Data606_Lab3_JagdishChhabria

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In this lab we'll investigate the probability distribution that is most central to statistics: the normal distribution. If we are confident that our data are nearly normal, that opens the door to many powerful statistical methods. Here we'll use the graphical tools of R to assess the normality of our data and also learn how to generate random numbers from a normal distribution.

The Data

This week we'll be working with measurements of body dimensions.This data set contains measurements from 247 men and 260 women, most of whom were considered healthy young adults.

```
load("more/bdims.RData")
```

Let's take a quick peek at the first few rows of the data.

```
head(bdims)
```

```
##   bia.di bii.di bit.di che.de che.di elb.di wri.di kne.di ank.di sho.gi
## 1   42.9   26.0   31.5   17.7   28.0   13.1   10.4   18.8   14.1  106.2
## 2   43.7   28.5   33.5   16.9   30.8   14.0   11.8   20.6   15.1  110.5
## 3   40.1   28.2   33.3   20.9   31.7   13.9   10.9   19.7   14.1  115.1
## 4   44.3   29.9   34.0   18.4   28.2   13.9   11.2   20.9   15.0  104.5
## 5   42.5   29.9   34.0   21.5   29.4   15.2   11.6   20.7   14.9  107.5
## 6   43.3   27.0   31.5   19.6   31.3   14.0   11.5   18.8   13.9  119.8
##   che.gi wai.gi nav.gi hip.gi thi.gi bic.gi for.gi kne.gi cal.gi ank.gi
## 1   89.5   71.5   74.5   93.5   51.5   32.5   26.0   34.5   36.5   23.5
## 2   97.0   79.0   86.5   94.8   51.5   34.4   28.0   36.5   37.5   24.5
## 3   97.5   83.2   82.9   95.0   57.3   33.4   28.8   37.0   37.3   21.9
## 4   97.0   77.8   78.8   94.0   53.0   31.0   26.2   37.0   34.8   23.0
## 5   97.5   80.0   82.5   98.5   55.4   32.0   28.4   37.7   38.6   24.4
## 6   99.9   82.5   80.1   95.3   57.5   33.0   28.0   36.6   36.1   23.5
##   wri.gi age  wgt   hgt sex
## 1   16.5  21 65.6 174.0   1
## 2   17.0  23 71.8 175.3   1
## 3   16.9  28 80.7 193.5   1
## 4   16.6  23 72.6 186.5   1
## 5   18.0  22 78.8 187.2   1
## 6   16.9  21 74.8 181.5   1
```

You'll see that for every observation we have 25 measurements, many of which are either diameters or girths. A key to the variable names can be found at http://www.openintro.org/stat/data/bdims.php, but we'll be focusing on just three columns to get started: weight in kg (`wgt`), height in cm (`hgt`), and `sex` (`1` indicates male, `0` indicates female).

Since males and females tend to have different body dimensions, it will be useful to create two additional data sets: one with only men and another with only women.

```
mdims <- subset(bdims, sex == 1)
fdims <- subset(bdims, sex == 0)
mdims
```

```
##     bia.di bii.di bit.di che.de che.di elb.di wri.di kne.di ank.di sho.gi
## 1     42.9   26.0   31.5   17.7   28.0   13.1   10.4   18.8   14.1  106.2
```

```
## 2      43.7   28.5   33.5   16.9   30.8   14.0   11.8   20.6   15.1  110.5
## 3      40.1   28.2   33.3   20.9   31.7   13.9   10.9   19.7   14.1  115.1
## 4      44.3   29.9   34.0   18.4   28.2   13.9   11.2   20.9   15.0  104.5
## 5      42.5   29.9   34.0   21.5   29.4   15.2   11.6   20.7   14.9  107.5
## 6      43.3   27.0   31.5   19.6   31.3   14.0   11.5   18.8   13.9  119.8
## 7      43.5   30.0   34.0   21.9   31.7   16.1   12.5   20.8   15.6  123.5
## 8      44.4   29.8   33.2   21.8   28.8   15.1   11.9   21.0   14.6  120.4
## 9      43.5   26.5   32.1   15.5   27.5   14.1   11.2   18.9   13.2  111.0
## 10     42.0   28.0   34.0   22.5   28.0   15.6   12.0   21.1   15.0  119.5
## 11     40.3   29.0   33.0   20.1   30.3   13.4   10.4   19.4   14.5  117.1
## 12     43.7   29.0   31.3   20.5   29.7   