

**Energy cost and energy consumption in spastic hemiplegia:  
do orthoses or surgery make a difference?**

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Background

The literature suggests that multi-level surgery in spastic diplegia can decrease energy consumption during gait. Furthermore, there is some evidence that the use of orthoses can decrease the energy cost. The effect of isolated foot surgery on energy consumption has not been previously studied. The aim of this study was to examine the influence of foot surgery or Ankle Foot Orthoses (AFO) on energy cost and consumption in patients with spastic hemiplegia.

Subjects

15 healthy children (mean age 9.5 years, range 6-14 years, 10 female, 5 male) and 38 subjects with hemiplegic CP (mean age 10.7 years, range 6 – 16 years) were included in the study. Ten of the CP children were treated surgically (plantarflexors lengthening with or without tibialis anterior transfer) and 28 conservatively.

Methodology

Healthy children were tested on 3 occasions, spaced at a minimum of 2 weeks apart. CP children were also tested on 3 occasions (baseline, 8 and 14 months). At each visit all patients underwent routine gait analysis, EMG of the gastrocnemius and tibialis anterior and energy measurements including walking velocity [m/sec] (+ normalised to leg length), oxygen consumption [ml/kg/min] (+ normalised to leg length), and oxygen cost [ml/kg/m] (+normalised to leg length), according to Baker and Schwartz<sup>1</sup>. All subjects were tested barefoot. CP children using AFOs (n=21) were also tested with their orthoses. The procedure involved all subjects walking at their self-selected speed and reaching steady state. Resting for 2 minutes was followed by walking for 5 min and resting again for a further 2min.

Normal range for the energy measurements was defined from healthy subjects as 95% confidence interval. Significant difference between healthy and CP subjects was defined by an independent T test ( $p < 0.05$ ). Significant change (pre/post surgery, barefoot/AFO) was defined as 2.77 x within subject standard deviation (derived from healthy subjects).

Relative repeatability of absolute and normalised values were defined by dividing standard deviation by the mean.

Results

**Healthy (n=15)**

Walking speed: 1.19m/sec (0.11 SD), normalised: 0.44 (0.04 SD)

Absolute walking speed (SD/mean) = 0.09

Normalised walking speed (SD/mean) = 0.10 – comparable repeatability

Energy consumption = 18.43ml/kg/min (3.00 SD), normalised: 0.13 (0.03 SD)

Energy cost = 0.26 ml/kg/m (0.04 SD), normalised: 0.29 (0.07 SD)

Energy consumption (SD/mean) = 0.16, normalised = 0.26 (worse normalised)

Energy cost (SD/mean) = 0.15, normalised = 0.23 (worse normalised)

**CP baseline (n=38)**

Elevated normalised energy cost (0.29) compared to healthy

Normalised energy consumption not significantly different to healthy (0.15)

**AFO (n=21)**

Higher energy consumption with AFO (0.17) but energy cost the same as barefoot.

**Foot Surgery (n=10)**

No significant change in normalised energy consumption or cost following surgery.

Discussion

CP patients had similar normalised energy consumption as healthy subjects but higher energy cost. This is due to lower walking speed in CP patients, who use the same amount of energy in any given time, but cover less distance, and are, therefore, less efficient.

Walking speed increased with AFOs, therefore patients walked further and used more energy in any given time, but efficiency remained the same, hence the increase in consumption but not in cost.

Despite the lengthening of the plantarflexors we observed similar EMG activity of the gastrocnemius before and after surgery. This may relate to the unchanged energy consumption and cost in the surgical group. Alternatively, it could be argued that walking may not be aerobically challenging enough for these patients to elicit a change in energy measurements. Unlike previous literature we did not find AFOs to reduce energy cost. Despite our expectations, normalisation did not improve repeatability. This may relate to error in the clinical measurement of leg length.

Conclusion

Neither surgical nor orthotic intervention for foot deformity in spastic hemiplegia has any beneficial effect on energy consumption and cost.

References

1. Baker R, Sshwartz M. *The effect of walking speed on net non-dimensional oxygen cost*, *Gait and Posture* 20 (suppl 1) p 66-7, 2004.