

Differences between male and female feet

ZACH ARMITAGE considers how shoemakers need to take into account the sex and gender of the consumer when designing their collections.

Taking the end consumer into consideration during the design stage will produce a more specific and successful product. When making footwear, the designer needs to consider both the sex and the gender of the end consumer, in addition to other factors. However, to cater for a mass market some generalisations are usually made to maximise population coverage and minimise costs.

Sex is defined as 'the genetic differences between men and women'. Men generally have two 'X' chromosomes and women have an 'X' and a 'Y'

chromosome (although some men are born with two or three 'X' chromosomes and some women are born with a 'Y' chromosome). While both sexes share the same hormones, women have higher levels of oestrogen and progesterone, while men have higher levels of testosterone, which leads to distinctions in size and shape. Generalisations can be made between men and women to better target an end consumer.

Gender, while related to sex, is independent of it. Gender refers to an individual's sense of identity and expression. A woman may identify as a

man, and express that identity through the clothes they wear. Much more so than sex, gender is non-binary. A man may identify as male, but express as female through clothing and make-up.

Gender identity and expression is constantly evolving. Some colours and fashions are associated with one gender or another – for example, pink for girls and blue for boys. Although a gender custom has evolved to associate these colours with girls or boys, this expression of gender has not always been the case. In the 1900s, pink was considered in some quarters as the



Table 1: Average weight (kg)

	Men	Women
Australia	88.8	73.0
Brazil	78.7	68.6
China	70.5	59.4
Ethiopia	56.7	51.1
Germany	88.8	71.6
India	59.1	50.6
UK	86.8	72.9
USA	90.9	78.0

masculine colour and blue the feminine colour. This is just one way in which gender identity has evolved. Another is the use of high heels, which was originally a military feature designed to increase control and stability in the stirrups while riding a horse. High heels were adopted by the aristocracy in the 17th century to enhance a masculine visage. This was embraced by women and coexisted for a time as both a male and female fashion before declining in the 18th century. The fashion for heels was re-established in the mid-19th century as a feminine look.

Niche marketing?

A footwear designer may consider the gender identity and expression of the end consumer when choosing his or her creation's style, colours, materials and structure. For instance, a highly fashionable women's shoe may be brightly coloured, with a high, pointed heel, open or strapped upper and a peep-toe. A similar shoe designed for a man may have exactly the same design choices, but there will be size and structural differences to accommodate for the different user.

The story of UK-based WJ Brooks Limited, immortalised in the film and musical *Kinky Boots*, demonstrates the success of designing for a target audience and highlights the shape and structural differences needed between male and female footwear. This 'traditional' Northamptonshire shoe manufacturer reinvigorated the business by producing niche fashion boots for men. Up to that point, the style of such products available on the market were all of women's sizes and failed to consider the increased average weight and size of a male consumer.