15.0   11.7   20.9   16.0  123.5
## 13     47.4   29.6   35.7   20.8   31.4   16.1   11.3   21.5   15.4  116.5
## 14     40.3   27.5   31.4   21.7   28.0   13.3   10.3   18.8   13.2  113.0
## 15     41.0   26.8   32.2   21.9   28.6   14.9   10.6   17.8   14.0  107.5
## 16     45.0   27.0   33.2   21.7   30.6   13.7   11.1   20.7   14.0  112.0
## 17     39.9   30.0   34.5   21.0   29.4   15.6   11.9   21.2   16.0  112.2
## 18     43.0   26.5   30.3   19.3   30.0   14.8   11.2   19.7   14.7  120.0
## 19     43.1   28.6   33.4   22.2   29.5   14.9   12.2   20.8   14.8  109.0
## 20     43.6   29.3   34.4   20.2   32.6   15.4   10.9   20.7   15.5  118.5
## 21     42.0   27.5   30.7   21.3   32.0   13.1   11.1   19.2   13.9  116.0
## 22     43.8   28.0   33.3   20.0   32.0   15.0   11.5   20.4   14.4  111.0
## 23     42.3   26.4   31.2   18.0   30.9   14.6   10.8   18.6   13.8  117.7
## 24     42.7   29.9   35.0   21.8   32.8   14.3   11.2   19.8   14.1  123.9
## 25     44.8   27.8   32.2   18.3   31.5   15.2   11.6   19.4   14.7  120.6
## 26     46.0   30.1   34.5   20.2   31.1   16.4   13.3   22.2   14.9  129.5
## 27     45.4   31.8   35.2   20.2   32.3   14.6   10.5   20.2   15.3  115.0
## 28     40.5   28.3   33.4   19.2   28.8   14.6   11.1   20.8   14.5  116.0
## 29     39.4   25.5   30.2   17.6   27.7   13.0   10.2   18.9   13.2  107.8
## 30     40.2   27.2   31.7   18.1   26.5   13.3   10.1   18.6   13.2  100.2
## 31     44.2   30.3   34.7   19.4   30.0   14.9   11.0   19.1   15.8  113.0
## 32     41.0   23.6   30.2   22.9   28.0   14.3   11.2   18.2   14.0  117.9
## 33     44.0   31.0   35.3   19.2   31.0   15.2   11.4   21.2   15.1  112.5
## 34     41.6   32.0   35.3   23.6   27.0   15.5   11.3   20.9   15.0  110.5
## 35     41.0   25.1   31.9   20.8   27.9   13.6   10.8   18.8   12.9  112.0
## 36     41.5   24.5   30.5   17.7   26.7   13.3   10.8   18.6   14.0  104.0
## 37     41.1   27.8   31.4   19.0   31.5   14.5   11.9   18.5   13.0  114.8
## 38     38.8   27.2   31.6   18.5   25.5   13.4   10.8   19.0   14.0  108.0
## 39     36.2   27.5   30.4   18.7   28.0   13.6   10.8   19.0   15.4  111.2
## 40     42.1   27.5   32.4   18.2   28.0   16.2   12.0   21.0   16.4  118.3
## 41     40.3   29.4   32.9   23.7   31.5   14.6   11.3   19.8   15.2  115.2
## 42     41.7   27.1   32.6   21.6   28.0   14.1   11.5   19.7   13.8  129.9
## 43     37.8   27.1   31.5   18.5   27.3   14.6   10.8   19.5   14.9  112.9
## 44     39.2   26.1   30.8   19.4   29.9   14.3   11.2   20.0   16.0  112.2
## 45     41.5   30.8   33.3   19.4   30.6   14.8   11.3   20.2   16.0  117.1
## 46     42.5   27.8   33.5   20.6   30.2   15.9   12.8   22.4   16.3  118.7
## 47     39.4   26.1   34.4   20.4   27.3   15.1   10.6   20.0   15.3  109.2
## 48     43.6   33.1   33.5   21.6   33.1   15.6   12.0   20.7   16.5  128.1
## 49     38.9   24.9   28.7   19.7   26.8   14.2   10.2   18.0   14.4  113.3
## 50     37.6   24.4   28.0   18.0   26.4   14.2   10.6   17.3   13.4  108.4
## 51     39.4   28.3   30.6   20.2   28.7   15.0   11.5   18.4   14.4  118.7
## 52     38.5   26.1   30.8   20.6   30.8   15.1   11.4   19.8   14.2  126.3
## 53     40.1   27.8   33.1   19.2   31.3   15.4   11.5   20.6   15.4  124.2
## 54     40.3   28.0   32.0   20.9   31.7   14.8   10.6   19.4   15.0  126.7
## 55     37.6   26.6   29.9   17.3   25.6   12.8   10.0   17.0   13.0  103.3
```

```
