

# Is it important to Know the Load Mass in Lifting Tasks to Prevent Falls?

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## 1. INTRODUCTION

Lifting an object of the ground involves a dynamic process of maintaining postural balance (Toussaint, Michies, Faber, Commissaris, & van Dieën, 1998). When this movement is performed frontally, the mass of the object is added to the subject. Consequently, the subjects body center of mass (CM) is displaced to the front, mainly in the moment of lifting up the object, which significantly affects the postural balance and increase the occurrence of falls (Toussaint et al., 1998). This phenomenon is usually related with the loads' manual handling, since the body CM is displaced to the periphery of the support basis, increasing the body oscillations which contributes to the occurrence of instability situations (Kollmitzer, Oddsson, Ebenbichler, Giphart, & DeLuca, 2002; Pan, Chiou, & Hendricks, 2003). In order to avoid this effect, the human body needs to do some postural adjustments. In essence, the achievement of the postural stability depends on the voluntary and involuntary movements to the postural muscles activation, so the center of pressure (CP) can be adapted (Massion & Woollacott, 2004; Tang & Woollacott, 2004).

The processes associated with the balance control during the manual loads lifting were already described in literature (Toussaint et al., 1998; van der Burg, van Dieën, & Toussaint, 2000). In fact, it was showed that when a load is lifted, there is an anticipation process of the central nervous system to minimize the adverse effects of the CM oscillation (Yiou, Deroche, Do, & Woodman, 2011). This process allows the increase of the force moment to the posterior direction, in order to avoid the excessive dislocation of the CM to the anterior limit of the support basis. Additionally, it produces an increase in the body angular moment in the positive direction that allows the inversion of the trunk flexion when the load is lifted. This phenomenon is accompanied by an anterior dislocation of the CP to allow the CM posterior movement (Toussaint et al., 1998). However, these anticipation processes depends on the subjects' knowledge and expectation about the loads' weight and its manipulation (Commissaris & Toussaint, 1997; Toussaint et al., 1998; van der Burg et al., 2000). As a result, when consecutive movements are performed on similar objects, the anticipation will be always adjusted to the loads previous lifted (Commissaris & Toussaint, 1997). When there is not a previous sequence of lifting similar loads, the anticipation will be in accordance with the objects' dimension as well as with the comparison with other objects (Commissaris & Toussaint, 1997). These anticipation processes of the loads' weight may impair the postural stability when the load is significantly different that the expected by the subject. In this case, the postural stability and balance may be compromised (van der Burg et al., 2000). Therefore, individuals must adopt a set of corrective responses that allow the central nervous system to organize and implement balance reestablishing strategies, such as moving a step forward (Commissaris & Toussaint, 1997; Toussaint, Commissaris, Hoozemans, Ober, & Beek, 1997; Toussaint et al., 1998). This study aims to examine the influence of load knowledge in postural balance while lifting loads of several weights through the application of postural stability indexes namely the Index of proximity to the stability boundary (IPSB).

## 2. MATERIALS AND METHOD

### 2.1. Subjects

Thirteen healthy male subjects ( $23,8 \pm 3,1$  years;  $73,5 \pm 7,8$  weight;  $179,1 \pm 7,5$  height;  $25,7 \pm 1,2$  cm foot length) participated in the experiment, after given informed consent. None of them reported history of body disorders.

### 2.2. Tasks

All subjects had to perform a series of tasks, in which three boxes of 5kg, 15kg and 25kg of mass, with the same size and colour, had to be lifted. They were not informed about the sudden changes on the load mass that were going to take place. Subjects were induced to overestimate the weight to be lifted, because they lifted the box of 15kg, then the box of 25kg and finally the box of 5kg. The subjects were standing in front of a box and, at the instructive signal, flexed the knees to reach the object, grabbed it up to an static and balanced posture, with the box held aloft at breast height. No specific instructions were given about lifting technique, but subjects were instructed to keep the heels on the ground during the entire time of task. Imbalance in a trial was judged to occur when the forefoot lost contact with the ground or when a compensatory step was made to prevent falling.

