

GAIT AND BALANCE COMPARISONS BETWEEN LEATHER AND RUBBER BOOTS IN PROFESSIONAL FIREFIGHTERS

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INTRODUCTION

Firefighters are presented with numerous occupational challenges that elevate the risk of death and injury. The challenge of fighting fire is exacerbated by environmental hazards (i.e., working on roofs, in smoky places, and on slippery surfaces) and the use of protective equipment, including fire-protective clothing and a self-contained breathing apparatus (SCBA). The National Fire Protection Association estimates that 80,800 firefighter injuries occurred in the line of duty in 2002. Results by type of duty indicate that 37,860 or 46.9% of all firefighter injuries in 2002 occurred during fire-ground operations. Overexertion and strain (32%), and falls, slips, and jumps (25.9 %) were the leading causes of fire-ground injuries (Karter AND Molis, 2003). Unpredictable and rapidly changing work conditions, in association with high physical strain, require an alert postural control system for firefighters. In addition, lifting and carrying victims in rescue work demands continuous control of balance. Those tasks also necessitate the use of fire-protective clothing and equipment that increase challenge to the postural control system and might predispose the firefighter to postural instability (Kincl et. al. 2002).

A firefighter's boots play a critical role in working effectiveness and personal

safety. The OSHA regulations and standards for appropriate foot and leg protection for fire brigades state that this must include either fully extended boots which provides protection for the legs or protective shoes or boots worn in combination with protective trousers. Firefighters use two types of boots that meet these requirements, a rubber boot and a leather boot. An argument can be made that although the rubber boot may provide greater protection from chemical hazards, the leather boot provides greater tactile sensitivity. This sensitivity may be important in maintaining balance and limiting falls.

The purpose of this study is to examine differences in balance and gait in professional firefighters wearing rubber and leather boots participating in a fire simulation activity.

METHODS AND PROCEDURES

Twelve professional firefighters (33 ± 6.8 years; height of 179 ± 6.47 cm; weight of 95.08 ± 21.47 kg), whom received, within the past 8 months a medical evaluation, including resting 12-lead EKG analysis, and clearance by a physician to participate in firefighting participated in this study. Each firefighter participated in two identical testing sessions [leather (5.37 ± 0.45 lbs) and rubber boots (6.45 ± 0.53 lbs)] on two separate days.

During each session, firefighters performed 2 sets of a three minute simulated firefighter stair climb wearing a 50 lb weighted vest to simulate their typical personal protective equipment, two 12.5 lb weights on the shoulders to simulate the weight of a high-rise pack (hose bundle), and a Helen Hayes marker set (motion capture retro-reflective markers). The 12.5 lb weights were only worn during the stair climbs.

On each condition day (leather, rubber) the firefighter conducted 10 gait trials (6-M2-camera VICON system 460 at 120 Hz), followed by a balance assessment (Sensory Organization Test: Equitest, NeuroCom) consisting of 6 sensory conditions: eyes open/closed, fix/sway referenced visual scene, fix/sway referenced surface. Dependent measures for gait included stride length (SL), stride width (SW), step period (SP), and walking velocity (V); dependent measures for balance was sway velocity. Following the initial gait and balance protocol, the firefighter conducted a Simulated Firefighter Stair Climb (The Fire Service Joint Labor Management Wellness/Fitness Initiative - Candidate Physical Ability Test, 1999) for 3 minutes at a rate of 60 steps per/min. At the completion of the stair climb, the firefighter repeated the gait and balance procedure. Following a 3 minute rest period, the complete procedure (gait, balance, stair climb) was repeated. A total of 3 gait and balance procedures and 2 stair climbs were completed.

RESULTS

A series of repeated measures ANOVA analyses revealed a statistically significant

between boots difference(s) for all balance (Figure 1.) and gait measures (Table 1.).

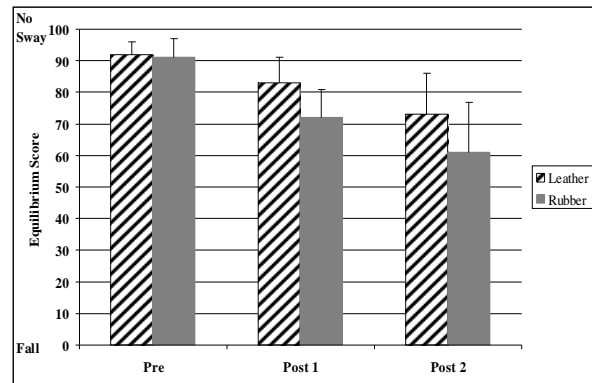


Figure 1. Ensemble average (100 = least sway velocity, 0 = Fall) of each of the 6 sensory conditions

DISCUSSION

In general, while postural stability degrades over both dynamic balance conditions, the results suggested that the leather boots contributed less to the degradation than that of the rubber. These findings have practical implications in the firefighting occupation when developing a safety and personal protective strategy. The implications lead to an assumption that given the varying degrees of advantages and disadvantages of each type of boot, the leather boot provides a stability advantage.

REFERENCES

Karter MJ. and Molis JL. (2003). NFPA Journal, Nov/Dec, 66-67.

Kincl et al. (2002). *Applied Occupational & Environmental Hygiene*, 17, 4, 256-266.

Table 1. Stride length, stride width, step period, and walking velocity, normalized by height, for each boot type.

	Leather			Rubber		
	Pre	Post 1	Post 2	Pre	Post 1	Post 2
SL(m/ht)	.54±.01	.48±.01	0.45±.01	.52±.01	.43±.01	.36±.02
SW(cm)	90±.44	10.2±.18	11±.32	10.3±.18	11.2±.31	12.1±.32
SP(s)	.68±.01	.63±.01	.56±.02	.66±.01	.46±.01	.38±.01
V(m/s)	.78±.02	.75±.02	.61±.02	.76±.01	.63±.02	.58±.01