## 56    38.3   25.2   30.2   17.0   26.4   13.2   10.4   18.8   13.0  101.2
## 57    39.7   28.6   32.1   19.1   27.1   13.4   10.0   18.2   14.8  104.3
## 58    42.2   29.0   33.7   22.5   30.4   15.6   12.0   19.8   16.2  113.2
## 59    41.1   30.4   35.1   23.2   32.6   15.5   11.6   21.5   15.4  121.9
## 60    40.5   29.3   33.7   19.6   29.8   13.8   11.7   19.7   14.4  113.1
## 61    41.5   28.6   30.4   20.8   26.9   14.8   11.2   20.7   16.5  108.5
## 62    43.4   32.4   36.4   20.3   32.1   15.6   12.0   20.8   16.3  113.9
## 63    43.5   26.0   31.6   19.1   30.9   14.3   11.4   19.5   14.6  112.6
## 64    41.3   27.1   32.4   17.5   27.6   14.1   10.8   20.2   15.5  110.2
## 65    40.3   29.5   33.3   18.4   26.2   14.0   11.0   19.4   14.8  108.7
## 66    36.3   29.2   33.0   20.0   29.0   14.1   11.7   20.4   14.3  104.0
## 67    39.9   28.3   32.0   18.3   31.4   13.5   11.4   18.9   14.4  115.2
## 68    39.8   28.8   33.0   19.7   28.7   12.4   10.7   18.5   13.2  111.9
## 69    43.5   33.2   34.0   23.9   34.3   15.8   12.0   18.6   13.2  127.0
## 70    41.2   26.6   30.6   19.5   28.0   13.1   10.4   19.0   13.8  111.2
## 71    44.0   28.4   32.0   22.5   29.7   14.9   10.9   21.0   14.8  122.0
## 72    41.8   28.5   31.6   21.6   31.5   13.3   10.3   18.9   14.3  114.5
## 73    42.9   27.5   30.3   18.9   29.6   12.6   10.4   19.2   13.8  109.5
## 74    38.7   24.6   28.5   18.3   29.8   14.0   11.2   18.9   13.6  110.8
## 75    41.4   26.4   32.3   18.6   31.3   14.9   11.5   18.9   14.6  118.8
## 76    39.6   27.5   30.2   19.2   28.9   13.5   10.4   19.3   14.2  108.0
## 77    40.5   27.5   32.3   19.4   28.8   12.6   10.6   18.4   14.0  114.3
## 78    34.1   28.1   30.1   21.8   25.8   12.9    9.9   18.6   12.3  105.4
## 79    43.5   28.8   34.0   20.6   29.0   14.3   10.5   19.8   14.2  115.0
## 80    44.1   29.2   35.3   23.6   30.9   15.8   12.5   20.2   15.2  119.5
## 81    42.2   32.6   36.6   22.4   34.5   14.1   11.1   18.2   13.9  130.0
## 82    42.2   30.1   31.4   21.2   29.7   14.0   11.6   21.6   14.1  113.3
## 83    43.0   26.5   31.6   20.6   29.5   13.4   10.4   18.8   13.6  113.2
## 84    39.8   28.7   33.3   19.3   29.2   13.5   11.6   19.5   14.6  106.9
## 85    37.7   29.7   32.7   20.2   28.8   13.3   11.1   18.3   13.2  113.8
## 86    39.6   27.9   33.3   20.2   29.5   12.6   10.7   18.5   12.9  117.3
## 87    43.2   26.3   30.5   19.7   30.6   14.4   12.3   20.2   13.6  124.2
## 88    44.3   28.2   32.2   21.2   31.8   14.2   11.6   20.0   14.4  123.0
## 89    43.3   28.2   33.0   19.4   31.6   13.8   11.1   17.8   13.2  117.8
## 90    42.8   27.5   31.5   19.2   31.8   14.1   11.1   19.1   14.7  118.8
## 91    41.5   30.0   33.4   19.1   29.4   14.8   11.0   19.8   13.8  112.0
## 92    42.0   27.6   32.2   19.7   29.4   13.9   10.0   18.7   13.8  113.0
## 93    41.2   27.1   29.8   20.1   31.0   12.9   11.6   18.8   13.5  116.0
## 94    43.8   29.5   31.2   18.2   29.5   13.1   10.3   19.1   13.2  112.8
## 95    46.2   31.0   36.0   25.0   33.1   14.6   12.0   20.9   15.1  125.0
## 96    40.4   28.6   31.4   19.8   27.6   13.9   10.1   20.0   13.4  108.3
## 97    40.8   27.1   29.4   17.8   29.4   13.3   10.4   18.5   12.8  108.2
## 98    43.9   27.0   33.5   22.3   31.0   13.2   10.4   19.1   13.1  113.0
## 99    44.2   27.9   32.0   21.6   32.9   14.3   11.0   21.1   14.9  115.0
## 100   41.6   28.0   35.0   24.2   31.0   13.4   11.2   20.6   14.4  123.0
## 101   38.1   30.1   33.2   21.6   31.3   14.2   12.3   19.2   15.2  120.2
## 102   42.0   28.0   33.0   18.1   28.4   14.3   11.1   20.2   15.2  114.0
## 103   37.0   27.3   31.1   18.2   25.0   13.2   10.5   18.7   13.4  102.9
## 104   41.6   27.5   32.0   18.1   29.5   13.8   10.7   19.0   13.9  112.5
## 105   40.1   19.4   28.0   17.1   26.8   13.0   10.6   16.9   12.6  104.5
## 106   38.7   25.2   28.8   19.1   25.6   13.0   10.2   17.9   13.5  111.3
## 107   37.4   29.9   33.5   22.3   30.8   14.4   11.5   20.5   16.8  117.2
## 108   41.7   28.0   32.9   19.4   29.7   14.6   11.0   19.5   15.3  112.8
## 109   38.0   27.1   28.3   18.2   25.9   13.8   11.0   18.9   14.8  104.8
```

