When to Share Product Platforms: An Anthropometric Review

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INTRODUCTION

The proper fit of cycling product is an important factor that can have huge implications on the ride experience. Improper cycling postures are known to detract from riding comfort (1) and performance (2,3), as well as cause overuse injuries in the legs and spine (4). As the producers of bicycles and equipment, it is important to have a deep understanding of human anatomy and design products that fit a large range of cyclists.

Specialized believes deeply in data-driven approaches to product design. Every year, we analyze data from three main areas to drive our product decisions. These areas include rider insights, retailer insights, and technical information from in-field data acquisition programs like Retül. Rider and retailer insights provide valuable information about user perception, while the technical data provides objective results about the human body and bike fit that allow us to improve rider experience through product development.

Providing appropriately sized bicycles, components, and equipment directly to the rider is the job of our retail partners. The technological advances offered by Retül, combined with the product and fit education of SBCU, aim to provide our retailers with best-in-class tools and training to serve each rider's needs. We believe that dynamic bike fit with digital measuring is the ultimate way to ensure proper fitting bikes and equipment.

Several methods exist to size a rider for the appropriate product. Most methods rely on obtaining measurements of the body (anthropometrics) and predicting the correct size product to match. Other methods are less data-driven and rely on personal knowledge and/or assumptions about the consumer.

Gender-specific products exist in the market today for many different reasons. Ultimately, the goal for us, as a company, is to provide an appropriately-fit product to a rider. Previously, this was based on the notion that gender is a predictor of sizing and fit. Using new sources of data, however, we have found that gender is likely a poor predictor of many anthropometric proportions though, in general size differences, exist between genders.

In order to provide our riders with the best fitting product, we do not want to rely on assumptions about how riders are built, how body proportions vary between men and women, or how each fit on a bike. We want to rely on true knowledge about the rider. This report is a large step in this process and seeks to understand the variability *within* and *between* the sexes as it relates to bike and equipment size. Armed with this knowledge, we can make better informed decisions about product design.

GOALS

1. Review all the Retül data that relates to anatomical body parts/segments, cycling-specific proportions, and bicycle fit coordinates.
2. Analyze the sex differences (within and between) across three categories of product: bikes, bike spec, and equipment.

DATA

The archived data from the Retül fit system includes 3D digitized body segment lengths, segment proportions, as well as the resulting bicycle fit coordinates. This is believed to be the most accurate and extensive fit database in the bicycle industry.

Segment length. A segment length is defined as the 3D distance, measured in millimeters, between two major joints of the body. Important segment lengths used in this report include the length of the foot, lower leg, upper leg, torso, upper arm, and lower arm.

Segment proportion. A segment proportion is defined as a ratio between different body segments. An important segment proportion used in this report is leg/torso ratio.

Fit Coordinate. A fit coordinate is defined as the 3D distance, measured in millimeters, between different contact points of a bicycle. Important fit coordinates used in this report include the 3D distances between the bottom bracket and saddle, saddle and handlebar, and saddle height and handlebar reach.

The data is archived with recorded factors such as age, gender, cycling discipline, cycling level, desired experience, rider goals, etc. with the purpose of analyzing certain trends. Over the last 11 years, Retül HQ has analyzed 7,750 fits. The data in this report was recorded during commercial and sponsorship-based bike fitting sessions from 2016 to 2018 across the global landscape. Since the employees that conducted the fits are based out of the USA (Boulder, CO and Morgan Hill, CA), however, it is presumed that the sample is biased towards North American riders.

The data is captured under power outputs that represent 6-7 on an RPE (rating of perceived exertion) scale of 10. This represents the theoretical power a cyclist can hold for 1 hour. For the purposes of this analysis, records that fell outside of three standard deviations from the mean for a given attribute were filtered out to eliminate outliers caused by erroneous measurement or data entry errors.

BIKES

Since 2002 women's-specific geometries have become popular across the major bike brands. It is possible that our assumptions as an industry regarding female body proportions have led to this movement. The assumption is that women have proportionally shorter torsos than men.

Depending on the sample of the global population that is obtained, these results can, and will, vary. Lending support to the assumption that women have proportionally shorter torsos than men, a 2010-2012 survey of United-States-based military recruits (5) found this to be true (Figure 1). More recently, a 2015-2018 survey of global cyclists, as measured on the bike, suggests that men and women have very similarly proportioned bodies in terms of leg/torso ratio (Figure 2). One thing that seems certain in both surveys is that the body proportions can vary as much within a sex as between sexes.

