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# Postural adaptations to unilateral knee joint hypomobility induced by orthosis wear during gait initiation

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**KEYWORDS** knee orthosis; gait initiation; anticipatory postural adjustments; central nervous system

## 1. Introduction

Gait initiation (GI) is the transient phase between quiet standing posture and ongoing walking (Brenière et al., 1987). GI can be divided into two phases: the 'Anticipatory Postural Adjustments' (APAs), followed by a step-execution phase ending. APAs are known to be predictive of motor performance (Brenière et al., 1987) and postural stability (Yiu et al., 2016) during GI.

The role of knee mobility during GI has received much less attention compared to hip and ankle (Delafontaine et al., 2015). Honeine et al. (2016) reported that stance knee flexion during APAs could contribute to the anticipatory mediolateral COP shift and would thus be involved in the maintenance of postural stability.

Swing knee mobility is also involved in the maintenance of postural stability, due to the contribution of knee flexion at the end of APAs in clearing the swing foot from the ground and thus avoid stumbling. Swing knee mobility is also involved in GI performance, due to the contribution of knee extension in reaching the intended step length. Changes in stability and performance were observed in patients suffering from knee hypomobility or knee trembling (Jacobs et al., 2009).

However, it remains unclear whether the changes in GI process could be primarily ascribed to normal adaptation to knee hypomobility or to abnormal APAs programming due to impairment in the neural pathways/structures involved in the coordination between posture and movement.

The goal of the present study was to get further insight into the role of knee mobility on GI in able-bodied participants.

The effects of an experimentally-induced knee hypomobility by means of an orthosis placed over the stance- or

swing-leg knee were investigated. It is hypothesized that stance- and swing-leg knee hypomobility will require adaptive changes in the balance control parameters of GI so as to maintain stability unchanged at the cost of reducing motor performance as compared to GI without orthosis.

## 2. Methods

### 2.1 Population, material and protocol

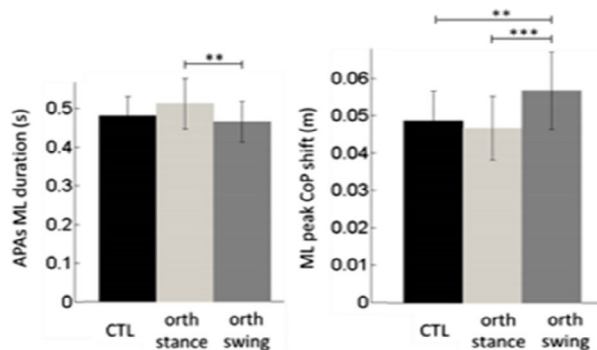
Twenty-seven healthy adults (Table 1) performed series of gait initiation on a force-plate in the following conditions: without orthosis ('control'), with knee orthosis over the swing leg ('orth-swing') and stance leg ('orth-stance'). Subjects walked bare-footed at a self-paced speed. Within each knee orthosis condition the order of starting limb was randomly assigned. In the 'orth-swing' and 'orth-stance' conditions, the swing leg was considered to be that in which subjects always stepped to recover balance following a push from behind. Each experimental condition comprised 10 trials. The normality of data was checked using the Kolmogorov-Smirnov test and the homogeneity of variances was checked using the Bartlett test. One way repeated measures ANOVAs with the condition ('control', 'orth-swing', 'orth-stance') as within subject factor was used. A significant outcome was followed-up with the Tukey *post hoc* test.

### 2.2 Biomechanical parameters

During the APAs phase, anteroposterior and mediolateral displacement of center of pressure, duration and mediolateral stability were measured. During the step-execution phase, step length and width, duration of execution phase,

**Table 1.** Characteristics of population.

Height (m)	Age (year)	Body mass (kg)
1.7 ± 0.1	26 ± 4	77 ± 13



**Figure 1.** Comparison of selected APAs parameters between the three conditions in the main experiment. Reported are mean values (all participants together) ± 1SD. \*\* and \*\*\* indicates a significant difference between bars with respectively  $p < 0.01$  and  $p < 0.001$ .

swing leg's vertical force impact at foot contact and progression velocity were examined.

### 3. Results and discussion

In orth-stance, mediolateral (ML) APAs duration was longer and ML COP shift lower than in orth-swing (Figure 1).

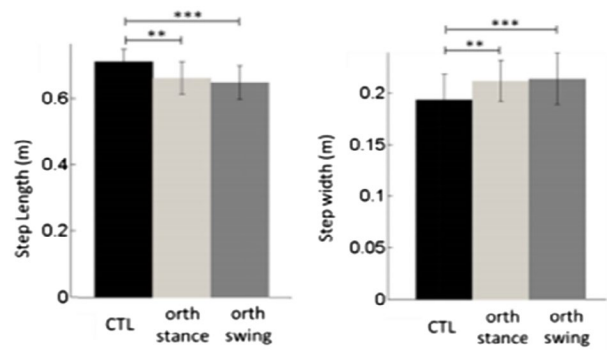
In orth-swing, the amplitude of mediolateral APAs and step width (Figure 2) were larger, execution phase duration longer and anteroposterior APAs smaller than in control.

As a consequence, step length (Figure 2) and progression velocity were altered whereas stability was enhanced compared to control.

The vertical force impact at swing foot-contact did not change across conditions, despite a smaller step length in the orthosis conditions compared to control.

The application of a local mechanical constraint thus induced profound changes in the global organization of gait initiation, altering motor performance but ensuring greater stability.

It was proposed that the central nervous system (CNS) sets reference values for stability and vertical disturbance before stepping. The CNS would then plan the APAs features, step width and length so as to reach these desired reference values.



**Figure 2.** Comparison of selected step execution parameters between the three conditions in the main experiment. Reported are mean values (all participants together) ± 1SD. \*\* and \*\*\* indicates a significant difference between bars with respectively  $p < 0.01$  and  $p < 0.001$ .

### 4. Conclusions

This study presents evidence that the application of a local mechanical constraint, herein induced by unilateral knee hypomobility, induced profound changes in the global organization of gait initiation, altering motor performance but ensuring greater stability. It was proposed that the CNS sets 'global' reference values before stepping, one for the mediolateral stability and one for the vertical disturbance at the time of swing foot collision with the ground. These reference values would be set based on an internal representation of the current state of the postural system, the task dynamics and its novelty. The CNS would then plan APAs features, step width and length so as to reach the desired reference values.

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