```
## 110   40.5   24.9   29.7   19.0   30.2   14.4   11.8   19.5   14.9  117.7
## 111   35.6   28.5   29.4   17.7   25.2   14.0   10.8   19.1   15.0  107.7
## 112   43.6   30.2   32.4   21.8   33.1   15.2   11.3   19.8   15.2  125.2
## 113   37.6   24.4   28.3   17.7   24.7   12.9   10.8   18.0   14.3  109.1
## 114   41.1   31.7   34.2   22.8   34.0   13.8   11.8   19.4   15.4  122.6
## 115   42.1   30.6   34.0   22.1   30.6   15.0   11.4   20.2   15.4  117.3
## 116   40.5   28.3   32.4   19.4   27.8   13.4   11.0   19.0   14.5  109.1
## 117   40.9   28.5   31.3   21.1   29.7   14.3   11.7   19.0   15.6  116.7
## 118   43.0   30.6   33.8   23.3   35.3   15.6   12.0   21.6   16.4  124.9
## 119   40.5   27.8   31.1   21.8   30.6   15.0   11.6   20.4   15.2  118.6
## 120   41.9   25.4   30.2   14.4   26.8   12.6    9.8   18.8   13.6  108.8
## 121   42.1   28.5   33.1   20.2   30.6   15.6   12.2   19.7   15.6  121.9
## 122   43.8   29.2   32.6   18.7   30.4   14.6   11.7   20.0   15.2  117.3
## 123   42.1   28.5   31.7   19.4   28.0   14.0   11.3   19.0   14.4  115.0
## 124   43.4   32.0   36.2   23.5   35.6   16.1   12.6   23.0   16.3  134.8
## 125   38.7   26.8   31.5   21.4   27.8   13.8   10.8   18.2   13.3  113.8
## 126   39.6   28.7   32.4   18.2   28.3   15.2   11.8   19.6   14.8  119.4
## 127   43.4   30.6   32.9   21.6   28.3   15.0   12.0   20.5   17.2  117.9
## 128   40.5   29.7   31.7   22.1   32.6   15.2   11.3   21.2   15.2  127.3
## 129   40.3   30.4   34.2   21.1   34.0   13.6   12.0   19.2   13.8  118.8
## 130   44.2   30.6   33.8   22.1   32.4   15.3   11.5   20.9   16.5  122.4
## 131   41.3   26.8   32.2   21.4   31.1   13.6   11.0   19.1   15.0  111.5
## 132   39.8   25.6   31.3   23.5   32.0   14.0   11.2   21.2   16.4  113.2
## 133   41.3   29.0   32.2   25.2   30.8   14.4   11.0   19.7   15.8  115.3
## 134   38.9   27.5   32.9   22.5   33.3   14.6   11.0   20.5   15.3  122.5
## 135   41.1   25.6   29.9   23.3   25.2   14.1   10.7   19.0   15.1  114.4
## 136   41.5   30.6   35.8   21.1   28.0   15.0   11.8   21.0   15.6  112.8
## 137   38.5   27.8   31.7   19.7   26.4   13.1   11.0   18.4   14.8  112.2
## 138   39.4   29.7   33.1   23.0   30.4   14.2   11.6   20.4   15.0  119.4
## 139   40.9   26.1   27.5   20.2   28.0   13.2   10.4   18.6   14.8  108.4
## 140   41.1   23.0   29.4   21.8   30.6   15.0   10.8   19.3   14.5  122.4
## 141   43.6   28.0   32.4   27.5   33.5   14.6   11.7   21.4   15.1  128.8
## 142   39.8   29.0   34.9   22.5   28.3   14.3   11.7   19.8   15.4  118.0
## 143   42.1   27.8   31.7   20.2   28.7   14.3   11.5   19.6   15.6  116.5
## 144   41.1   27.1   33.8   24.9   29.4   14.4   12.4   18.0   15.1  120.4
## 145   44.2   30.4   36.5   21.6   31.5   15.4   11.6   20.4   15.4  123.1
## 146   38.9   26.8   31.5   20.4   29.0   13.6   10.8   18.9   15.2  117.2
## 147   40.1   28.7   32.2   18.0   29.4   15.2   11.8   20.7   15.4  113.0
## 148   38.7   26.8   31.5   18.0   27.8   12.9   10.4   18.0   14.3  109.4
## 149   35.6   26.4   30.8   19.2   29.4   14.6   11.5   19.6   15.3  105.7
## 150   40.5   26.8   30.6   21.4   32.4   15.0   11.8   20.4   15.8  119.7
## 151   41.1   25.4   32.0   21.6   28.7   14.3   12.4   19.6   14.3  118.0
## 152   38.7   26.1   29.2   18.2   24.9   13.6   10.4   17.6   14.2  104.3
## 153   38.9   27.1   30.4   20.4   28.7   14.8   11.7   19.4   