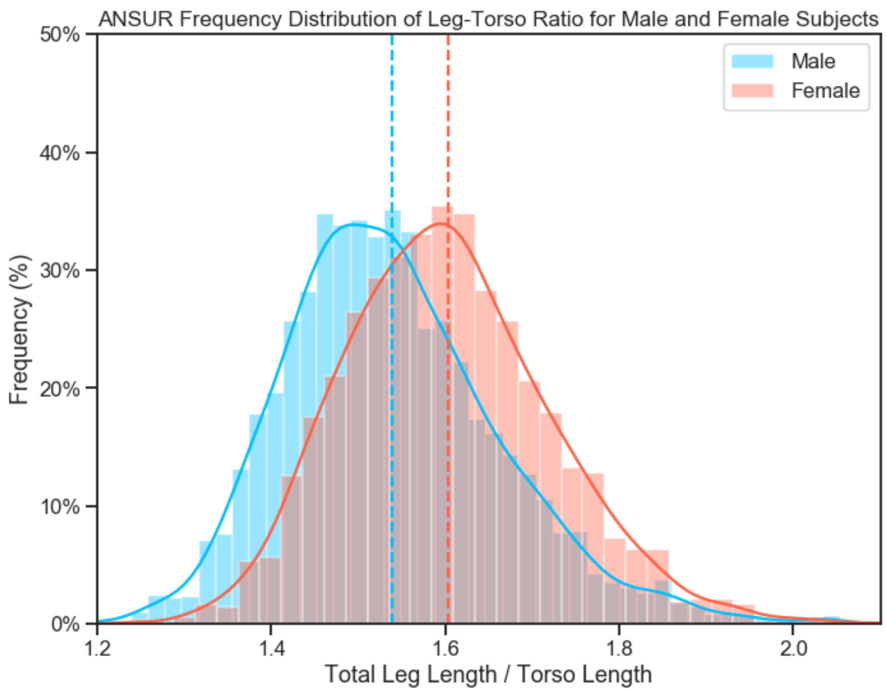

Figure 1: This shows a frequency distribution leg/torso ratios for men and women as measured by the ANSUR II anthropometric survey of US ARMY recruits between the years of 2010 and 2012. This demonstrates that in this sample women, on average, have longer legs relative to torso compared to men.

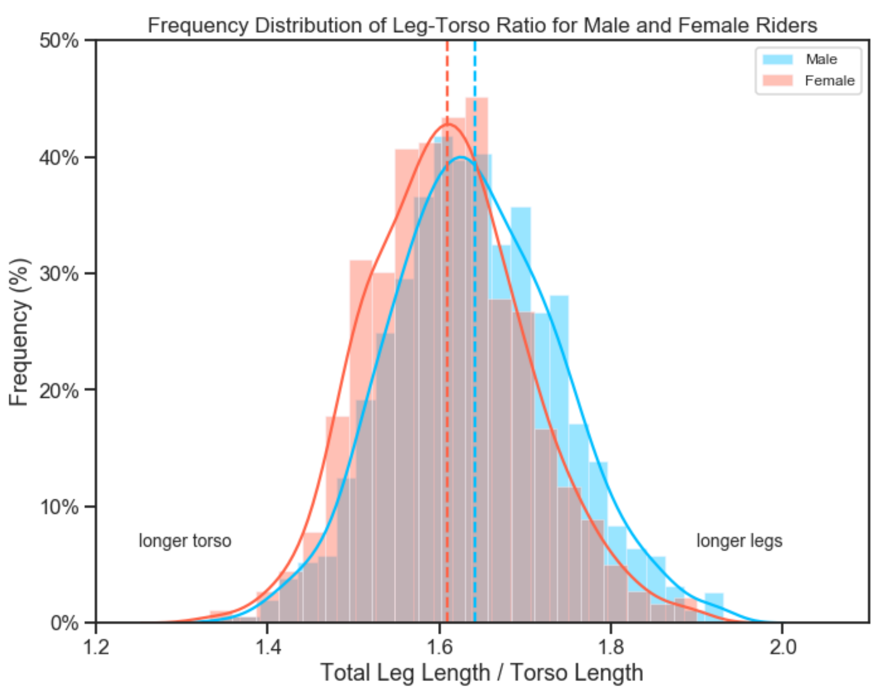

Figure 2: This shows the frequency distribution of leg/torso ratios for men and women recorded by the Retül anthropometric survey between the years 2015 to 2018. This data demonstrates that men and women have similar proportions of leg and torso lengths

The discrepancy in findings between the Retül and the ANSUR surveys could be explained by a few factors. First, it is possible that the US-based population is different than the global population. Second, the tools used to collect data were different between the surveys. Although the measurements were taken by skilled professionals, the ANSUR group used traditional tools found in many basic anthropometric measurement kits that have been associated with high intra- and inter-rater errors (5,6). The Retül survey was conducted using a commercially-available and independently validated (7,8) 3D Motion Capture system to obtain the measurements. Third, the ANSUR group used a seated and standing posture, while the Retül data was obtained on-bike while pedaling under moderate intensity.