### 2.3. Data analyses and Statistics

Descriptive statistics were calculated including mean and standard deviation (SD). To assess the effect of weight overestimation on the postural stability, the Index of Proximity to Stability Boundary (IPSB) was calculated according to literature (Bagchee & Bhattacharya, 1998). Additionally, the length of postural sway in anterior-posterior direction were computed (Park, Lee, Lockhart, & Kim, 2011). The posterior length was defined as the distance between the CP in start position and the most posterior distance reached in lifting task.

To determined differences between the two conditions tasks (without knowledge – WO; and with knowledge – WI), a Wilcoxon test was performed. To identify any difference within each group, One-way ANOVA was performed and, if

any significant differences existed, Tukey's post-hoc analysis was completed to determine which load mass were different from each other. The level of significance was set at  $p < 0.05$ .

### 3. RESULTS AND DISCUSSION

The results were shown in table 1.

Table 1 – Index of Postural Stability Boundary; Total Length and Posterior Length of CP displacement (mean ± SD)

	IPSB		TOTAL LENGTH [cm]		POSTERIOR LENGTH [cm]	
	WO	WI	WO	WI	WO	WI
15 kg	167,8 ± 112,0 <sup>a</sup>	212,1 ± 157,2 <sup>a</sup>	10,3 ± 1,9	9,7 ± 2,3 <sup>a</sup>	1,7 ± 1,0 <sup>a</sup>	1,4 ± 0,9
25 kg	161,9 ± 129,9 <sup>b</sup>	145,4 ± 95,7 <sup>b</sup>	11,5 ± 1,7	11,4 ± 2,5 <sup>b</sup>	2,7 ± 2,3	2,4 ± 1,5
5 kg	388,4 ± 274,8 <sup>a,b,*</sup>	565,8 ± 102,7 <sup>a,b,*</sup>	11,4 ± 5,0 <sup>*</sup>	6,0 ± 1,4 <sup>a,b,*</sup>	4,8 ± 3,0 <sup>a,*</sup>	1,4 ± 1,1 <sup>*</sup>

a. differences between 15kg and 5 kg; b. differences between 25kg and 5 kg; \* differences between without knowledge and with knowledge  
IPSB – Index of Postural Stability Boundary; WO – Without Knowledge; WI – With Knowledge

Observing the table 1 we found differences in IPSB between 15kg and 5kg, and between 25kg and 5kg in both conditions. This results shown an increased IPSB in 5kg lifting task, who represents better postural stability (Bagchee & Bhattacharya, 1998). However, this result was misleading, because the IPSB ratio results of anterior direction measures and don't show any posterior imbalance. This is supported by the result of posterior length (higher in 5kg load WO, when compare to 15kg and 25kg), who represents more posterior displacement in 5kg lifting task WO (figure 1). Also, the results show an increase postural stability when the lifting task was done with load knowledge (IPSB higher and Posterior Length lower in 5kg WI condition).

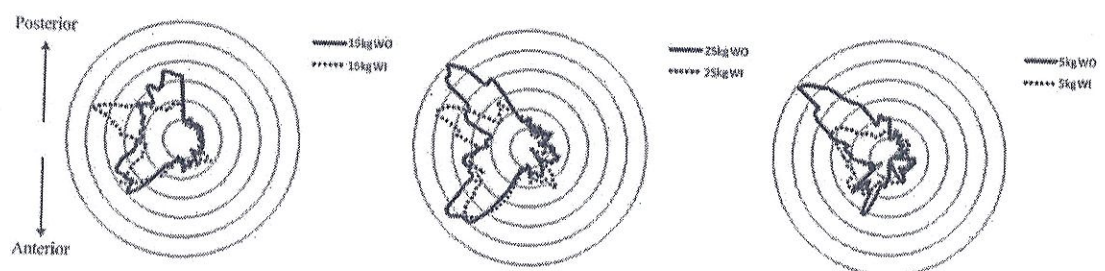


Figure 1– Posturogram of the 3 loads on the 2 conditions (With – WI; and Without Knowledge - WO)

### 4. CONCLUSIONS

According to the results, we concluded that the unknowledge of the load to lift could represent a risk of fall or posterior stability imbalance, especially when the workers change from heavy to light loads. So, it is important to provide to workers the adequate information about the load mass in order to avoid the occurrence of accidents related with falls.

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