14.6  114.1
## 154   39.4   29.7   33.1   22.3   31.5   15.6   12.0   19.5   14.8  119.0
## 155   37.6   27.8   32.2   20.2   31.3   14.6   11.0   21.5   15.8  113.8
## 156   39.8   25.9   31.3   19.4   29.2   14.3   11.2   18.7   14.3  118.0
## 157   40.3   27.3   30.4   20.4   29.0   15.0   11.3   19.1   14.6  116.0
## 158   40.3   25.2   29.2   18.7   28.5   13.2   10.2   18.9   14.3  108.3
## 159   43.8   30.4   34.9   24.0   33.3   15.4   11.6   17.8   14.6  129.2
## 160   41.1   27.8   32.9   18.0   26.8   14.6   11.2   19.5   15.8  109.2
## 161   41.7   30.6   34.7   24.9   32.0   14.9   10.8   18.9   14.1  124.3
## 162   45.4   30.8   35.6   20.9   29.7   15.2   10.8   18.6   15.0  122.6
## 163   43.0   30.8   34.7   22.1   32.2   16.0   13.2   19.5   16.1  122.4
```

```
## 164   41.1  25.4  30.4  19.2  29.9  14.8  10.6  18.7  15.2  114.9
## 165   41.1  29.2  31.5  19.7  29.9  14.8  11.0  18.0  15.0  111.1
## 166   45.2  32.2  36.0  22.5  33.5  15.8  11.3  20.5  14.8  126.0
## 167   39.8  34.7  34.7  23.5  30.2  14.8  10.6  20.6  14.3  115.5
## 168   39.6  28.7  32.0  20.2  32.9  14.3  11.5  19.6  15.1  124.7
## 169   42.3  30.2  34.4  25.4  32.2  15.2  10.7  18.8  14.8  125.3
## 170   40.9  29.0  32.2  20.2  29.2  13.8  10.4  18.4  14.4  118.2
## 171   39.8  28.0  34.2  23.3  31.5  14.0  11.0  19.7  13.8  124.3
## 172   42.3  27.1  31.7  17.3  29.4  14.4  11.6  21.2  15.8  118.3
## 173   42.3  26.8  32.0  25.4  28.7  15.0  11.2  18.4  14.4  122.3
## 174   40.5  28.7  30.4  22.1  29.2  14.3  11.2  18.5  14.5  116.5
## 175   42.7  28.5  36.7  23.7  30.8  15.8  12.9  19.3  16.0  123.0
## 176   43.6  30.8  33.3  20.4  29.7  14.3  10.9  19.6  15.4  117.6
## 177   42.5  31.3  33.1  19.4  32.0  14.8  11.3  20.1  15.5  117.5
## 178   41.3  30.8  33.3  22.5  28.3  13.0  10.5  19.7  13.4  117.3
## 179   41.3  24.7  35.4  22.5  30.2  14.8  11.3  20.4  16.0  114.5
## 180   42.3  26.6  33.3  23.3  28.7  14.2  11.1  19.5  14.3  122.9
## 181   36.9  25.9  31.7  19.9  27.3  14.8  10.6  19.4  14.3  115.5
## 182   40.3  28.5  35.1  19.2  32.0  14.8  12.0  21.2  16.2  116.1
## 183   40.1  26.4  32.0  21.4  32.6  14.8  12.0  20.0  15.2  121.6
## 184   43.2  31.3  34.0  23.0  32.6  15.7  11.5  20.5  15.2  131.6
## 185   45.0  29.0  33.3  25.4  30.8  15.4  11.0  18.8  15.0  124.5
## 186   42.1  29.7  35.6  23.5  31.3  14.3  11.0  18.2  14.8  115.6
## 187   40.9  28.7  33.5  23.7  30.2  15.8  11.6  19.3  16.8  117.0
## 188   41.3  27.3  32.2  20.2  28.3  13.8  11.4  18.0  13.0  108.6
## 189   42.1  29.7  32.9  24.9  30.8  15.3  11.5  19.2  14.6  120.2
## 190   45.2  29.7  33.8  19.9  32.0  15.5  11.8  19.6  16.1  116.2
## 191   42.1  31.1  34.9  22.1  31.3  15.2  11.0  19.0  14.4  115.4
## 192   41.2  29.8  32.2  22.4  29.8  15.6  11.2  19.6  14.8  120.0
## 193   41.7  29.2  33.8  19.2  29.7  13.8  10.7  18.6  14.2  110.3
## 194   43.0  29.4  33.8  24.7  31.5  14.2  11.2  19.4  14.2  119.7
## 195   41.7  28.5  33.8  23.5  32.9  15.6  12.0  18.4  16.3  123.5
## 196   38.0  29.7  34.0  22.8  27.3  13.1  10.8  17.3  15.5  107.8
## 197   41.9  27.8  33.3  19.0  28.7  15.1  11.3  19.2  14.9  118.7
## 198   40.7  28.0  35.3  19.4  31.7  14.4  10.7  18.6  14.4  120.7
## 199   41.3  29.7  34.7  22.8  32.0  15.5  11.2  18.4  15.6  118.7
## 200   40.9  28.7  32.9  21.6  30.6  15.0  11.0  18.7  13.8  118.0
## 201   41.7  26.8  32.0  19.7  27.8  14.0  10.5  18.4  14.6  105.0
## 202   41.3  31.1  34.9  26.4  30.2  15.0  11.6  18.8  15.8  110.6
## 203   41.1  27.8  32.0  21.1  30.6  14.8  11.4  17.6  14.2  123.1
## 204   43.4  27.3  34.7  19.9  31.3  14.0  11.2  20.2  14.3  121.0
## 205   40.7  27.8  