In this Retül dataset, the distance from the shoulder marker to the greater trochanter marker with the rider in the riding position was used as a proxy for torso length. The sum of the length of leg segments, captured by the greater trochanter marker, knee marker, and lateral malleolus marker was used to quantify leg length. The difference in the ANSUR data and Retül data can be largely attributed to the back measurement taken in the riding position in the Retül fit data and standing upright in ANSUR.

Given the above information, it is important to consider that women, post bike fit, could have different fit coordinates than men with similar body proportions. Rider muscular flexibility is an important driver of bike fit and differences in riders of the same proportions can lead to different fits. Figure 3 shows the ratio of saddle-height-to-handlebar-reach in the Retül fit database. Saddle height is measured (in millimeters) from the center of the bottom bracket to the top, mid-point of the saddle. Handlebar reach is the horizontal distance (in millimeters) from the center of the bottom bracket to the center of the handlebar. This figure shows that sex is a poor predictor of handlebar reach normalized to saddle height.

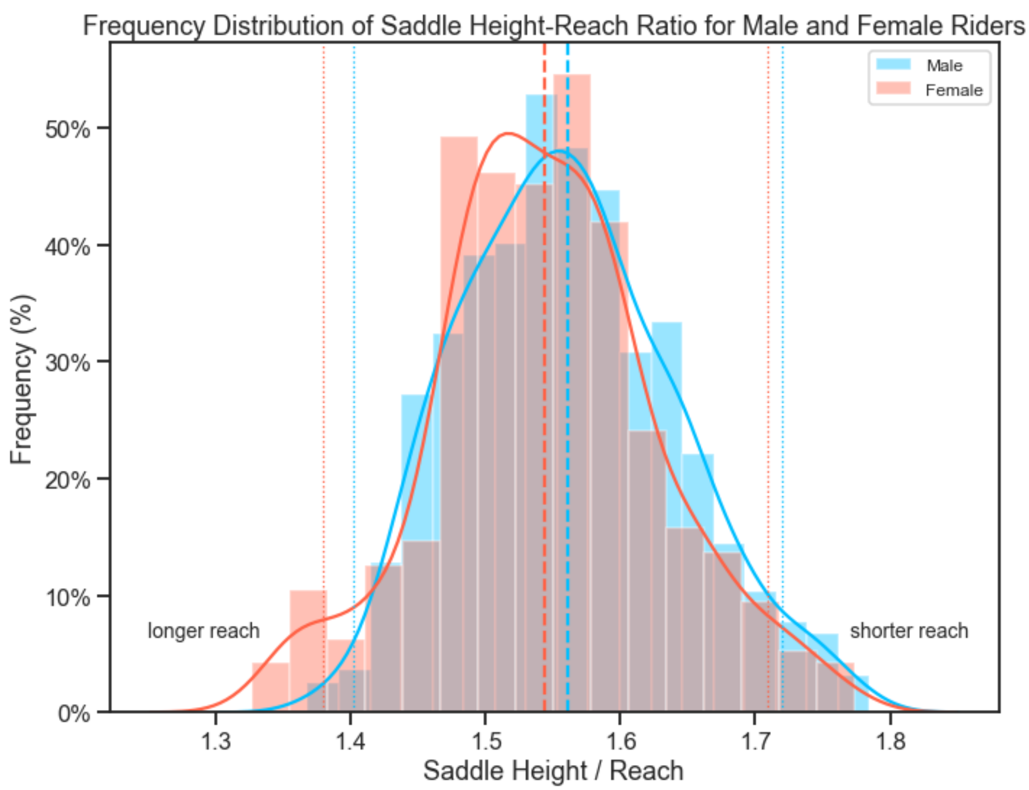

Figure 3: This shows the frequency distribution of saddle-height-to-handlebar-reach ratios for men and women, and it demonstrates that men and women have comparable fit coordinates on road bicycles.

FIT

The Retül database also provides extensive biomechanical information about how riders fit and pedal bikes. We have learned that men and women sit differently on saddles and therefore have documented differences in resulting saddle positions from bike fits. On average, the female rider will have a saddle positioned lower (Figure 4) than a male with the same leg length. We believe this to be a result of the saddle-pelvic interface differences between the sexes, with women typically choosing a more rearward position on the saddle. We also believe this to be an attempt to lessen the pressure on the genitalia.