There are several examples of a typically male fashion being adopted into

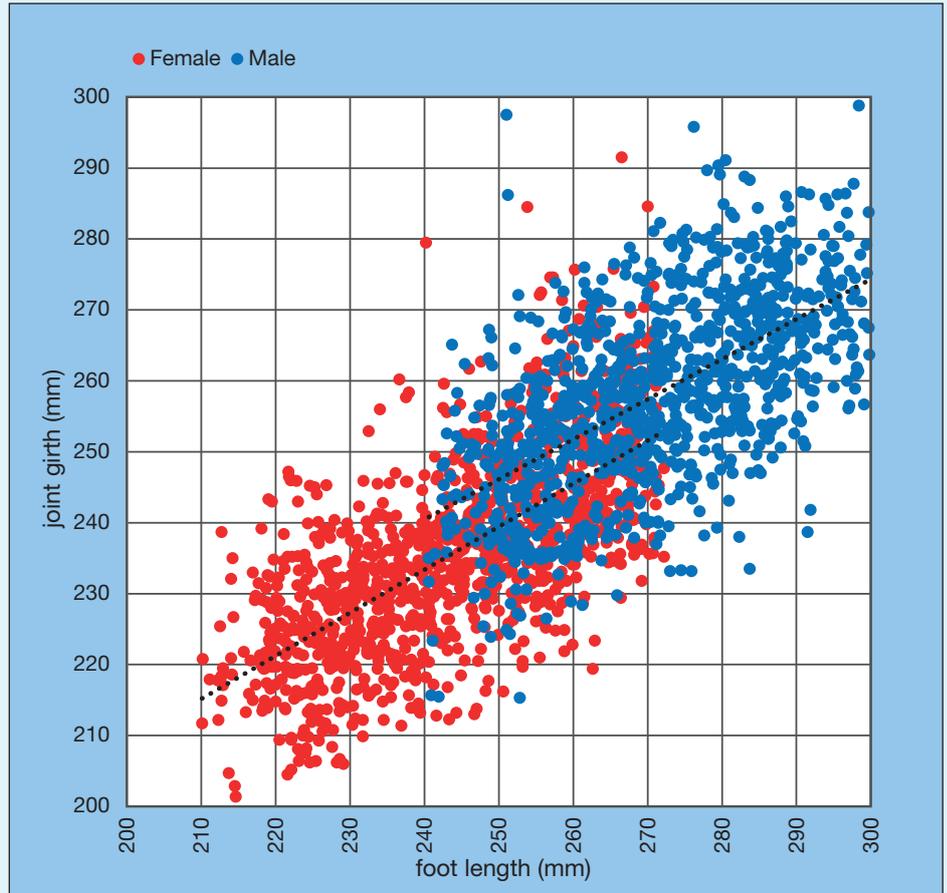


Figure 1: US data for male/female joint girth against foot length



Increasing numbers of women are wearing footwear which had previously been viewed as male styles

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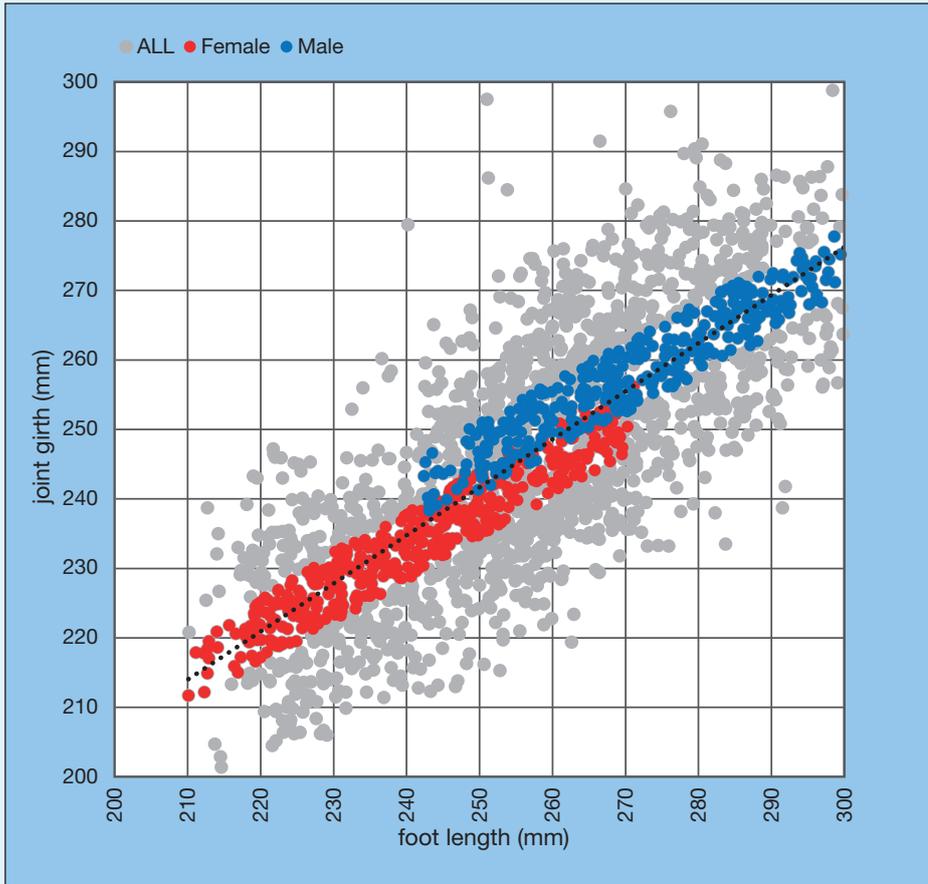


Figure 2: Differences between two grade rules and a single grade rule

Foot length	Joint girth		Foot breadth		Instep girth	
	Female	Male	Female	Male	Female	Male
220	221	229	91	95	221	235
230	227	235	94	97	227	240
240	233	241	96	100	232	245
250	239	246	99	102	238	250
260	245	252	102	105	243	255
270	251	258	104	107	249	260
280	257	263	107	110	254	265
290	263	269	109	112	259	270
300	269	275	112	115	265	275

female fashion, such as epaulettes and berets and, in more modern times, traditional Oxford-style footwear. Masculinity has been associated with power, which may have influenced the adoption of male fashions by women. However, with the rise of female empowerment we have increasingly seen women embracing femininity as an expression of power. In the future, women’s fashions may be adopted by men, or at least there may be a blurring in distinction between masculinity and femininity as equality grows.