34.0  21.1  29.4  15.6  12.0  21.2  16.4  111.7
## 206   42.5  25.2  30.6  20.9  30.4  15.3  11.4  18.9  13.8  111.0
## 207   40.3  28.3  30.6  18.2  29.2  12.9  10.6  20.2  14.2  112.0
## 208   39.8  27.8  32.9  22.3  29.7  16.6  11.8  20.8  15.3  115.9
## 209   39.8  28.3  30.4  19.7  30.2  12.9  11.0  18.6  12.7  121.0
## 210   40.5  29.9  34.9  21.4  32.9  14.5  11.7  20.4  15.0  123.6
## 211   41.1  26.8  32.4  20.2  31.1  14.4  11.8  20.4  15.2  120.0
## 212   42.5  29.4  34.2  23.5  34.7  15.1  11.8  21.8  15.8  128.7
## 213   42.5  29.4  34.4  19.9  34.0  14.5  11.0  21.3  14.4  124.5
## 214   38.5  24.4  30.4  18.0  29.9  14.3  10.1  18.3  13.2  112.4
## 215   43.8  29.2  35.6  19.9  28.3  14.8  12.8  20.7  14.3  112.2
## 216   41.5  29.0  33.3  21.4  32.4  15.3  11.0  20.6  15.0  127.0
## 217   40.3  27.8  33.5  20.6  29.9  15.3  11.2  20.4  13.8  115.3
```

```
## 218   40.3   30.2   32.2   20.6   29.2   14.5   11.5   20.0   16.9  111.5
## 219   42.1   27.1   32.2   20.2   30.6   13.7   10.8   18.9   14.3  118.3
## 220   42.1   31.3   35.1   20.6   31.1   16.7   12.0   21.0   15.1  118.0
## 221   38.9   29.4   33.3   24.2   33.5   14.2   12.8   20.6   15.5  127.0
## 222   44.4   24.0   30.2   20.6   32.0   14.2   11.2   20.2   14.5  124.4
## 223   40.9   24.4   28.7   18.7   29.0   14.3   11.4   17.8   14.6  112.4
## 224   42.1   28.7   33.5   25.2   29.4   14.3   11.5   18.0   13.8  125.8
## 225   43.0   27.1   33.5   25.2   31.5   15.2   11.8   19.3   15.1  131.7
## 226   38.0   27.1   32.2   20.6   28.0   13.9   10.3   19.1   14.0  117.3
## 227   37.1   24.2   30.6   17.7   27.8   13.8   11.0   17.8   14.6  107.6
## 228   41.1   24.0   29.4   21.6   30.8   13.6   11.7   18.8   14.6  122.4
## 229   40.9   24.4   30.6   19.7   29.9   13.8   11.5   19.0   15.1  117.0
## 230   38.9   27.1   31.7   21.6   29.7   15.0   12.2   20.5   15.2  119.0
## 231   40.9   28.3   34.0   23.7   28.5   14.3   12.0   19.0   14.3  123.5
## 232   39.2   26.8   34.0   23.7   30.8   14.2   11.2   19.1   14.5  121.4
## 233   41.7   26.6   31.5   19.9   29.9   14.6   11.2   19.2   14.8  112.3
## 234   39.4   26.6   31.7   24.0   31.1   13.8   11.8   20.0   15.8  113.2
## 235   40.1   26.4   32.0   21.8   30.2   15.8   12.4   20.7   15.8  121.7
## 236   38.9   25.6   32.9   21.1   29.0   15.6   10.6   20.2   14.8  116.6
## 237   38.9   26.4   31.7   21.6   27.8   14.4   11.3   19.6   14.8  117.8
## 238   41.7   26.4   31.1   20.2   28.3   14.6   10.2   18.4   15.3  118.0
## 239   43.2   26.8   32.6   22.1   32.9   15.4   12.0   20.5   16.8  131.1
## 240   40.5   29.2   33.5   23.7   31.1   15.2   11.3   20.0   16.1  121.4
## 241   39.2   23.5   29.9   19.7   29.0   15.4   11.5   19.0   14.8  116.3
## 242   40.9   25.4   32.0   20.6   30.2   16.1   11.5   19.3   15.8  121.8
## 243   41.7   27.3   31.5   21.8   29.7   14.9   11.8   18.9   13.6  118.2
## 244   43.8   32.2   38.0   25.4   32.0   16.0   10.7   21.0   16.8  126.3
## 245   41.9   28.0   33.1   26.4   29.9   15.6   11.5   21.2   15.9  121.0
## 246   43.0   27.8   34.2   21.4   31.5   14.3   11.1   21.0   14.8  123.1
## 247   41.5   28.5   33.5   19.7   29.4   14.5   10.5   19.4   15.3  114.9
##     che.gi wai.gi nav.gi hip.gi thi.gi bic.gi for.gi kne.gi cal.gi ank.gi
## 1     89.5   71.5   74.5   93.5   51.5   32.5   26.0   34.5   36.5   23.5
## 2     97.0   79.0   86.5   94.8   51.5   34.4   28.0   36.5   37.5   24.5
## 3     97.5   83.2   82.9   95.0   57.3   33.4   28.8   37.0   37.3   21.9
## 4     97.0   77.8   78.8   94.0   53.0   31.0   26.2   37.0   34.8   23.0
## 5     97.5   80.0   82.5   98.5   55.4   32.0   28.4   37.7   