INTRODUCTION

When people stand naturally during daily life activities, they stand in an unconstrained manner. The ability to transfer weight from one lower limb to the other is essential during unconstrained standing in order to avoid musculoskeletal discomfort or fatigue caused by remaining in the same posture for a prolonged period. However, little is known about body weight (BW) distribution during such natural standing tasks [1,2].

Some researchers have observed an unequal BW distribution between lower limbs during quiet standing in paretic stroke patients and even in healthy young and elderly adults [3-6]. So far, it is not known whether BW asymmetry can be observed during natural standing, and whether it depends on the task.

Our hypothesis is that during an unconstrained task, the BW distribution asymmetry will increase compared to quiet (symmetrical) standing. The goals of this work were 1) to compare BW asymmetry during unconstrained standing to that during quiet standing while subjects performed two different tasks, and 2) to examine reproducibility of the consistency of the subjects’ asymmetry between tasks and sessions.

METHODS

Forty-one healthy young individuals, 24 women and 17 men (age = 24±7 years, height = 1.7±0.1 m, and mass = 71±15 Kg), 36 with right leg dominance and 5 with left leg dominance, were asked to perform two unconstrained tasks: (1) watch a television documentary (Video) and (2) read a text (Reading) while standing for 15 minutes on each task. The order of these two tasks was random.

They also performed an upright quiet standing (Quiet) for 70 seconds, during which they were instructed to remain as quiet as possible. In all tasks, the subjects were required to stand with each leg placed on a different force plate. During the unconstrained task they were allowed to change their posture freely at any time, but they were instructed not to step off the force plate.

Each subject participated in two sessions with a one- to two-week interval between sessions. We analyzed the vertical component of the ground reaction force of each force plate to quantify the asymmetry index (AI), calculated as the difference between the BW of the right and left legs normalized by the total BW:

\[ AI = \frac{F_{\text{R}} - F_{\text{L}}}{F_{\text{R}} + F_{\text{L}}} \]

Values different from zero mean that the participant was standing asymmetrically; negative values of AI indicate that the BW was transferred to the left side and positive values indicate that the BW was transferred to the right side. Intraclass correlation coefficient (ICC) was determined to evaluate the reproducibility between sessions and type of tasks, and t-tests were conducted to compare differences between mean AI values for quiet and unconstrained tasks and sessions.

RESULTS AND DISCUSSION

Figure 1 shows representative examples of the BW time series on each leg for tasks and sessions. We observed that subjects exhibited asymmetric standing during both quiet standing and unconstrained standing (Table 1). The relative values of the AI revealed that during the quiet standing task, the subjects tended to shift BW to the left side, whereas during the unconstrained standing task, the subjects tended to shift BW to the right side, but these side preferences were not significant. There was a significant difference for the AI absolute values between the quiet and the unconstrained standing tasks (Table 1). Table 2 shows the intraclass correlation coefficient values. We observed a strong correlation Video2×Reading2, (ICC=0.77) and a moderate correlation for all other comparisons (between tasks, intra and inter-session).

We observed a high variability in BW asymmetry among participants. Even in a symmetric task, such as quiet upright standing, we observed that healthy young adults do not stand exactly with 50% of their BW on each lower limb. A few studies have also found some degree of lower limb asymmetry (AI of 7.6%) in healthy young adults during quiet standing [3,7] where the right leg loading was greater than left leg. In the present study we found an AI of 5% during quiet standing while on unconstrained standing tasks the AI was about 8%. One possible explanation for BW asymmetry relies on dominant side and anthropometric characteristics: the right side of the human body is heavier [3]. However, this hypothesis does not explain the BW distribution in the present study.
It seems that the unequal BW distribution is not preferentially based on participants’ dominant side and that independent of the type of natural standing task or day session, the young subjects have an independent particular way of transfer the BW between lower limbs.

CONCLUSIONS
Our results suggest that people are naturally asymmetric, independent of the nature of the task, there is no side preference and that this asymmetry seems to be a consistent behavior within subject during upright standing.

ACKNOWLEDGEMENTS
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REFERENCES

Figure 1: Example of time series of the normalized vertical ground reaction forces (Fz) on the right (R) and left (L) leg in units of body weight (BW) during prolonged unconstrained (Video or Reading) and quiet (Quiet) standing tasks.

Table 1: Mean and standard deviation of the asymmetry index (AI) values in units of body weight (BW) during experimental tasks
*Significantly different than zero (p<0.005). Significantly different between quiet and unconstrained (Video, Reading) standing tasks (*p<0.005).

<table>
<thead>
<tr>
<th>ASYMMETRY INDEX</th>
<th>Video 1</th>
<th>Reading 1</th>
<th>Quiet 1</th>
<th>Video 2</th>
<th>Reading 2</th>
<th>Quiet 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute AI</td>
<td>0.08±0.06*</td>
<td>0.08±0.07*</td>
<td>0.05±0.05*</td>
<td>0.08±0.07*</td>
<td>0.09±0.08*</td>
<td>0.05±0.04*</td>
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<tr>
<td>AI</td>
<td>0.02±0.10</td>
<td>0.02±0.11</td>
<td>-0.01±0.07</td>
<td>0.02±0.11</td>
<td>0.03±0.12</td>
<td>-0.01±0.06</td>
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</table>

Table 2: Reliability analysis for the comparisons of the AI across tasks and sessions (*p<0.001).

<table>
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<th>Video1</th>
<th>1.00</th>
<th>0.57*</th>
<th>-0.05</th>
<th>0.53*</th>
<th>0.66*</th>
<th>0.13</th>
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<tbody>
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<td>0.63*</td>
<td>0.53*</td>
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<tr>
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</tr>
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<td>Video2</td>
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<td>0.63*</td>
<td>0.08</td>
<td>1.00</td>
<td>0.77*</td>
<td>0.23</td>
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<tr>
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<td>0.53*</td>
<td>0.00</td>
<td>0.77*</td>
<td>1.00</td>
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</tr>
<tr>
<td>Quiet2</td>
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<td>0.44</td>
<td>0.69*</td>
<td>0.23</td>
<td>0.25</td>
<td>1.00</td>
</tr>
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