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Quantifying Grip Strength Requirements While Riding Freight Cars During Slack Action Events

Steve Fleming[1], George B. Page[1], Greg G. Weames[2], and John Vanderpool [1]

[1]Page Engineering, Inc.
Jackson, MI 49201

[2]Page Engineering, Inc.
Georgetown, Ontario L7G 3E5

Corresponding author's e-mail: steve@pageengineering.net

Abstract: Since the 1800s, railroad conductors and brakemen have ridden on freight car ladders during train movements. Today, the most common occurrence of holding and riding freight cars occurs when the conductor serves as the engineer's lookout while moving a cut of cars from one location to another, a practice known as "protecting the shove." Freight cars are connected to each other by a coupler mechanism and drawbar, which is connected to the freight car's draft gear. The draft gear acts as a shock absorber by allowing the drawbar to slide in the fore-aft direction, effectively compressing or rebounding depending on the forces acting upon it. "Buff" forces cause the drawbar to be compressed while "Draft" forces cause the drawbar to be extended. Changes in the movement of the train that cause the draft gear to compress or extend, can create a sudden acceleration or deceleration of the freight car, known as "slack action." The peak accelerations tend to occur when the movement of the drawbar tops or bottoms out. Slack action events have been reported to contribute to incidents involving the conductor losing his/her grip and falling from the freight car. This research endeavors to determine the grip strength required to maintain one's handhold on a freight car during a typical slack action event. A 10G triaxial accelerometer was used to quantify the typical range of accelerations that a freight car is subjected to during typical yard operations. Over 30 slack events were observed at three different locations. Acceleration data was collected on all common freight car types and the characteristics of the train were noted. Using TekScan hand force measurement equipment, real-time hand forces were measured while holding and riding a freight car throughout the range of measured accelerations. The correlation between freight car acceleration data and the measured hand force data was used to create a nomogram of required grip strength based on gender and body weight. The nomogram can be used to provide guidance regarding the grip strength required to hold on during a typical slack action event.

Keywords: Grip Strength, Slack Action, Railroad

1. Introduction

Acceleration data was collected in North Platte, NE; Houston, TX; and Roseville, CA in an effort to acquire as robust of a sample as possible. Sampling in different geographic locations provided a variety of different train consists, train yard topography, and shove situations to help ensure that the data collected is representative of typical train movements. Test conditions were repeated in Houston, TX using TekScan grip force measurement equipment. Real-time grip force data was collected synchronously with acceleration data and two video camera views.

2. Methods

Biomechanical analyses were performed using the University of Michigan Static Strength Prediction Program (3DSSPP). Hand forces were determined for the 5th, 50th, and 95th percentile male and female using a sensitivity analysis whereby the hand force requirements were steadily increased to the maximum amount that would allow the balance of the model to be maintained. This information was used to determine the required grip force during non-slack events. The TekScan hand force measurements were then used to calculate a multiplier for the force required to hold on during slack events. In Figure 1, the top left video frame shows the rider holding on mostly with his left hand as the train moves from right to left. In the middle video frame, the rider braces during a slack event, which is represented by the large peak force (shown in green) for the left hand. The top right video frame shows the rider holding on using both hands, using relatively equal effort following the slack event. Acceleration data recorded simultaneously with the TekScan force data will be used to determine the relationship between the acceleration data and the hand force data.

