STIFF-KNEE GAIT IN STROKE—ROLE OF RECTUS FEMORIS AND VASTII

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SUMMARY

The study describes activity patterns of rectus femoris (RF) and Vastii in 20 patients with chronic stroke who walked with a stiff-knee gait.

CONCLUSIONS

Contrary to common belief that components of Vastii are responsible for the stiff-knee gait in stroke, this study found that in the majority of subjects (17 out of 20) only RF was active during swing. The amplitude of activity varied with the amount of knee excursion. In none of the subjects isolated Vastus Intermedius (VI) activity was found during swing phase.

INTRODUCTION

Many patients with neurological disorders such as cerebral palsy (CP) and stroke walk with stiff knee. In CP this inability to flex the knee during swing is attributed to over-activity of RF. However, in patients with stroke, the role played by Vastii and RF in producing stiff-knee gait is not known. Stiff-knee gait could be due to RF function abnormality, just as in CP, or be due to swing phase activity of any one or all of the elements of Vastii. Differentiation of activity patterns of RF and the components of Triceps Femoris (Vastus Lateralis (VL), VI, and Vastus Medialis (VM)) in stroke has clinical implications. The objective of this study was to define activity patterns of RF and Vastii in patients with stroke who walk with a stiff-knee gait.

PATIENTS/MATERIALS AND METHODS

Twenty chronic stroke patients participated in the study (age range 32–74 years, 6 females and 14 males, 10 right and 10 left-sided hemiplegics, duration after stroke longer than 1 year). They all walked with a stiff-knee gait on visual observation. None of them had fixed deformities. On the paretic side, dynamic EMG was measured from RF using fine wire and surface electrodes simultaneously, that from VL and VM using only surface electrodes. VI activity was determined by a process of elimination. Presence of activity on surface EMG of RF and the absence of simultaneous activity on fine wire EMG of RF and surface EMG of VL and VM was considered to be the indication of VI activity. Electronic biaxial goniometer (Penny and Giles) was used to measure knee trajectory and foot contact switches were used to recognize gait cycle events. Subjects walked along a 7.5 m walkway with their shoes on (they were allowed to use the AFOs and walking aids if needed) at four different self-selected speeds (slow, normal, fast and fastest). Data was collected using a K-Lab EMG measurement system and was stored using VICON 370 system. The data was processed using Matlab v6.5.

RESULTS

The mean walking speeds were as follows: slow 0.55 m s^{-1} (S.D. 0.14), normal 0.61 m s^{-1} (S.D. 0.14), fast 0.82 m s^{-1} (S.D. 0.2), and fastest 1.01 m s^{-1} (S.D. 0.3). Mean knee excursion during the gait cycle was 32.5° (S.D. 9). There was no difference in the excursion range at different speeds. In 17 subjects only RF was active during pre-swing, initial swing and mid-swing phases. The amplitude varied depending on the amount of knee excursion. In three subjects VL and VM showed activity during initial and mid-swing phases. There was no evidence of isolated VI swing phase activity in any subject. In six subjects RF showed activity during loading response along with VL and VM. Surprisingly in eight subjects during terminal swing only VM showed some activity, VL was completely inactive.

DISCUSSION

Contrary to the expected variety of muscle activity, in the majority of subjects only RF was active during swing. The amplitude was lower in subjects with smaller knee flexion. These subjects tended to swing their legs like a pendulum in the absence of hip flexion/plantar flexion couple. Previous studies have suggested that multiple impairments, not just at the knee, but also at the hip and ankle, lead to stiff-knee gait in stroke. In the absence of impairments at hip and ankle levels, patients with stiff-knee gait caused by isolated prolonged activity of RF could be effectively treated with distal RF transfer, as done in patients with CP. In case of swing phase activity of VI alone, the gait could be improved with a release of VI surgically. However, in the event of swing phase activity of combined Vastii the situation becomes difficult to treat.

THE EFFECT OF ANKLE FOOT ORTHOSES ON WALKING EFFICIENCY IN CHILDREN WITH SPASTIC CEREBRAL PALSY

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SUMMARY

Gait and oxygen data from 186 children with spastic cerebral palsy (CP) was analyzed to examine the effect of ankle–foot orthoses (AFO) on walking efficiency and performance.

