Effectiveness of Partial Weight Bearing in Lower Extremity Injury Patients Using a Weight Bearing Indicator

*+Ordway, N R; *Mann, K A; *Young, M; *Simpson, R B; **Walczyk, D
* SUNY Upstate Medical University, Syracuse, NY, ** Rensselaer Polytechnic Institute, Troy, NY
Senior author ordwayn@upstate.edu

INTRODUCTION
Prescription of a cam boot and crutch-assisted gait with partial weight bearing (PWB) is common for patients with lower extremity injuries. A standard clinical protocol for PWB does not exist; protected weight bearing depends upon the severity of the injury and the discretion of the clinician. Verbal instruction and a “bathroom weight scale method” represent the standard of care used by clinicians for instructing PWB patients. However, both of these techniques have been shown to not be reliable. Weight bearing indicators (WBI) placed in the cam boot provide continuous biofeedback to the patient. This could be advantageous in terms of the healing process and patient compliance with the PWB protocol. The objective of this study was to examine the effectiveness of PWB based on the severity of the injury and instruction technique. Two research questions were addressed:

1. Does the severity of the injury influence the effectiveness of PWB?
2. Does continuous biofeedback, in the form of a WBI, assist with the effectiveness of PWB in comparison to standard of care techniques?

METHODS
Thirty subjects were tested that were representative of two typical patient populations. Group 1 were asymptomatic subjects with no injury (n=20) and may therefore not conform to the PWB instruction. Group 2 consisted of patients with surgically treated ankle fractures (n=10) that would have an extended period of PWB due to pain and potential low non-conforming risk. All subjects provided IRB-approved informed consent and were fitted with crutches and a cam boot (Fracture Walker Plus, Biomet Inc., Parsippany, NJ) on the affected limb.

Three conditions of PWB were examined: verbal instruction, instruction with the use of a bathroom (weight) scale, and instruction with the use of a snap dome WBI (Fig 1) placed under the ball of the foot in the cam boot sole. For the verbal instruction condition, subjects were verbally told to limit weight bearing to 133N or less, but were given no additional instruction. For the weight scale instruction condition, subjects were allowed to receive biofeedback and place the limb with the cam boot on a digital weight scale for a period of one minute with the goal of limiting their weight to 133N or less. In the WBI instruction condition, an effective 133N snap dome WBI (Teak Industries, Inc., Brunswick, NY) gave an audible/tactile click when the force threshold was exceeded.

The test protocol for each condition consisted of five trials of ambulating with crutches and cam boot over a 10m walkway at a comfortable pace. Force-time history data of a single cam boot foot strike was collected for each trial from a force plate embedded into the walkway. The peak load from each force-time history was determined. The five trials for each subject and ambulation condition were averaged and the average peak load was normalized to the subjects’ body weight. A 2-way ANOVA was performed to examine differences between PWB instruction conditions and population groups. Post hoc t-tests were performed when appropriate. Regression analyses were performed for each condition to examine the relationship between peak load and subject body weight. Significance was set at $\alpha = 0.05$ for all tests.

RESULTS
The 2-way ANOVA analysis revealed the main effect for PWB condition was significant ($p<0.001$) and the peak load applied during PWB was less with either the weight scale or WBI technique in comparison to the verbal instruction (Fig 2). In addition, the WBI technique had significantly lower ground reaction forces when compared to the weight scale technique in Group 1 subjects. All three techniques were not fully effective at reducing PWB to the prescribed level of 133N or below, however the techniques were effective at reducing the fraction of body weight placed on the affected limb (peak load normalized to body weight). For Group 1 the effectiveness of verbal instruction, weight scale, and WBI techniques in reducing the amount of body weight during PWB was 58, 45, and 33% of body weight, respectively. For Group 2 the effectiveness of verbal instruction, weight scale, and WBI techniques in reducing the amount of body weight during PWB was 46, 31, and 43% of body weight, respectively. Regression analysis of average peak load and body weight on Group 1 revealed another significant finding when comparing techniques (Fig 3). There were positive correlations between the average peak load and body weight for both the verbal instruction and the weight scale techniques, but there was not a significant relationship for the WBI technique.

Fig 1. Sectional view of a snap dome WBI.

Fig 2. Comparison of average peak load for three PWB techniques.

Fig 3. Regression analysis of avg peak load & body weight for group 1.

DISCUSSION
The prescribed PWB limit of 133N used in this study clinically represents a ‘toe-touch’ or the initial stage of the rehabilitative weight bearing process. The ability of patients with lower extremity injury to attain the prescribed PWB limit proved difficult regardless of the severity level. Biofeedback with the WBI assisted with effectiveness of PWB in comparison to standard of care techniques. During crutch assisted gait, the WBI technique was more effective at PWB in comparison to the verbal instruction and weight scale method in individuals at higher risk of not conforming (Group 1). Importantly, the effectiveness of the WBI device during PWB was not sensitive to body weight, which is potentially an added benefit for clinical utility. For the ankle fracture patients (Group 2), the ground reaction forces measured using the WBI device were generally greater than the weight scale method and compared to the Group 1 subjects using the WBI device. One of the main differences between these two groups was in the gait pattern. The ankle patients tended to walk with a heel-toe gait as opposed to a toe-touch gait. As such, the effectiveness of the WBI device placed in the fore foot was less effective for this population.

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