38.6   24.4
## 6     99.9   82.5   80.1   95.3   57.5   33.0   28.0   36.6   36.1   23.5
## 7    106.9   82.0   84.0  101.0   60.9   42.4   32.3   40.1   40.3   23.6
## 8    102.5   76.8   80.5   98.0   56.0   34.1   28.0   39.2   36.7   22.5
## 9     91.0   68.5   69.0   89.5   50.0   33.0   26.0   35.5   35.0   22.0
## 10    93.5   77.5   81.5   99.8   59.8   36.5   29.2   38.3   38.6   22.2
## 11    97.7   81.9   81.0   98.4   60.5   34.6   27.9   38.9   40.1   23.2
## 12    99.5   82.6   82.5   95.0   58.5   38.5   30.4   39.0   38.4   24.3
## 13   103.0   85.0   94.5  103.0   59.0   33.5   29.0   40.5   40.0   26.0
## 14    99.6   85.6   89.2   98.0   59.1   35.6   29.0   35.8   36.0   21.5
## 15   101.5   78.0   89.5   95.0   57.0   36.0   29.0   34.5   35.0   22.0
## 16   104.1   82.0   84.0   97.0   56.0   34.5   29.5   39.0   35.7   24.0
## 17   100.0   88.3   93.5  105.0   65.8   37.0   28.8   40.9   41.7   24.2
## 18    93.8   73.6   74.9   90.1   54.1   31.2   26.9   36.4   35.6   22.0
## 19    98.5   78.5   86.0   94.5   55.0   34.5   28.5   38.0   36.5   23.0
## 20   104.0   87.3   88.0  101.1   59.5   37.0   30.5   39.8   42.0   26.5
## 21   100.0   92.0   91.0   98.0   57.5   32.0   27.6   37.5   35.2   21.0
## 22   100.0   80.0   83.7   99.5   57.0   37.0   30.0   37.5   35.5   23.0
## 23    99.0   74.5   75.9   92.2   53.4   31.2   26.9   36.2   33.3   23.5
```

```
## 24   101.0   90.6   89.6  101.2   59.5   37.0   28.3   35.4   40.6   22.9
## 25   101.6   81.4   81.6   98.8   61.3   39.4   31.9   38.5   41.2   22.8
## 26   108.8   89.5   89.5  106.0   59.5   37.5   30.1   39.9   41.5   23.5
## 27   100.0   85.0   94.5  105.0   62.0   35.5   28.5   38.0   40.0   23.5
## 28    88.0   73.5   77.7   97.0   56.3   32.5   27.8   39.0   38.2   23.5
## 29    88.7   75.8   83.0   89.0   52.6   31.2   26.5   37.0   37.4   21.5
## 30    84.5   74.0   81.0   93.5   50.5   27.5   24.8   34.0   32.8   21.0
## 31    93.6   77.5   82.1   95.0   56.5   32.8   26.2   37.6   36.3   21.0
## 32   105.0   74.0   72.0   90.0   54.2   34.1   28.6   36.2   36.6   22.4
## 33    90.9   74.0   78.8   96.4   51.8   29.8   27.0   36.4   34.6   22.9
## 34    91.2   82.0   89.5  100.0   57.5   32.8   28.0   40.7   40.1   24.3
## 35    98.4   73.0   83.0   95.4   56.3   36.4   27.5   37.2   34.5   21.8
## 36    85.0   70.5   84.0   90.0   50.0   29.0   26.0   36.0   34.5   21.5
## 37    97.2   75.0   77.2   91.3   49.5   31.0   26.1   36.3   35.1   21.0
## 38    91.5   72.1   79.2   91.0   54.9   29.5   24.5   36.1   37.2   22.9
## 39    91.2   78.8   78.0   93.2   55.8   31.9   27.4   36.4   35.1   23.0
## 40   101.1   77.5   78.0   97.0   55.0   37.7   29.9   38.3   39.6   23.3
## 41   104.3   91.5   93.2  103.9   62.0   36.3   29.0   36.7   39.4   23.1
## 42   110.8   84.9   83.0  102.6   66.4   42.3   30.9   37.0   37.7   22.6
## 43    96.3   79.1   78.3   97.1   60.1   35.5   28.8   36.9   38.2   23.4
## 44   102.7   77.9   77.9   90.7   56.7   35.4   28.3   35.6   35.5   22.9
## 45   103.9   91.7   89.4  101.8   61.0   35.7   29.4   37.7   40.0   22.2
## 46   105.6   86.6   87.3  103.9   63.2   37.8   29.7   39.0   40.2   24.3
## 47    95.8   84.7   84.0  101.4   60.0   35.0   28.5   38.4   37.9   23.2
## 48   111.2   90.3   93.5  108.7   66.9   40.2   32.4   39.2   40.1   25.7
## 49   100.0   79.7   87.1   98.4   61.1   36.3   28.6   34.5   36.1   21.4
## 50    91.6   73.1   75.4   86.5   50.6   30.8   26.1   31.7   33.6   20.3
## 51   108.0   79.8   82.5   94.8   58.3   39.8   29.6   34.2   38.1   21.1
## 52   109.6   81.6   86.5  100.9   61.7   39.5   31.7   38.8   36.5   22.7
## 53   