CONCLUSION

The use of AFO's causes a statistically significantly decrease in the energy cost of walking. This is related to both a faster and more efficient walking pattern.

INTRODUCTION

There is a general consensus that energy cost of walking in children with CP is increased compared to healthy children [1]. Orthotic treatment has been employed to improve gait patterns, and reduce the energy cost of walking. There are only a few studies, each with small sample sizes, examining the effect of orthotic treatment in subgroups of children with CP [2,3]. The purpose of the current study was to extend previous research on a significantly larger sample and determine whether AFO's improve walking efficiency.

METHODS

A retrospective study was performed on pre- and post-AFO intervention data of 186 children (age range: 55–413 months) with spastic CP. Subjects were chosen based on the following criteria: (1) a diagnosis of spastic CP, (2) a solid or posterior leaf spring AFO, (3) barefoot (BF) and AFO gait analyses performed on the same day, (4) no assistive devices. Data consisted of: three dimensional joint kinematics, expressed as the Gillette Gait Index (GGI) (formerly Normalcy Index [4]), non-dimensional speed (*speed*), net non-dimensional (NN) energy cost of walking (*cost*) [5], and NN cost as a percentage of speed-matched controls (*normalised NN cost*).

RESULTS

The NN energy cost was 11% lower ($p < 0.001$), normalised NN cost was 25% lower ($p < 0.001$), and walking speed was 9% faster ($p < 0.001$) when walking with an AFO compared to BF (Fig. 1). The GGI remained unchanged ($p = 0.838$).

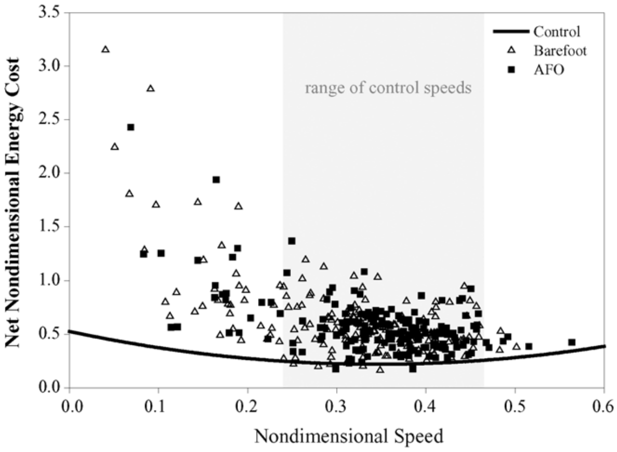

Fig. 1. The normalised NN cost of BF and AFO walking. It can be seen that AFO gait occurs at a faster speed.

DISCUSSION

This was the first extensive study to examine the effect of AFO's on walking efficiency and performance in a large population of spastic CP children. The 25% reduction in normalised NN cost of AFO walking is in agreement with prior study results that were based on small samples sizes [2,3]. The energy cost improved in an absolute sense, and as a percent of speed-matched control. This suggests that the improvements were not solely due to increases in speed (which would occur at a constant normalised cost), but also due to a shift of walking pattern toward a more efficient gait. Curiously, this shift was not reflected in the GGI, which remained unchanged. The improvements in efficiency may not be manifested as a systematic shift towards the control data, but may rather consist of subtle, joint specific changes that are energetically favourable. To gain more insight into these changes an additional and objective quantification of walking kinematics and kinetics is needed.

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Session 6

Modelling & Orthopaedics

Modelling

STATIC OPTIMIZATION TO DETERMINE INDIVIDUAL MUSCLE FORCES DURING GAIT

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SUMMARY

A mathematical optimization algorithm to calculate individual force contributions of the lower limb muscles was developed. Results during a normal gait cycle were compared to electromyography (EMG) activity.

CONCLUSIONS

The algorithm used has provided estimations of muscle forces that compare reasonably well to the muscle activation patterns in normal gait. It can be readily applied to pathological gait and shows great potential to not only describe abnormal muscle actions, but to contribute to treatment decision-making.