EFFECTS OF Z-COIL® SHOE ON FOOT PRESSURES DURING WALKING AT FREE AND FAST VELOCITIES.

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Introduction

The Z-coil® shoe has a unique design that combines a rocker bottom, an elevated metal coil heel and a rigid orthotic. The manufacturer claims the shoe decreases and equalizes foot pressures. They market the shoe to people with musculoskeletal pathologies.

Z-Coil® Shoes

Purpose:
The purpose of this study was to determine if the Z-coil® shoe changed foot pressure magnitude or distribution during free and fast walking as compared to conventional athletic shoes.

Methods

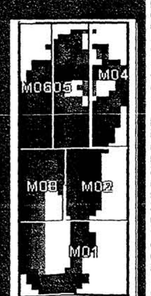
Subjects:
Twenty subjects (13 women, 7 men, mean age 28.7 years) with no complaints of musculoskeletal or neurological symptoms participated in the study.

Pedar® Insoles

Instruments & Procedure:
The Pedar© in-shoe measurement system (Novel GMBH Munich) was used to measure plantar pressures while subjects walked 3, 6-meter trials in their comfortable athletic shoes and in Z-coil® shoes at free velocity (69.7—92.4 m/min)and fast velocity (92.5—120.0 m/min). Plantar pressure variables were recorded for 6 plantar regions of the foot: Whole foot **(W)**, heel **(H)**, medial and lateral mid foot **(MM, LM)**, metatarsal 1 and great toe **(GT)**, metatarsals 2-3 and corresponding toes **(M23)**, metatarsals 4-5 and corresponding toes **(M45)**.

Subject Set-Up

Data processing & analysis:
Repeated measures MANOVAs identified significant differences in peak pressure **(PP)**, maximum mean pressure **(MMP)**, pressure time integral **(PTI)**, maximum force **(MxF)**, mean force **(MF)** and contact area **(CA)** between shoe conditions at the different areas of the foot. We used an overall alpha level of 0.05.



Foot Regions

Results

In general we found a decrease in forces (MxF, MF) and pressures (PP, MMP, PTI) at **MT 2-5** and increases in pressure variables at the MM with the Z-coil® shoe. Contact area did not differ between shoes. Results were similar but not identical for free and fast walking speeds in all variables.

Contact Area (cm^2)
Contact area was similar between shoes at both walking velocities.

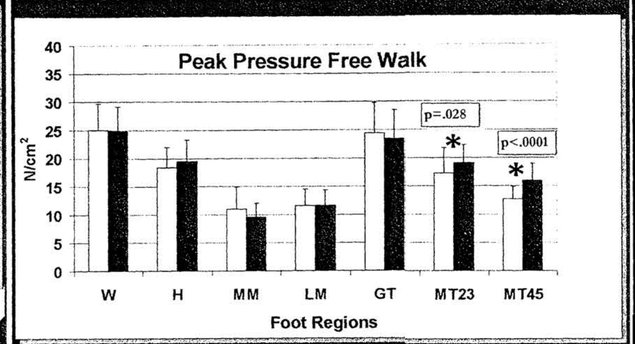
Free Walk	Z-coil Shoes		Athletic Shoes	
	Mean	SD	Mean	SD
WF	160.4	28	165.0	26
H	47.3	7	47.7	6
MM	20.9	9	23.5	7
LM	33.8	5	34.3	4
GT	20.6	3	20.8	3
MT23	23.3	3	23.9	3
MT45	14.4	2	14.8	2

