THE RELATION BETWEEN GAIT STABILITY AND ECONOMY IN HEMIPARETIC GAIT

Han Houdijk, Laura Droog, Yvette Kerkum, Danielle Rijntjes and Maarten Tolsma

Research institute MOVE, Faculty of Human Movement Sciences, VU University Amsterdam, The Netherlands
Heliomare Rehabilitation, Research & Development, Wijk aan Zee, The Netherlands
email: h.houdijk@fbw.vu.nl

SUMMARY
We investigated the relation between balance impairments and gait economy in stroke patients by comparing walking with and without handrail support on an instrumented treadmill. Handrail support without excessive weight bearing reduced energy cost of stroke patients by 15.6% compared to 3.9% in a healthy control group. This was accompanied by an increase in step length and decrease in cadence, step width and step length asymmetry, all indicators of improved gait stability. We conclude that impaired balance control substantially contributes to the reduced economy of hemiparetic gait.

INTRODUCTION
Stroke patients frequently suffer from a unilateral paresis which impairs their walking ability. It has been established that hemiparetic gait is less economic and requires 1.5 to 2 times more metabolic energy compared to normal gait [6]. Additionally, balance control is affected after stroke, which affects gait stability and increases fall risk [1,7]. Although these gait impairments are often considered independently, both could well be inter-related. The increased energy cost of paretic gait is most frequently related to mechanical constraints such as an impaired leg swing or push off [2,3]. However, the effort for balance control during gait might also require substantial metabolic energy [5,8]. To test this we investigated the effect of balance support on metabolic energy cost and gait characteristics related to stability in hemiparetic gait.

METHODS
Fifteen stroke patients (age 58±12 y, weight 83±15 kg, height 1.79±0.08 m, TSI 1-115 months, FAC 3-5) and thirteen control subjects (age 55±10 y, 81±15 kg, 1.80±0.10 m) participated in this study. All subjects performed two four-minute walking trials at comfortable walking speed on a motorized instrumented treadmill (Forcelink, the Netherlands). In one trial they walked unsupported. In the other trial they were allowed to use the handrail of the treadmill for support without excessive weight bearing. During both walking trials metabolic energy cost (J·kg⁻¹·m⁻¹) was derived from open circuit respirometry (Oxycon Delta, Jaeger, Germany). Step characteristics were derived from the center of pressure profiles recorded with a forceplate embedded in the treadmill.

Additionally, average support force was assessed from the vertical ground reaction force recorded on the treadmill

RESULTS
Comfortable walking speed was significantly lower in stroke patients compared to controls (0.59±0.30 vs. 1.2±0.19 m·s⁻¹). Energy cost of walking was two-fold higher in stroke patients compared to controls. Providing support had a significantly larger effect on stroke patients compared to controls. Stroke patients experienced a 15.6% reduction against 3.9% for controls (Figure 1). On average the vertical support force on the handrail was 4.6% (±2.5) body weight for the stroke patients and 2.0% body weight (±0.9) for the control group. The reduced energy cost during the support condition in the stroke group, coincided with a significant decrease in cadence, step width and step length asymmetry and an increase in stride length (Figure 2).

Figure 1: Energy cost of walking without (dark bar) and with (light bar) handrail support for stroke patients and healthy controls. Energy cost was higher in the stroke group and handrail support had a larger effect on stroke patients than controls.
**DISCUSSION**

Despite large heterogeneity in the stroke group, providing tactile support reduced energy cost of walking significantly in stroke patients. On average the reduction in energy cost amounted to 15%, which is approximately one third of the increase in energy cost in stroke patients compared to healthy control subjects. Hence, the effort for balance control seems to explain a substantial part of the reduced economy of hemiparetic gait.

Providing handrail support increased stride length and reduced cadence, step length asymmetry and step width. These adaptations are all associated with improved gait stability [4]. Based on these adaptations it can be hypothesized that handrail support reduces the constraints imposed on the selection of step characteristics for balance control and allows stroke patients to adopt a step pattern closer to the energetic optimum. Moreover, handrail support seems to be a more economic way of controlling balance compared to these adaptations in step parameters.

Energy cost and step pattern adaptations in hemiparetic gait are frequently related to functional deficits such as impaired swing initiation and propulsion [2,3]. This study shows that not only these basic mechanical requirements of gait but also stability requirements affect these parameters.

**CONCLUSIONS**

It is concluded that the increased energy cost of hemiparetic gait can be partly attributed to the increased effort for balance control. Providing manual external support (and possibly also other ways of balance training or support) not only increases gait stability and reduces fall risk but also improves walking economy and reduces fatigue. This should be considered when selecting interventions aimed at improving walking ability after stroke.

**REFERENCES**