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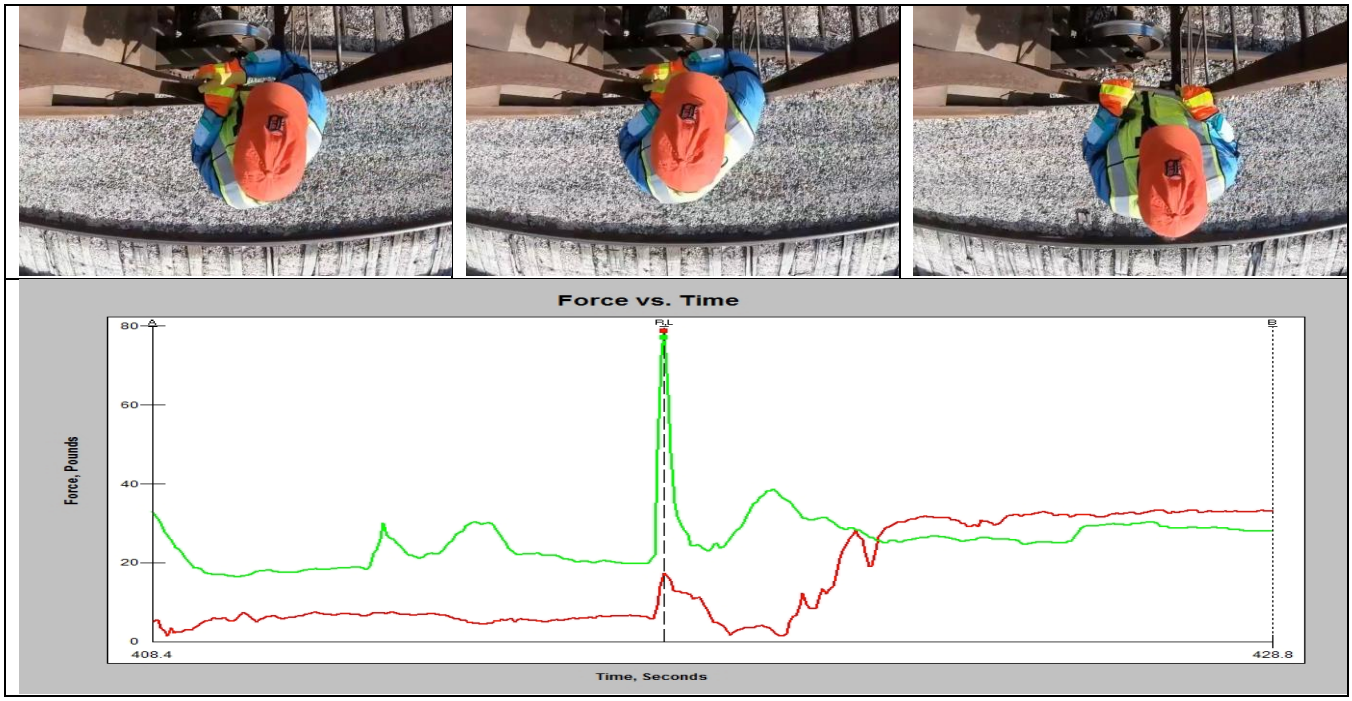

Figure 1: Overhead video – posture during first 10 seconds, at 10 seconds, and after 10 seconds (top left, middle, and right). The left (green) and right (red) hand forces are shown over a 20-second span (bottom).

3. Results

Young et al. (2012) have shown breakaway grip capabilities to be equal to two times clinical grip strength. Figure 2 shows the preliminary results of the relationship between body weight and the clinical grip strength (required grip strength) that would result in the breakaway strength necessary to overcome a typical slack event while holding on with two hands. The nomograms are subject to change under different postural scenarios, such as holding on with two hands vs. one hand, or leaning away from the ladder vs. standing upright on the ladder.

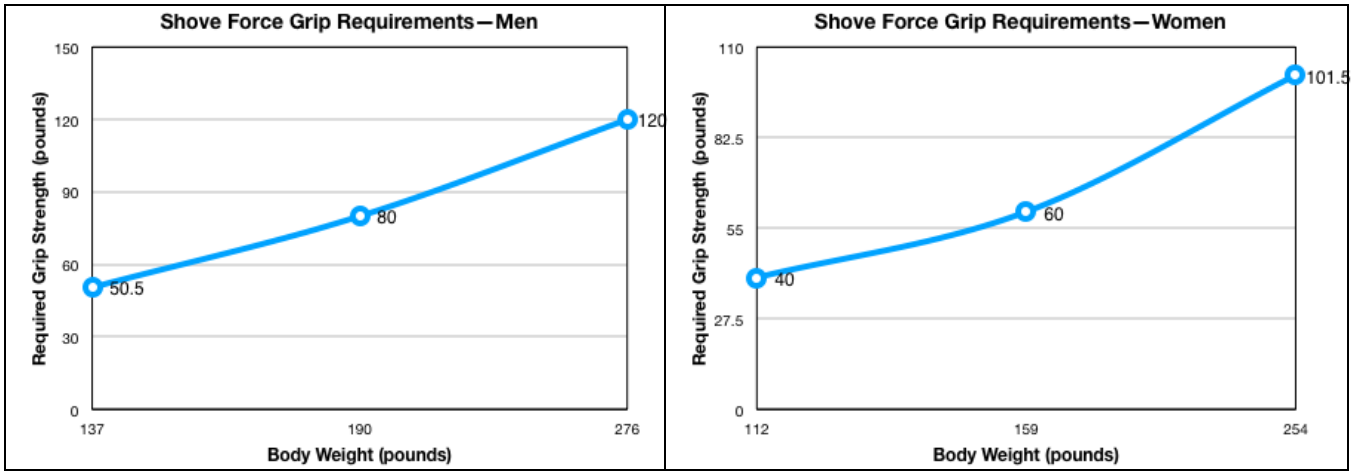

Figure 2: Shove force grip requirements for men (left) and women (right)

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4. References

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