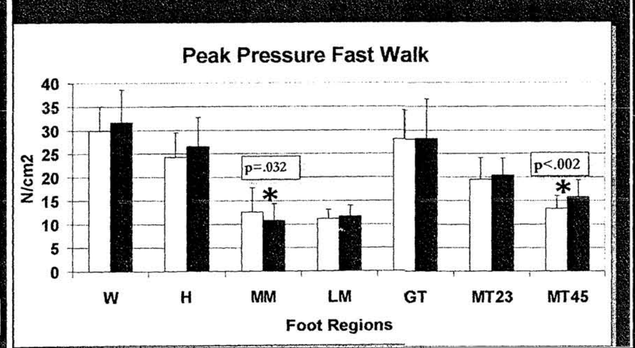
Fast Walk	Z-coil Shoes		Athletic Shoes	
	Mean	SD	Mean	SD
WF	157.7	29	162.0	28
H	46.7	8	47.4	7
MM	20.3	9	21.6	8
LM	32.9	5	33.8	5
GT	20.3	3	20.6	3
MT23	23.0	3	23.7	3
MT45	14.5	2	14.8	2

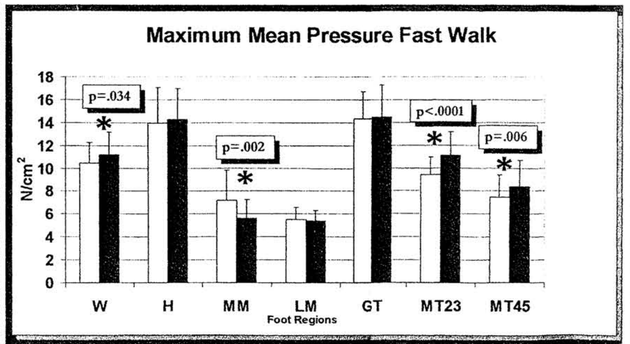
Z-coil®
Athletic shoes

W = Whole Foot
H = heel
MM = medial midfoot
LM = lateral midfoot
GT= Great toe
MT23 = metatarsal 2,3
MT45 = metatarsal 4,5

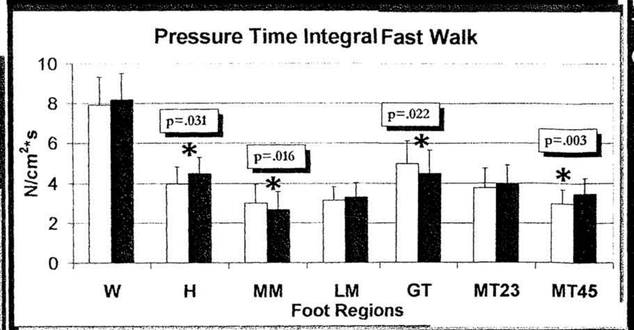
Peak Pressure (PP, N/cm^2)
At free velocity PP decreased 9% under **M23 &** 21% under **M45** with Z-coil®. At fast velocity PP also decreased 28% under **M45** but increased 17% at **MM**.



