PLANTAR PRESSURE DISTRIBUTION DURING GAIT IN A SUBJECT WITHOUT ADIPOSE TISSUE IN THE HEEL AND BALL OF THE FOOT.

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INTRODUCTION

The compliant, cushioning behavior of the foot's fat pads is believed to attenuate impact forces and reduce peak plantar pressures on the plantar surface during walking (Alexander, 1986). However, the consequences of walking without fatty tissue cushions beneath the heel and metatarsals are not known. This study reports the results of plantar pressure measurements from the walking gait of a lipodystrophic subject with the absence of normal heel and forefoot fat pads. Compared with data from normal subjects, these measurements improve our understanding of the role that specialized fat deposits have in these two regions of the foot.

REVIEW AND THEORY

Normal anatomy of the human foot includes deposits of adipose tissue beneath the heel and metatarsal heads. These viscoelastic fat pads dissipate energy and attenuate shock during gait. In both regions of the foot, fat is retained within specialized micro or macro chambers formed by a framework of collagen or elastic fibrous tissues (Blechschmidt, 1934; Bojsen-Møller, 1979). Familial partial lipodystrophy is a rare genetic condition in which almost all subcutaneous adipose tissue in the lower extremities is absent and hypertrophic deposits of fat accumulate in the upper extremities, trunk, neck, shoulders, face and back (Köbberling et al., 1986).

The purpose of this study was to determine the effects of the human heel and metatarsal fat pads on plantar surface loads during walking, by comparing plantar pressures in a case of lipodystrophy with normals. In-vivo and in-vitro studies of fat pad properties (DeClerq et al, 1994; Aerts et al, 1995) led us to hypothesize that the absence of adipose tissue in the foot would cause plantar pressures to be greater and more spatially concentrated.

PROCEDURES

A 32-year old female subject with a clinical diagnosis of familial partial lipodystrophy was recruited for the study. A whole-body magnetic resonance imaging was performed to confirm the clinical findings of a near-total absence of subcutaneous fat in the feet and lower extremities. Barefoot plantar pressure measurements were recorded with a capacitive pressure distribution platform (EMED, Novel Electronics, St. Paul, MN) and a Pedar pressure distribution measurement system (Novel Electronics, St. Paul, MN) was used for in-shoe measurements. Two studies were conducted. The first study compared peak pressures from subjects with normal plantar foot fat pads to those from the lipodystrophic subject. The second study evaluated the effect of a total contact, custom molded, viscoelastic foot orthosis on plantar foot pressure distributions in the lipodystrophic subject.

RESULTS AND DISCUSSION

The data from this study show that the fat pads under the heel and ball of the foot make a significant contribution to the reduction of peak pressures during walking. Plantar pressures in the lipodystrophic subject were tightly focused on bony prominences and peak pressures were greater in magnitude. Peak heel pressures were 180 % greater than normals walking at 1 m s^{-1}, 110 % greater under the 5th metatarsal head and 174% greater under the 1st metatarsal head. Additional studies showed that a custom molded, viscoelastic foot orthosis has the potential to reduce peak pressures to a level experienced by normals walking slowly in a moderately cushioned shoe. These results suggest that foot pathology resulting in atrophy of the heel and forefoot pads (e.g. diabetes, normal aging) could be treated with an orthosis to protect the weight bearing bony structures. The orthosis acts as a prosthetic substitute for the loss of normal anatomical cushioning in these regions of the foot.

Peak Pressures N / cm^2 Mean (SD)

Barefoot walking with the absence of heel and forefoot pads in a subject with lipodystrophy (1 subj x 1 trial x 6 steps)

	Heel	Arch	Arch	Midfoot	1st MTH	2nd, 3rd MTH	4th, 5th MTH	Hallux	Toes
	103 (12.4)			28.7 (15.1)	99.3 (21.0)	63.3 (16.8)	41.6 (7.0)	58.3 (25.9)	16.8 (2.6)

Barefoot walking with normal heel and forefoot pads (Shorten et al , 1989, 160 subjects x 1 step)

) m s^{-1}	36.7 (11.5)			13.6 (9.4)	36.2 (22.4)	46.2 (19.3)	28.8 (15.5)	45.0 (23.9)	20.2 (10.5)
m s^{-1}	51.7 (15.8)			11.0 (5.8)	45.8 (23.1)	55.4 (24.0)	24.7 (11.2)	54.2 (24.7)	25.2 (11.2)
) m s^{-1}	73.4 (18.4)			10.3 (4.6)	53.6 (24.6)	55.5 (24.8)	21.6 (11.0)	61.6 (24.1)	31.9 (11.7)

Lipodystrophy subject walking with a running shoe 1 subject x 5 right and 5 left steps x 3 trials)

ight & Left Foot	55.4 (6.5)	12.1 (1.8)	2.1 0.1		39.6 (3.4)	29.4 (3.4)	20.8 (2.5)	26.8 (2.7)	14.0 (1.0)

Lipodystrophy subject walking with a running shoe and a custom viscoelastic foot orthosis (1 subj. x 3 trials x 5 steps)

Left foot	35.3 (2.6)	12.1 (1.8)	2.1 (0.1)		26.3 (2.3)	27.9 (1.2)	17.7 (2.0)	21.3 (1.1)	11.1 (0.3)
Right foot	25.8 (0.6)	12.9 (1.5)	5.3 (0.4)		32.6 (2.0)	25.4 (0.6)	14.6 (1.0)	17.5 (2.0)	12.4 (0.8)

Normal subjects walking with minimal cushioning (33 subjects x 1 trial x 5 steps)

1.0 m s^{-1}	24.7 (3.7)	11.9 (3.8)	4.1 (2.2)		29.6 (8.6)	25.1 (4.9)	24.2 (6.3)	27.5 (7.6)	14.8 (5.8)
2.0 m s^{-1}	48.5 (6.7)	10.5 (3.6)	3.8 (1.9)		27.7 (6.5)	24.7 (6.3)	19.4 (5.3)	33.4 (7.3)	20.1 (4.9)

Normal subjects walking with a running shoe (33 subjects x 1 trial x 5 steps)

1.0 m s^{-1}	22.4 (3.2)	10.6 (3.0)	4.4 (2.1)		25.5 (7.1)	21.0 (3.9)	19.4 (5.1)	28.0 (9.2)	12.4 (3.6)
2.0 m s^{-1}	36.5 (4.0)	9.2 (3.0)	4.0 (1.0)		25.5 (7.0)	22.2 (5.5)	15.5 (3.5)	35.5 (8.2)	17.6 (3.7)

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