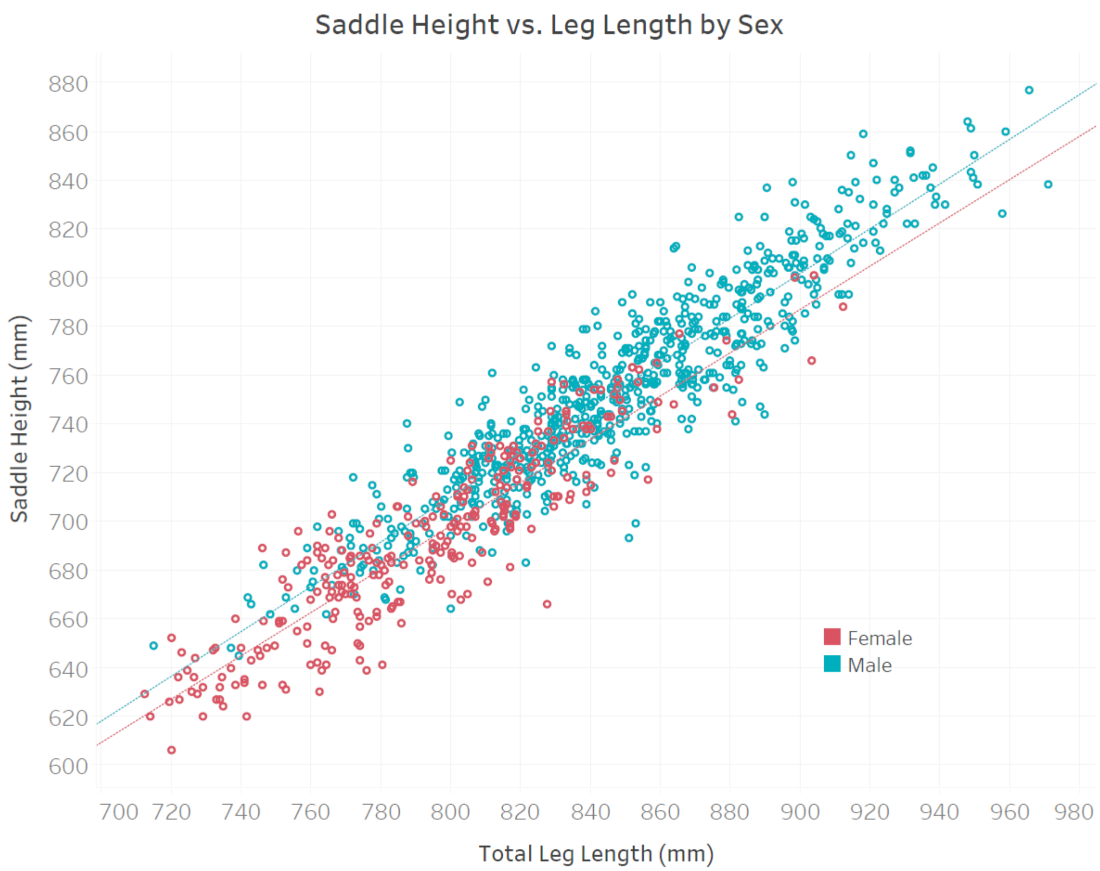

Figure 4: This is a scatter plot of the resulting saddle heights of men and women showing that for the same leg length a female rider will be positioned, on average, with a slightly lower saddle height.

The data findings related to saddle position highlight the main difference between men and women and suggests that saddle choice and bike fit are ultimately the answer to personalizing the fit for any rider regardless of sex. The variability in how humans sit on saddles is large and is currently unpredictable. Therefore, we suggest any rider to be properly sized for a saddle and have it installed during a dynamic bike fitting session. We firmly believe that getting a fit on a shared-platform bike will provide a much better cycling experience than riding a sex specific bike without a fit.

EQUIPMENT

SADDLES

Geometrically, saddles are designed based on shape and size. Many different shapes, or models, exist for men and women. Within these shape categories, we manufacture different widths. The width of a saddle is measured across the widest part of the saddle with the goal of providing adequate structural support for a matching ischial tuberosity (IT) width. Excessively narrow or wide saddles decrease rider comfort and increase injury potential (9, 10, 11).

Currently, we manufacture saddle widths of 130mm, 143mm, 155mm, and 168mm to support riders with the corresponding IT widths of <100mm, 101 – 120mm, 121-140mm, and >140mm, respectively. These anatomic IT widths are measured as the distance between right and left ischial tuberosities, or "sit bones." Figure 5 shows the distribution of sit bone widths in male and female riders. The sex difference is about 2cm on average, which could lend support for sex specific widths. But due to the variability within a sex, and our belief in the importance of proper saddle width for each rider, we choose to continue to produce male saddles in all widths and female saddles in all widths but 130mm.