For now, the difference in typical size range alongside the differences in preferred style and aesthetic of footwear means that men’s and women’s shoes are generally quite distinct and most people would identify one product as more feminine or masculine than another. With this distinction, footwear can be made to take in to consideration the physical differences between the sexes.

Variations on a theme

The first and most obvious difference between shoes for the male and female

markets is the average difference in size and weight of the user. Men are typically 12kg heavier than women (see table 1), and so male footwear will experience greater compression and impact forces. Niche boots require much stronger heels and shanks in men’s footwear. The average foot length also differs between men and women. The average foot length for men in the USA is approximately 270mm (UK 9, US 10 or EU 43) with 95 per cent of them falling between 244-296mm. In contrast, the average foot length for US women is 243mm (UK 6, US 8 or EU 38) with 95 per cent falling between 219-267mm. So, alongside the differing forces experienced between male and female shoes, they also occupy a different size range.

This difference in size is not present in children – a six-year-old typically has a foot length of 185mm, regardless of sex. It is not until puberty that a variation occurs. Girls tend to reach their adult foot length at the age of 12, while boys’ foot length generally continues to grow until they are 15. Foot length remains predominantly fixed throughout adulthood, while foot breadth tends to spread and increase slightly with age. The differences between girls’ and boys’ feet below the age of 12 are minor, and a unisex approach to sizing would be acceptable.

In addition to being nominally longer than women’s feet, men’s feet also tend to be broader for a given foot length (see figure 1), so that an average man’s foot of length 260mm will be wider than a woman’s foot of the same length. While this trend exists in the joint girth, foot breadth and instep girth, there is negligible difference for other dimensions, such as heel to tibiale length, heel breadth and joint height. The difference in joint girth between men and women is approximately 7mm, although the largest variation between a male foot and a female foot exists in the instep girth, in which the typical difference is 11 mm (table 2).

When making shoes for a male audience, the greater breadth of foot should be taken in to consideration in order to maximise population coverage for that group. Making a shoe the same width fitting as a women’s shoe would limit the number of men that would be comfortably accommodated because of the one width fitting difference. Similarly,

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and possibly more importantly, a shoe made for a female market should be narrower than the male equivalent. Several female styles are dependent on a close fit in order to stay clamped to the foot – particularly in the case of open court shoes and ‘plimsolls’ in which there are no fastening to secure the footwear to the foot. If these were made in the same width fitting as for men’s shoes, they would be too loose for the average market.

It is important to note that the dimensions provided in table 2 are the average foot measurements, calculated using a line of best fit. As can be seen in figure 1, while the line of best fit describes the typical foot dimensions for men and women and allows a general guideline or rule to be presented, the spread of data demonstrates the need to offer more than one width option to accommodate wide and narrow feet. The spread of joint girths in both men and women is in the region of 40mm, and while some variety in width fitting does exist from a few notable retailers, the vast majority of footwear is limited to a single width fitting.

However, this spread in data does present an advantage. It is clear from the line of best fit assessment of male and female data in figure 1 that footwear for a specific male or female market should be made in different width fittings to account for the broader male foot to maximise population coverage. However, in casual footwear such as fashion trainers where the level of fit to the foot is less demanding than in other styles, a unisex approach to fitting could be taken to minimise tooling and production costs. Foot dimension data presents in an ellipse with a high density of points in the centre and low density towards the edges. This means that slightly different paths through the data, provided that the line remains close to the centre of the ellipse, will result in very similar population coverages. In this way the grade rules can be adjusted while retaining a nominally ideal population coverage. For example, the grading between joint girths shown in table 2 is 6mm for women and 5.6mm for men (when incrementing length in 10mm intervals). This can be normalised to 6mm for both men and women with little loss in population coverage and a beneficial simplification to grade rules.

