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2017

# How do we fit underground coal mining work boots?

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## Publication Details

Dobson, J. A., Riddiford-Harland, D., Bell, A. F. & Steele, J. R. (2017). How do we fit underground coal mining work boots?. *Footwear Science*, 9 S77-S79.

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# How do we fit underground coal mining work boots?

## **Abstract**

Well-fitted footwear provides an appropriate level of protection, support and comfort during walking (de Castro et al., 2010), and reduces the potential for foot problems and foot pain (Manna et al., 2001). To fit properly, the internal footwear shape should match the shape of a wearer's foot. In underground coal miners, however, there are mismatches between the shape of their feet and the internal work boot dimensions. The impact these boot-foot mismatches have on work footwear satisfaction remains unclear (Dobson et al., 2017). Uncomfortable footwear does not have poor fit ratings at every point on a shoe. This indicates that work boot fit might be more important at some areas of the foot rather than others (Au & Goonetilleke, 2007), although this notion remains unexplored.

## **Disciplines**

Medicine and Health Sciences | Social and Behavioral Sciences

## **Publication Details**

Dobson, J. A., Riddiford-Harland, D., Bell, A. F. & Steele, J. R. (2017). How do we fit underground coal mining work boots?. *Footwear Science*, 9 S77-S79.

## How do we fit underground coal mining work boots?

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### Introduction

Well-fitted footwear provides an appropriate level of protection, support and comfort during walking (de Castro et al., 2010), and reduces the potential for foot problems and foot pain (Manna et al., 2001). To fit properly, the internal footwear shape should match the shape of a wearer's foot. In underground coal miners however, there are mismatches between the shape of their feet and the internal work boot dimensions. The impact these boot-foot mismatches have on work footwear satisfaction remains unclear (Dobson et al., 2017). Uncomfortable footwear does not have poor fit ratings at every point on a shoe. This indicates that work boot fit might be more important at some areas of the foot rather than others (Au & Goonetilleke, 2007), although this notion remains unexplored.

### Purpose of the study

The purpose of this study was to determine the association between the internal work boot shape-foot shape match and work boot satisfaction in underground coal miners.

### Methods

Three-dimensional foot scans (INFOOT; I-Ware, Japan) were collected for 197 underground coal miners ( $39.2 \pm 9.6$  yr of age;  $178.7 \pm 5.8$  cm;  $92.8 \pm 12.6$  kg). Boot moulds representing the internal dimensions of the standard safety footwear worn by underground coal miners in the Illawarra Region (Aus; gumboot and leather lace-up) were constructed out of Plaster of Paris (Uni-PRO, Aus). These

moulds were scanned using the same procedure. The following dimensions of each foot and boot mould were measured: length, ball girth circumference, breadth, instep circumference, heel breadth, height of the instep, ball girth height, and heel girth circumference. Differences between these measurements were calculated and grouped into 12 categories. Categories depended on the difference value; 0-10 mm, 10-20 mm, 20-30 mm, 30-40 mm, 40-50 mm, >50 mm and whether the miner's feet were smaller (-) or larger (+) than the internal dimensions of their work boots.

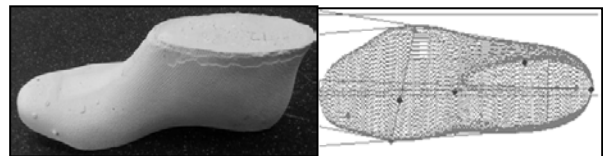


Figure 1. An example mould representing the internal shape of the gumboot and the associated 3D scanned image.

The participants also completed a survey, which sought information on their incidence of foot problems, lower limb and lower back pain history and ratings of work footwear fit and comfort.

To assess mining work boot fit relative to underground coal miner boot satisfaction, cross tabulations with a Pearson's Chi-squared test were applied to the survey data (foot problems, lower limb and lower back pain history and work footwear fit and comfort) and the difference in values between the miner's feet and their internal boot dimensions (SPSS

Version 21, USA). This design determined whether the position of a miner's foot inside their work boot was significantly associated ( $p < 0.05$ ) with their incidence of foot problems, lower limb and lower back pain history and ratings of work footwear fit and comfort.

## Results

Lower back pain incidence reported by the coal miners was significantly related to heel breadth ( $\chi^2 = 8.1$ ,  $p = 0.015$ ) and heel girth circumference difference values ( $\chi^2 = 15.4$ ,  $p = 0.038$ ). That is, a gap of 40- 50 mm at the heel girth circumference and 10- 20 mm at the heel breadth led to an increased incidence of lower back pain. Of the miners who reported having foot pain, heel girth circumference deviations significantly affected this occurrence ( $\chi^2 = 45.7$ ,  $p = 0.005$ ). Comfort ratings were significantly affected by heel girth circumference ( $\chi^2 = 75.6$ ,  $p = 0.001$ ) and ball girth height ( $\chi^2 = 46.4$ ,  $p = 0.000$ ) deviations (see Table 1). Whereas fit ratings were significantly affected by deviations in instep height ( $\chi^2 = 39.8$ ,  $p = 0.001$ ; see Table 1) and ball girth height ( $\chi^2 = 32.2$ ,  $p = 0.009$ ) (see Table 1). Finally instep height deviations significantly affected hip pain incidence ( $\chi^2 = 12.7$ ,  $p = 0.019$ ). No significant relationships were found in regards to length or foot breadth.

## Discussion and conclusion

Whether the shape of a work boot matches a miner's foot at the heel, ball girth and instep appears to be more important than the traditional measurements of length and width. Gaps of 0-10 mm between a miner's foot and the edge of their work boots in terms of width were insufficient for a boot to be deemed comfortable. A gap of 10-20 mm between the foot and boot appeared to be the minimum at the instep and ball girth, whereas 20-30 mm at

the heel, to ensure the workers deemed their footwear as satisfactory. This gap dimension may be required to allow for foot changes during work. There is a tendency for the miner's feet to become hot and sweaty over time, leading to swelling inside their boots.

The results of the present study have important implications for the fit of work boots for underground coal miners.

Table 1. Significant ( $p \leq 0.05$ ) relationships for the variables instep height, ball girth height and heel girth circumference based on the difference between the dimensions of underground coal miner's feet and their internal work boot dimensions.

	Difference	Instep Height	Ball Girth Height	Heel Girth Circumference
Boot Bigger	-20-30mm	Poor fit	Very comfortable Very good fit	Very comfortable
	-10-20mm	Less likely poor fit	Good fit Less likely indifferent comfort Less likely reasonable fit	Indifferent comfort
	-0-10mm		Uncomfortable - indifferent Poor - reasonable fit	Very uncomfortable

## References

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