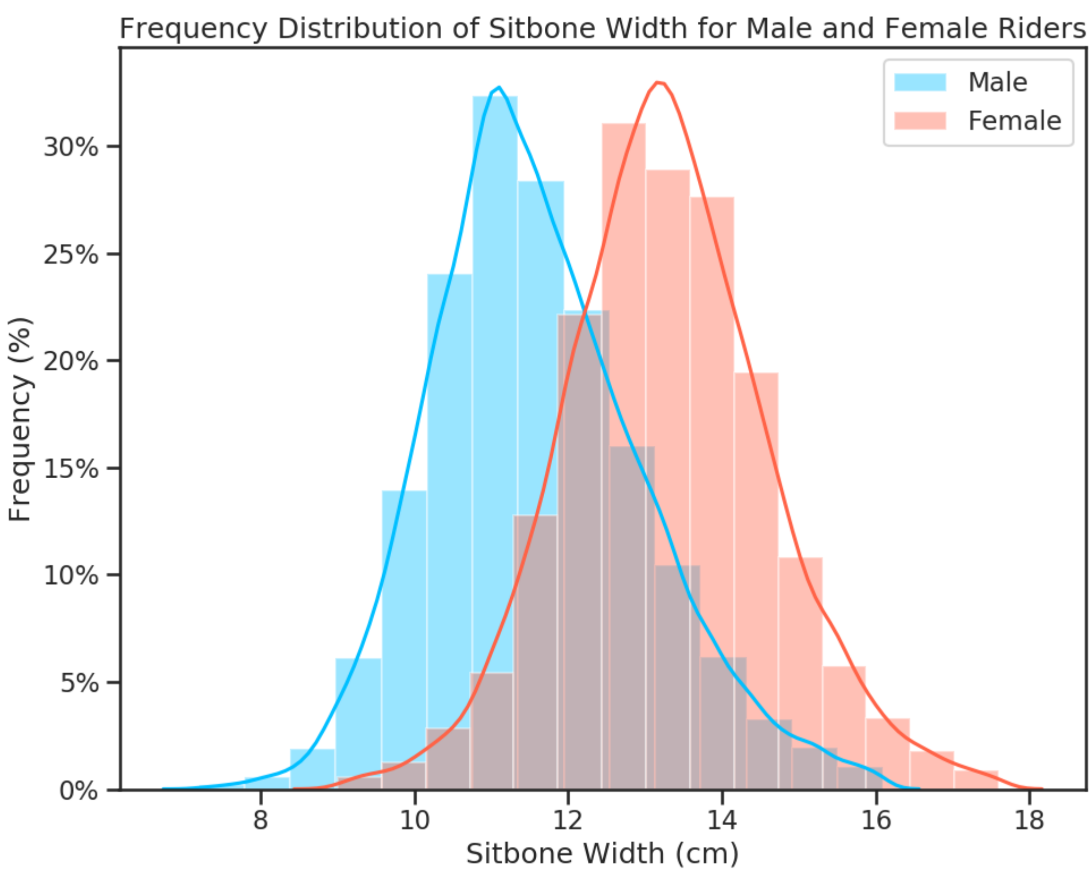

Figure 5: This shows the frequency distribution of ischial tuberosity (sitbones) widths for men and women and demonstrates that women, on average, have slightly wider sitbones compared to men.

Although the saddle is an integral part of riding a bicycle, the scientific literature examining determinants of cycling saddle preference and comfort is limited and inconclusive (13).

SHOES

Similar to bikes, the cycling industry began making sex-specific shoes in an attempt to better serve riders with regards to fit. Our current data from Retül Match (Figure 6) indicates that if we consider the proportion of the length of the foot to the circumference of the ball of the foot, there is very little if any difference between men and women. While size differences do exist, on average, between men and women, these differences are accommodated by offering a larger range of sizes for a given shoe model.

