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Effects of foot placement on postural stability of construction workers on stilts

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ABSTRACT

Stilts are elevated tools that are frequently used by construction workers to raise workers 18–40 inches above the ground. The objective of this laboratory study was to evaluate the potential loss of postural stability associated with the use of stilts in various foot placements. Twenty construction workers with at least 1 year of experience in the use of stilts participated in this study. One Kistler™ force platform was used to collect kinetic data. Participants were tested under six-foot-placement conditions. These 6 experimental conditions were statically tested under all combinations of 3 levels of elevation: 0″ (no stilts), 24″ stilt height and 40″ stilt height. SAS mixed procedure was used to evaluate the effect of different experimental conditions. The results of the multivariate analysis of variance (MANOVA) and repeated measures of univariate analyses of variance (ANOVAs) demonstrated that stilt height, foot-placement direction, and foot-placement width all had significant effects on the whole-body postural stability. This study found that the higher the stilts were elevated, the greater the postural instability. A stance position with one foot placed forward of the other foot produced greater postural instability than a position with the feet parallel and directly beneath the body. This study found that placement of the feet parallel and directly beneath the body, with the feet positioned a half shoulder width apart, caused a greater amount of postural sway and instability than one and one-and-half shoulder width. This study also found that construction workers using the stilts could perceive the likely postural instability due to the change in foot placements.

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1. Introduction

Stilts (Fig. 1) are elevated tools that are frequently used by construction workers to raise workers 18–40 inches above the ground without the burden of erecting scaffolding or a ladder. Recent NIOSH studies (Pan et al., 1999, 2000) further supported these hypotheses and indicated that workers perceived greater fall potential and physical stress when using stilts. A study from Duke University indicated that stilts were responsible for about 12% of falls among drywall workers in North Carolina homebuilders (Lipscomb and Dement, 2005). The median number of lost workdays associated with injury from stilt usage was 73, which was at least twice the median number for wallboard taping and texturing workers. The highest median total dollar amount paid for a claim in construction was also for construction workers using stilts. The increased lost workday severity and high paid claim figures indicate that those injuries tend to be extremely severe in terms of economic impacts (Whitaker, 2006).

Potential injury-exposure hazards associated with stilts use in construction have been widely recognized (Pan et al., 1999, 2000; Schneider and Susi, 1994). Both nationally and internationally, the use of stilts was not recommended, and/or was prohibited outright in construction, in the State of California, in New York City, and in the Provinces of Ontario, Canada and Victoria, Australia. The International Union of Painters and Allied Trades (IUPAT) (1998) recommends the maximum safe height for stilts be limited to 24 inches for painter apprentice training. Various governmental and labor institutions (e.g., Ontario Ministry of Labor and IUPAT) demand in-depth biomechanical analyses related to stilt use. However, no reliable quantitative data exist to identify biomechanical hazards associated with stilts in different foot positions at this time.

Research findings in the published occupational safety literature on hazards associated with stilt use in construction have been disparate and limited. It has been hypothesized that construction workers on stilts (e.g., drywall finishers and painters) tend to use extra efforts to maintain balance, which would result in accumulated muscle fatigue in the lower extremities, and would eventually produce postural instability while holding a prolonged standing position (Pan et al., 1999, 2000; Schneider and Susi, 1994). Other