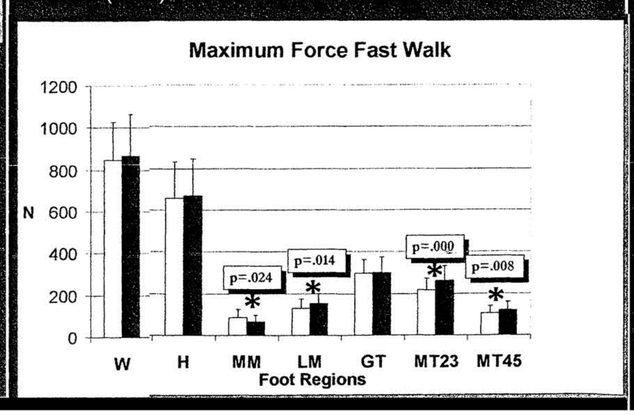




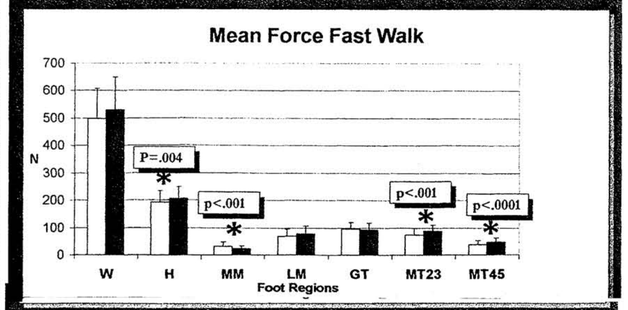
Maximum Mean Pressure (MMP, N/cm^2)
At free velocity, **MMP** was 18% lower at **MT23** and 15% lower at **MT45** in Z-coil® ($p<.0001$). Similarly, at fast velocity **MMP** decreased 15% at **MT23** and 11% at **MT45.** **MMP** significantly increased at **MM** by 18% and 28% at free and fast velocities respectively. At fast velocity MMP under the whole foot significantly decreased ($p=.034$).



Pressure Time Integral (PTI)
At both velocities **PTI** significantly decreased under **MT45** and increased under GT when wearing z-coil shoes. Moreover at fast velocity PTI significantly decreased (11%) under **H** and increased 12% at **MM.**



Maximum Force (MxF, Newtons)
MxF was significantly lower at MT 2,3 & MT 4,5 at both velocities in the Z-coil® shoes. MxF reduction ranged from 13% - 19%. Only at fast velocity, wearing the Z-coil® shoes caused a significant increase in MxF under the MM. and a significant decrease at LM.



Mean Force (MF, Newtons)
At free velocity, **MF** was lower in the Z-coil® shoe: 4% at **W** ($p=.006$), 16% at **MT23** ($p<.0001$) and 17% at **MT45** ($p=.002$). At fast velocity, **F** similarly decreased under **W**, **MT23** and **MT45** and, in addition, decreased 7% under the **H** in the Z-coil® shoe. The **MM**, however, experienced a 38% higher MF ($p=.001$) in the Z-coil®.

Discussion

Our results indicate a general decrease in lesser toes pressures and forces in the Z-coil® shoes as compared to athletic shoes. This decrease is most evident at MT45. PTI, an expression of pressure throughout sampling time, increased ~ 12% under the GT in the Z-coil® shoe. At fast velocity, pressures and forces shifted medially and anteriorly. All pressure and force variables increased under the MM while MxF decreased under the LM and PTI and MF decreased at the heel. The medial and forward shift of pressures and forces seen at fast velocity indicates that the Z-coil® shoe is more effective when forces and pressures are high.

This shift in pressures and forces may be caused by the combination of the elevated heel coil, rocker bottom and rigid orthotic of the Z-coil® shoe. The shift in pressure forward and medially, expected with an increase in heel height,[1] may be offset under the lesser toes in the Z-coil® shoe by the rocker bottom. Previous studies showed that rocker bottom shoes decrease forefoot pressures compared to standard shoes.[2,3] The rocker bottom may be less effective in decreasing pressures under the GT as forces and pressures are shifted medially in the Z-coil® shoe.

MMP and MF were lower under the whole foot (W) when walking with the Z-coil® shoe. The decrease in W force and pressure as well as the decrease in H force and pressure in the Z-coil® shoe suggests a decrease in force transmitted up the kinematic chain which might explain the anecdotal relief of pain reported by some Z-coil® users.

Finally the lack of difference in CA between the two shoes suggests that our subjects chose athletic shoes that contoured as well to the bottom of the foot as the orthotic in the Z-coil® shoe.

Because the Z-coil® shoe is marketed primarily to persons with foot, lower extremity or back pain, we are planning to study these populations.

References

1- Mandato, Nester. The effects of increasing heel height on forefoot peak pressure. *J Am Podiatr Med Assoc* 1999;89: 75-80.
2- Brown D, Wertsch JJ, Harris GF, et al. Effect of rocker soles on plantar pressures. *Arch Phys Med Rehabil* 2004;85: 81-86.
3- Nawoczenski DA, Birke JA, Coleman WC. Effect of rocker sole design on plantar forefoot pressures. *J Am Podiatr Med Assoc* 1988;78:455-60.