical exam. For the ankle however measured strength values are only 11% more than those required during gait. Grade 3 strength values were less than the maximum moment during gait for all subjects. For the ankle the moment during gait was over 70 times the Grade 3 moment. It is clear that Grade 3 muscle strength is not sufficient to allow normal walking and that it may have very little value at all in assessing the functional potential of knee and ankle muscles.

References

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