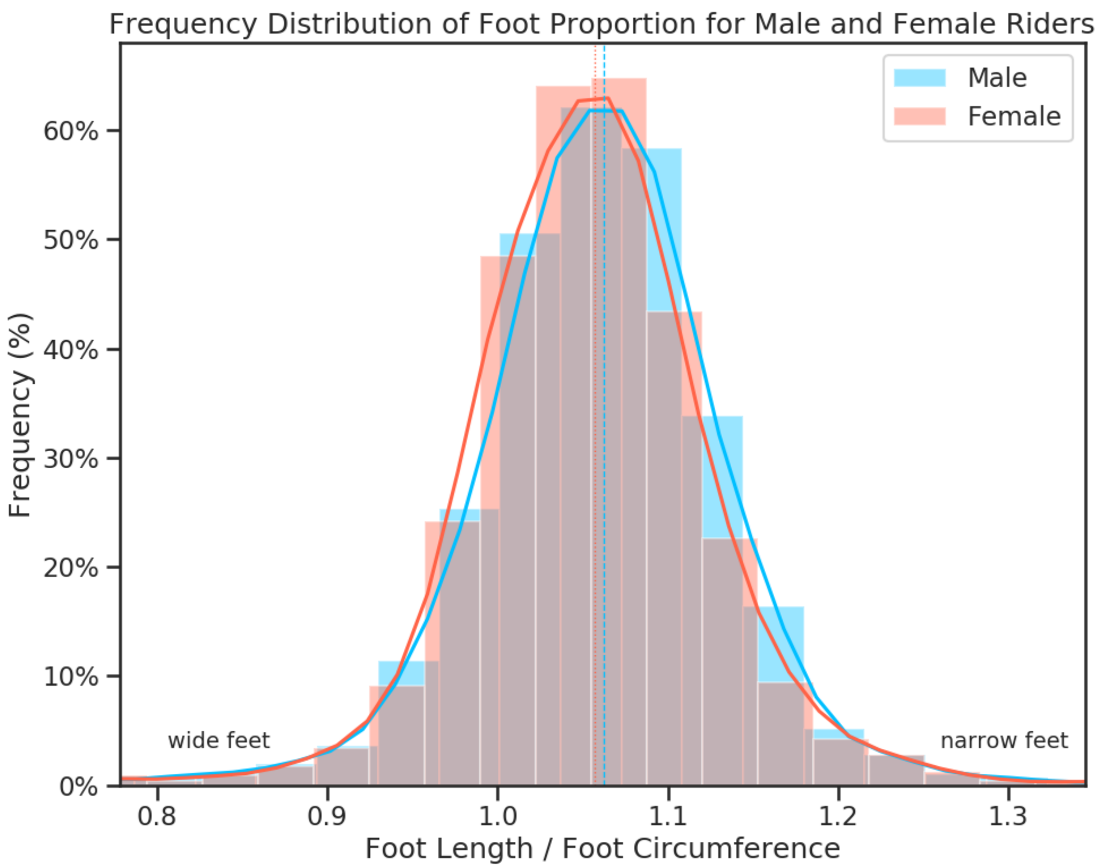

Figure 6: This shows the frequency distribution of foot proportions for men and women and demonstrates that women have similarly proportioned feet to men. Foot length is a value measured in mm's and represents the total length of the foot. And foot circumference (in mm's) is the distance of a tracing around the widest part of the forefoot. This dataset contained 9831 riders (7917 male, 1914 female)

BIKE SPECIFICATIONS

Equipment specifications (spec) are an important factor in overall rider comfort and performance. We believe that enjoyment can be optimized and injuries prevented when a bicycle is configured with the proper equipment for each rider. Bike fit and aftermarket equipment purchases, although costly, provide the ultimate personalization of any bike. Spec'ing a bicycle with original equipment that is suitable for a majority of people, however, is a goal. In this section, we will provide the rationale and data that supports our equipment specifications.

SADDLES

One of the goals of the shared-platform transition is to provide a saddle exchange program at retail to provide all riders a proper width saddle at the time of bike purchase. In an attempt to seed the markets with adequate numbers of saddles to achieve this goal, we plan to selectively place 143mm and 155mm saddles on certain bicycle sizes based on the distribution of data in the Retül Match database. If the shop does not have the correct saddle width to swap from a bike on the floor, the rider will have the option to pay for a saddle from the retailer's inventory.

Analysis of the Retül Match database of 42,818 DSD (Digital Sitbone Device) sessions and the resulting width recommendations from 2016 to spring 2018 is presented below. Figure 7 shows that saddle widths of 143mm and 155mm are recommended for a large percentage of riders, with widths of 130mm and 168mm being much less common. Figure 8 shows the same data split by sex and suggests that a majority of men are recommended the 143mm width and women the 155mm width.