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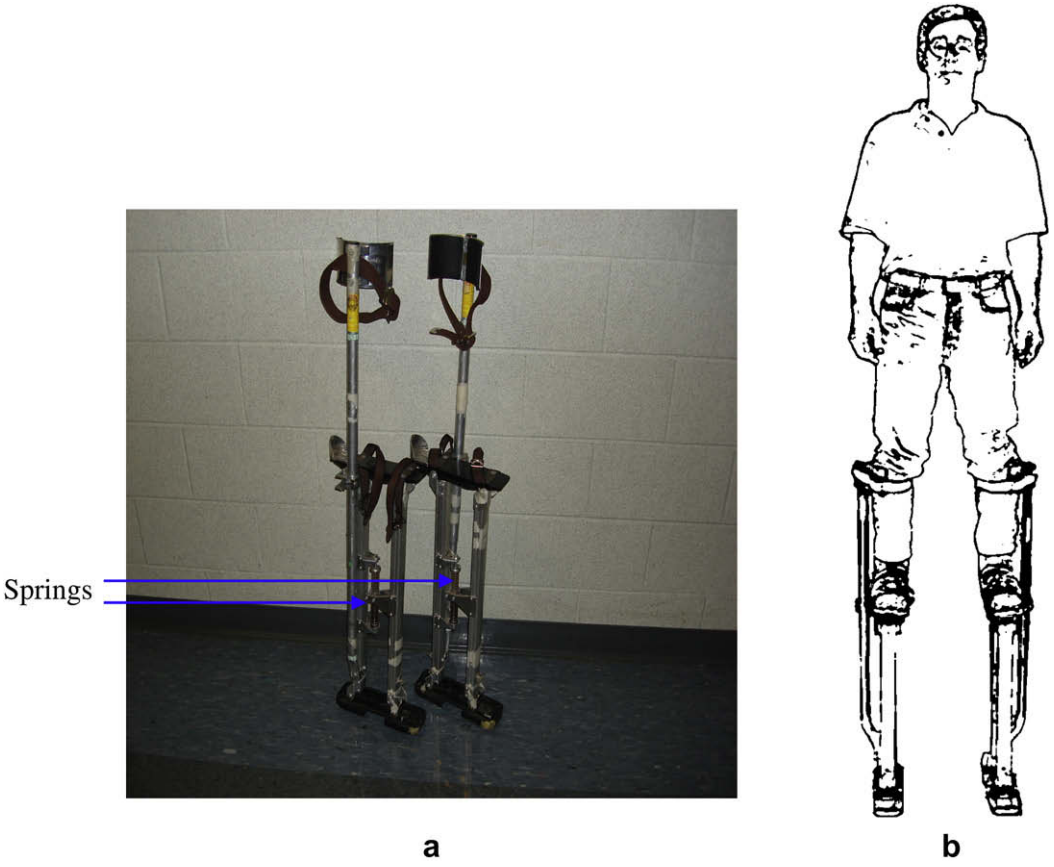

Fig. 1. (a) Stilts used for the present study; (b) standing posture of stilts.

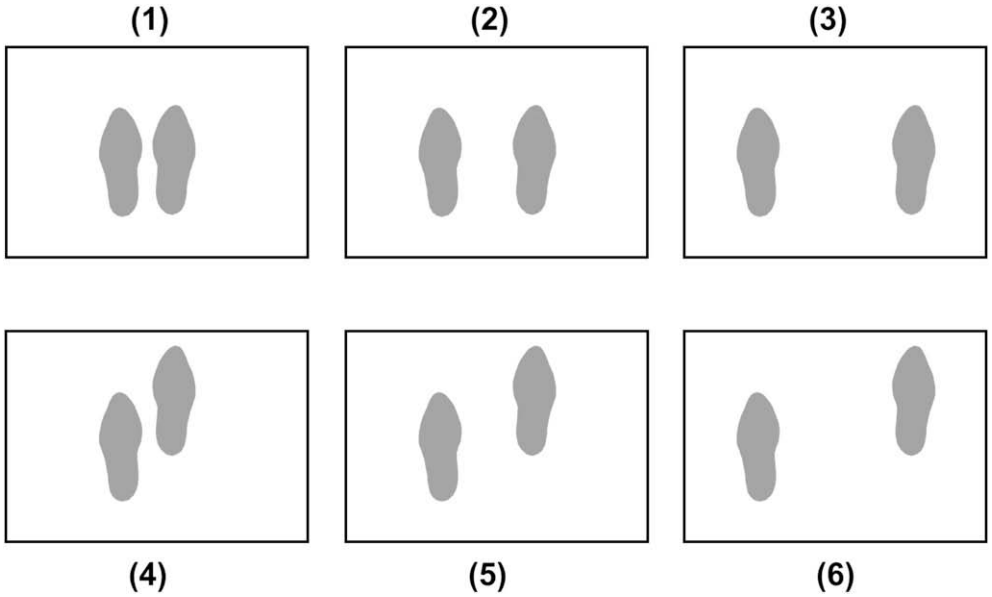

Fig. 2. Six-foot-placement test conditions at 3 levels (0″, 24″, 40″) of elevation. (1)–(3) are two-foot-parallel direction; (4)–(6) are one-foot-forward direction. (1) Standing, with feet at half of the individual's shoulder width, and directly beneath the body; (2) standing, with feet placed at participants' shoulder width and directly beneath the body; (3) standing, with feet placed at 1½ times shoulder width and directly beneath the body; (4) standing, with feet at half of the individual's shoulder width, and with the left foot beneath the body and the right foot placed forward a distance of half the individual's foot length; (5) standing, with feet placed at participants' shoulder width, and with the left foot beneath the body and the right foot placed forward a distance of half the individual's foot length; and (6) standing, with feet placed at 1½ times the participants' shoulder width, with the left foot beneath the body and the right foot placed forward a distance of half the individual's foot length. In these six test conditions the participant maintained an upright posture, with a zero degree of anterior or front lean angle (Holbein and Chaffin, 1997).