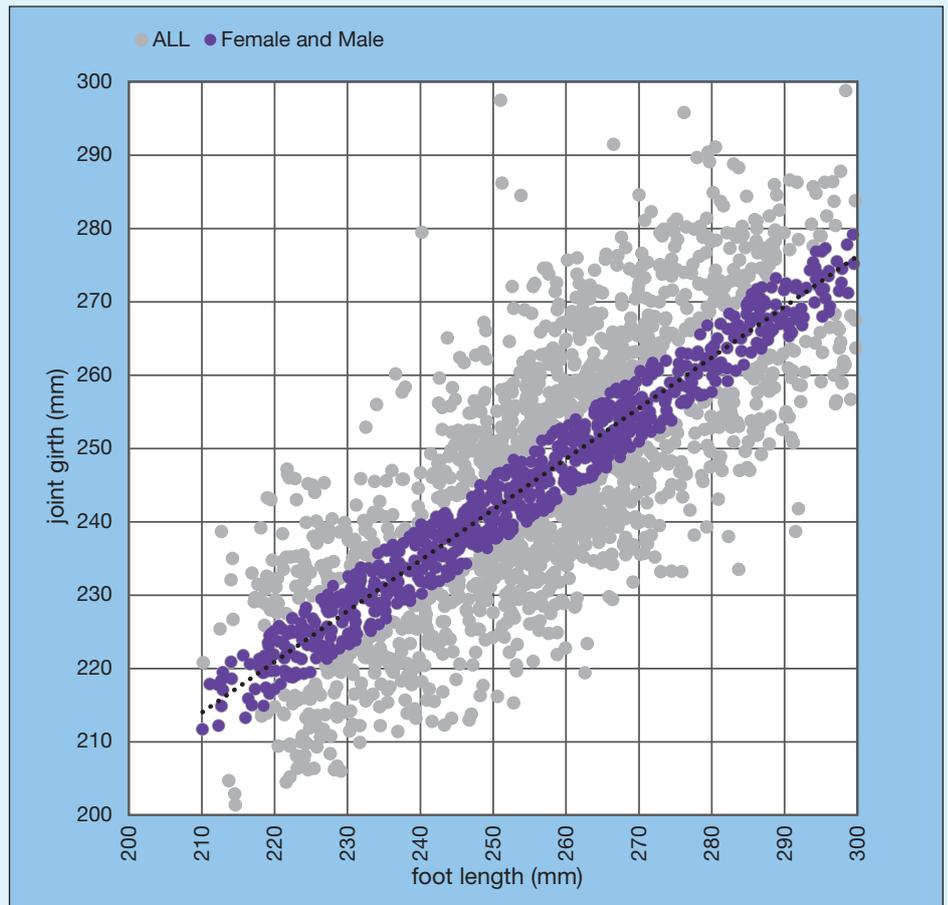


Figure 3: The benefit of the single grade rule

By taking foot dimensions data and disregarding whether participants are male or female, a line of best fit can be calculated to provide a unisex grade rule. This offers the benefit of a single grade rule and single set of tooling to accommodate both sexes. This is demonstrated in figures 2 and 3, where the approximated population coverage offered by the sex specific lines of best fit are shifted to a unisex line of best fit. An estimate of population coverage can be calculated by assuming a range of joint girths that would be accommodated by a grade rule. In figure 2, those individuals with a joint girth ± 5 mm from the line of best fit are assumed to be ideally accommodated by footwear made in that grade. These represent 38.9 per cent of the female population and 34.7 per cent of the male population. When shifting to a unisex line of best fit (figure 3), the population coverage only drops by a small amount to 37.3 per cent for women and 34.2 per cent for men.

There are physical differences between men and women that can be quantised and accounted for in footwear. Styles that require a closeness of fit should certainly

bear these differences in mind for shoes designed for a particular end consumer. In more forgiving styles with no particular gender expression, a unisex approach could be adequately deployed to offer similar population coverage values while reducing manufacturing and tooling costs.

SATRA digital last assessment

SATRA’s team of experts can provide specialist advice and information alongside a digital last assessment service (described on page 38 of this magazine) to ensure that a customer achieves the correct last dimensions for the intended end user, thus improving fit and comfort.

How can we help?

Please contact SATRA’s innovation and development team for further information on the use of the various sizing systems in use today.



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