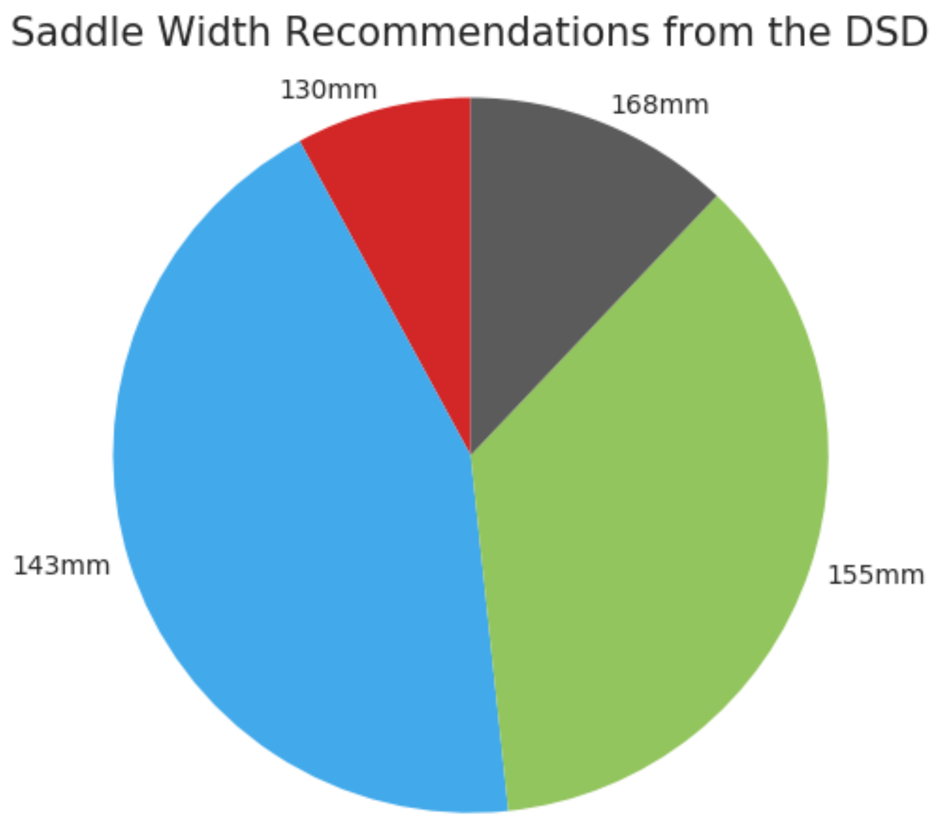

Figure 7: This pie chart shows the saddle widths recommended by DSD (digital sitbone device) measured sit bone widths across a global population of cyclists from 2016 – 2018.

