EFFECTS OF THE DIABETES PROGRESSION ON STAIR DESCENT KINEMATICS

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SUMMARY
The aim of this study was to investigate the influence of the diabetes progression on the lower limbs sagittal kinematics during stair descent. The disease evolution and the mechanical and motor control challenges of this particular motor task may reveal changes in the biomechanical strategies throughout the diabetes progression to peripheral neuropathy.

INTRODUCTION
Biomechanical alterations during level walking in the diabetic population have been extensively discussed in the literature1-2. However, investigations about other activities of daily living in this population, such as stair negotiation, is still insufficient. In daily living activities, diabetic individuals have to manage slopes, direction and speed changes during locomotion, step ascent and descent, and these activities may challenge the diabetic’s motor system to produce and control proper biomechanical responses even with sensorial and motor deficits.

From the mechanical point of view, dealing with stairs differs substantially from level walking considering the gravitational forces, the stability challenge and the muscle demands. If these demands are not well managed, they become risk factors for falls in diabetic neuropathic individuals3.

Particularly, stair descent is characterized mainly by energy absorption mechanisms performed by the knee and ankle joints which show a greater angular excursion, as opposed to the hip4. The ankle plays an important role on this task since its full range of motion allows a suitable distribution on the mechanical energy absorption at the initial foot contact on the step4,5.

Considering that, we expected that the diabetes progression, considered here as the occurrence of the peripheral neuropathy, and the typical muscular and proprioception losses, may reveal alterations in the joint kinematic pattern, especially in knee and ankle.

The aim of this study was to analyze and compare the sagittal kinematics of the lower limbs main joints in diabetic, diabetic neuropathic and non-diabetic individuals during stair descent; and to investigate the balance confidence in specific activities, such as stair negotiation.

METHODS
Forty-two adults (20 men, 22 women) were included into three groups: control group composed by 13 non-diabetic asymptomatic individuals (CG, 54.7±7.6 years, 72.1±12.2 kg, 1.69±0.1 m), 15 individuals diagnosed with diabetes (DG, 55±6.9 years, 81.6±16.4 kg, 1.69±0.1 m, 7.1±1.4 years of duration of diabetes, 135.8±39.1 mg/dL of glycemia, 3 out of 13 MNSI score) and 14 diabetic individuals clinically diagnosed with peripheral neuropathy (DNG, 60.2±4.0 years, 74.7±9.7 kg, 1.66±0.1 m, 13±4.3 years of duration of Diabetes, 185.2±87.1 mg/dL of glycemia, 7 out of 13 MNSI score). Groups were statistically different when comparing MNSI questionnaire (p<0.001), duration of diabetes (p<0.001) and glycemic level (p<0.001). All subjects were interviewed using the Activities-specific Balance Confidence Scale (ABC) before data acquisition6. All procedures were approved by the local Ethics Committee.

The 3D displacements of the passive reflective markers were evaluated with six infrared cameras. The automatic digitizing process, the 3D reconstruction of the markers’ positions, and the filtering of kinematic data were performed using the Arena software (Natural Point, OR, USA).

Before data acquisition, all participants received the instruction to descent a staircase of 5 steps without using the handrail, positioning one foot in each step. The cadence was controlled by a digital metronome. The last step performed was analyzed.

We calculated the maximal flexion and extension of each joint and their range of motion (ROM) during the stance phase in a custom-written math function in Matlab.

Statistical tests included an Analysis of Variance followed by a Newman-Keuls post hoc test. We adopted a significance level of 5%.

RESULTS AND DISCUSSION
The ABC score was statistically different among groups (p<0.01). CG reached a total score of 98.9(2.5) %. DG had 93.9(4.8) % and DNG, 82(10.7) %, indicating a progressive loss of confidence to execute daily life activities, such as stair negotiation.

Differences among groups were concentrated in the ankle joint kinematics: DG and DNG showed a greater dorsiflexion at the initial contact of stair descent, smaller plantarflexion at the end of the stance phase and smaller ROM compared to CG (Table 1, Figure 1). Since the analysis was done over the last
step of the stair, when there is a transition to level walking, a
greater plantarflexion would be expected at the end of this
phase in order to promote efficient propulsion in a normal gait.
The diabetic groups kept a smaller plantar flexion and this fact
could compromise the efficient propulsion in these groups.

The literature describes that this specific ankle function is
already altered in diabetic individuals. The gastrocnemius
lateralis and medialis showed a delayed activation in diabetic
neuropathic individuals during the propulsion phase of level
walking, suggesting that this joint does not perform a proper
role in this task. The total volume of the foot muscles is
decreased to half in patients with diabetic neuropathy which
also contributes to the lower propulsion force in locomotor
tasks. These results reveal once again this joint could impair
the locomotors performance in diabetic individuals, which is
the first one to be affected with important functional loss
because of the neurological characteristics of the disease.

Once the results found in the diabetic groups were not
sufficient to distinguish them into two different groups, and
they ended up being otherwise very similar when it comes to
coordination strategies.

CONCLUSIONS
The present study concludes that a diabetic individual, even
with the disease progression with the presence of neuropathy,
will present a progressive loss of confidence and inefficient
ankle ROM in stair descent. The decreased ankle range of
motion in the diseased groups suggests that alterations of
propulsion and mobility occur primarily at the most distal
joint.

<table>
<thead>
<tr>
<th>Variables (degrees)</th>
<th>CG (n=13)</th>
<th>DG (n=15)</th>
<th>DNG (n=14)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximal hip flexion angle</td>
<td>27.2 (0.1)</td>
<td>24.4 (6.4)</td>
<td>24.7 (8.0)</td>
<td>0.423</td>
</tr>
<tr>
<td>Maximal hip Extension angle</td>
<td>3.4 (7.8)</td>
<td>1.0 (3.6)</td>
<td>1.0 (2.2)</td>
<td>0.735</td>
</tr>
<tr>
<td>Hip ROM</td>
<td>22.3 (0.2)</td>
<td>23.2 (0.7)</td>
<td>24.4 (1.6)</td>
<td>0.872</td>
</tr>
<tr>
<td>Maximal knee flexion angle</td>
<td>26.5 (3.6)</td>
<td>25.3 (2.9)</td>
<td>29.6 (2.0)</td>
<td>0.145</td>
</tr>
<tr>
<td>Maximal knee Extension angle</td>
<td>14.2 (8.9)</td>
<td>8.3 (15.9)</td>
<td>9.2 (3.9)</td>
<td>0.264</td>
</tr>
<tr>
<td>Knee ROM</td>
<td>33.8 (4.2)</td>
<td>33.7 (2.3)</td>
<td>33.3 (3.2)</td>
<td>0.978</td>
</tr>
<tr>
<td>Maximal ankle dorsiflexion angle</td>
<td>13.7 (0.1) *</td>
<td>16.4 (0.8)</td>
<td>17.4 (3.7)</td>
<td>0.036</td>
</tr>
<tr>
<td>Maximal ankle plantarflexion angle</td>
<td>-17.3 (5.4) *</td>
<td>-10.9 (7.1)</td>
<td>-9.2 (1.6)</td>
<td>0.005</td>
</tr>
<tr>
<td>Ankle ROM</td>
<td>32.2 (5.4) *</td>
<td>27.2 (6.9)</td>
<td>26.0 (2.1)</td>
<td>0.089</td>
</tr>
</tbody>
</table>

* represents the statistically different group; * represents the marginally different group

Figure 1. Mean profiles of ankle sagittal angular excursion
during stance phase of stair descent for CG, DG, and
DNG.

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REFERENCES