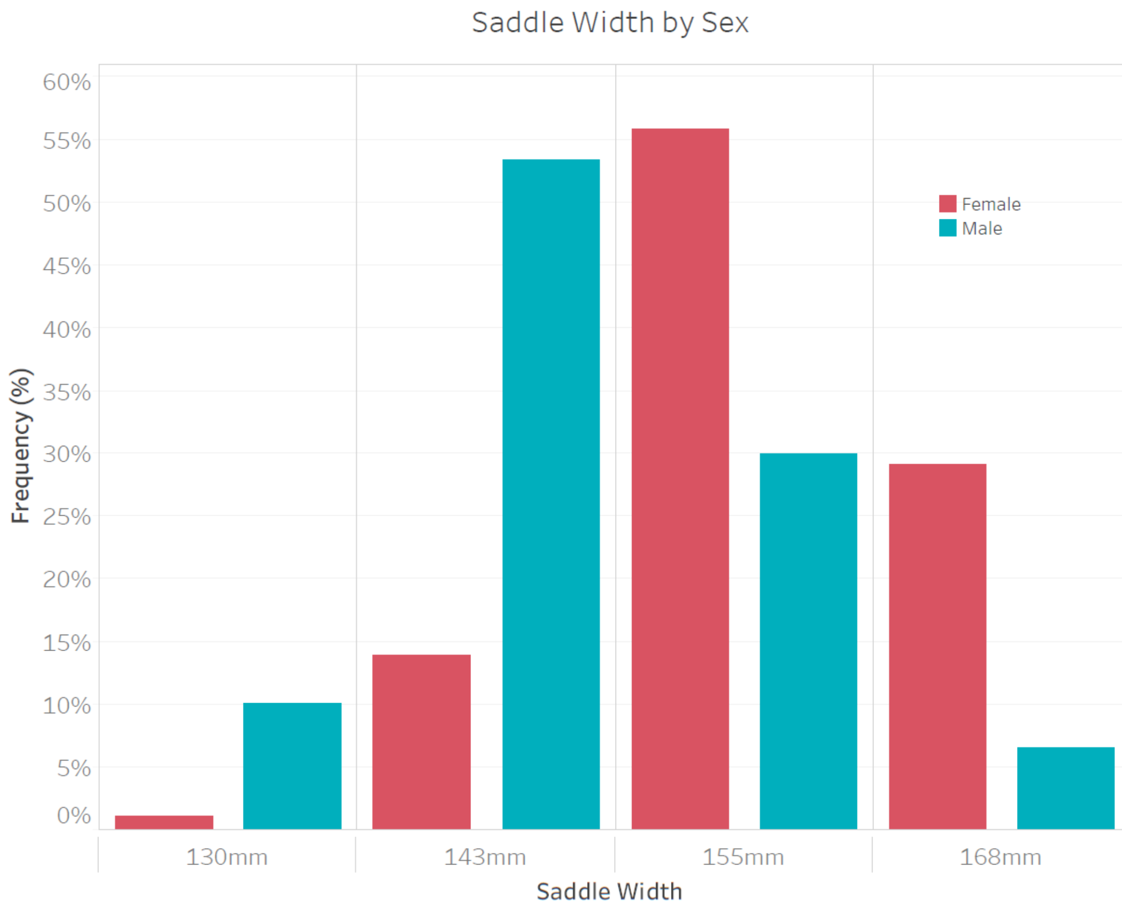

Figure 8: This bar graph shows the saddle widths recommended by DSD (digital sit bone device) measured sit bone widths, split by gender, across a global population of cyclists from 2016 – 2018.

To determine proper saddle width spec for bikes, we analyzed 25,812 unique Match sessions with both DSD (saddle width) and bike size recommendations. We chose to specify saddle widths on bikes based on the proportion of male and female ridership on that size (Table 1 and Table 2) and the likelihood that riders of that gender would ride a given saddle width. For example, if a bike size had a higher percentage of male riders matched to it, we would specify a 143mm saddle since this is the likeliest saddle match for male riders. Additionally, we compared the percentage of all bikes in sizes shipping with a 143mm and 155mm saddle to the percentage of all riders in Retül Match who match these saddle widths to seed the markets with an appropriate proportion of each saddle width for the saddle swap program.

Flat bar bikes

Bike Size	Total percent (%)	% of Men	% of Women
XS	1.99%	2.93%	11.11%
SM	16.98%	17.35%	42.26%
MD	37.17%	41.24%	38.87%

LG	33.64%	30.32%	7.16%
XL	9.62%	7.39%	0.54%
XXL	0.60%	0.76%	0.07%

Table 1: This table shows the size split of all flat bar bikes as well as the gender contribution to each size. This shows that women ride XS and S sizes proportionally more than men. And men ride MD, LG, XL, and XXL sizes proportionally more than women.

Drop bar bikes

Bike Size	Total percent (%)	% of Men	% of Women
49 and under	11.16%	8.96%	31.90%
52	19.86%	19.50%	34.39%
54	27.67%	29.34%	24.26%
56	24.10%	25.33%	7.75%
58	12.97%	12.83%	1.34%
61 and up	4.24%	4.04%	0.35%

Table 2: This table shows the size split of all drop bar bikes as well as the gender contribution to each size. This shows that women ride 44, 49, and 52 sizes proportionally more than men. And men ride 54, 56, 58, 61, and 64 sizes proportionally more than women.

Given the proportional gender contribution to each size bike, and the distribution of pelvic widths within each gender, the MY20 saddle size specification is shown in Table 3 below. The goal of this specification was to provide the markets with the correct distribution of saddle widths to serve our riders.

Bike Size	Saddle size (mm)
XS	155
SM	155
MD	143
LG	143
XL	143
49 cm and under	155
52 cm	155
54 cm	143
56 cm	143
58 cm	143
61 cm and up	143

Table 3: This table shows the saddle width specification for MY20 by bike size

BARS

Historically, shoulder width is thought to be a predictor of handlebar width. However, people can accommodate a range of handlebar widths driven by desired riding experience and handling. A professional bike fit is the best way for a rider to select a bar width to best meet their needs. We have insufficient data to quantify the relationship of shoulder width to handlebar width. We suggest a performance study to identify predictors of handlebar width for a given rider.

CONCLUSION

The anthropometric and fit data supports shared bicycle geometries and shoe dimensions for men and women.

In terms of saddle specifications, the data in this report supports placing 155mm saddles on the bike sizes ridden by the majority of women and 143mm saddles on bike sizes that are ridden by the majority of men. If a rider measures either 143mm or 155mm they will end up with the correct width saddle through a retail saddle swap program allowing saddles to be swapped between bikes as long as there is an identical saddle model to swap. If a rider measures either 130mm or 168mm or if the rider prefers a different model of saddle from the original equipment specification, the rider will have the option to pay for a saddle from the retailer's inventory.

Finally, the authors stress that personalized bicycle optimization is best accomplished during a dynamic fitting session. It is very important to remember that the size differences do exist and it is critical to continue to produce a wide size-range of product.

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