105.7   76.8   83.4   98.0   56.8   37.9   30.9   35.9   38.3   23.4
## 54   109.1   85.9   90.4  100.9   61.3   40.1   30.0   36.8   38.6   21.9
## 55    88.8   73.3   77.9   85.7   46.9   30.5   24.8   31.1   30.5   19.0
## 56    86.1   69.9   67.4   84.1   50.8   31.5   26.6   32.8   36.3   20.0
## 57    91.3   72.7   83.2   91.4   51.2   27.8   26.0   34.8   34.7   21.1
## 58   100.6   82.7   83.5   98.0   55.8   33.1   28.0   37.9   39.1   23.2
## 59   105.5   90.1   89.2  104.5   62.7   36.3   29.6   38.4   42.4   25.3
## 60    97.5   82.9   83.6   95.8   52.6   34.5   27.0   35.2   35.2   21.4
## 61    94.4   77.9   79.0   91.7   57.1   31.2   27.5   36.6   37.5   21.6
## 62    99.6   92.5   96.2  103.4   58.5   34.5   28.4   38.4   38.0   22.4
## 63    98.1   77.8   77.2   90.0   52.4   33.2   26.4   34.2   36.0   21.8
## 64    93.6   72.7   77.3   91.7   51.9   32.1   27.4   33.5   33.8   21.1
## 65    93.4   75.0   79.2   94.0   53.8   34.2   27.9   36.1   36.2   22.0
## 66    92.0   76.0   83.0   93.0   54.5   29.5   26.0   37.0   34.5   22.8
## 67    99.2   82.7   84.2   93.0   56.6   32.4   27.6   35.8   36.3   21.8
## 68    97.6   80.0   85.7   97.4   57.8   33.8   28.6   36.2   37.4   22.0
## 69   108.8  107.1  107.2  108.3   67.0   39.6   30.6   40.0   39.6   24.6
## 70    91.9   76.2   78.1   90.0   52.0   30.7   25.8   34.8   32.6   21.0
## 71   105.2   90.2   88.6  100.2   60.8   35.7   29.4   39.2   39.1   24.5
## 72    98.3   89.4   87.4   97.7   54.8   31.0   26.0   36.4   35.6   21.6
## 73    92.5   80.9   78.5   96.0   59.0   31.5   26.3   36.1   39.0   21.2
## 74    92.5   73.5   76.4   92.0   53.1   30.6   27.1   36.0   36.0   23.8
## 75   101.6   70.9   76.7   95.3   56.0   36.0   28.6   36.0   34.0   22.0
## 76    94.6   76.1   78.0   86.3   52.4   28.6   23.9   34.5   37.9   22.7
## 77    92.5   81.0   85.2   92.5   54.7   32.3   26.8   35.8   37.6   21.1
```

```
## 78    88.2  72.0  72.0  85.5  50.2  28.6  24.8  34.9  35.1  20.1
## 79    91.0  76.8  80.0  94.5  54.6  33.2  28.0  37.5  35.6  22.1
## 80   106.0  86.0  92.0 103.0  60.6  34.0  29.8  38.8  39.5  23.6
## 81   115.0  98.5 106.6 116.5  67.8  35.8  27.2  38.0  41.2  23.3
## 82   100.0  79.0  82.5  98.5  62.1  34.0  28.8  39.6  40.8  25.9
## 83    94.7  77.5  80.5  92.0  54.2  30.9  26.6  36.5  35.8  21.3
## 84    92.5  75.2  80.2  91.6  49.6  29.2  26.1  36.2  35.7  22.1
## 85    96.7  82.0  82.2  92.7  54.6  32.0  27.1  35.6  36.4  20.7
## 86    97.4  79.6  80.8  95.0  54.2  32.6  27.4  36.5  38.0  21.6
## 87   106.7  75.2  77.8  94.5  57.4  36.7  29.9  38.1  36.0  22.6
## 88   106.2  88.6  88.3 100.5  63.4  36.9  29.4  38.4  38.6  23.1
## 89   103.6  81.5  83.3  91.8  55.0  33.0  27.8  35.4  36.5  21.9
## 90    98.3  79.9  82.4  87.5  54.4  33.5  27.3  36.8  37.9  22.3
## 91    87.8  73.5  77.5  94.9  53.5  34.3  28.5  36.5  35.2  22.0
## 92    99.8  80.3  80.8  93.0  55.4  33.3  28.0  36.0  37.8  20.3
## 93   104.6  81.5  85.0  92.0  54.1  33.0  28.0  35.1  35.2  21.1
## 94    86.5  74.0  76.5  91.3  53.5  30.5  26.1  36.6  38.6  21.2
## 95   110.0 104.0  99.0 111.7  63.2  37.5  29.0  41.2  39.3  24.6
## 96    93.2  76.2  83.8  92.8  55.2  31.2  26.2  36.8  37.7  22.7
## 97    90.0  76.5  77.7  91.2  54.2  33.1  27.2  35.5  35.3  21.5
## 98    98.4  81.0  80.5  96.2  56.0  32.0  27.4  37.0  35.5  24.0
## 99   107.2  88.8  86.8 100.0  61.0  34.6  27.9  38.0  39.4  23.2
## 100  108.3  94.0  98.0 108.2  66.8  35.6  27.3  39.5  43.0  25.3
## 101  105.7  83.4  86.5 101.1  61.3  34.7  29.4  39.4  41.8  24.0
## 102   88.5  77.0  79.0  93.0  51.7  33.5  27.9  38.4  38.5  22.5
## 103   79.3  75.4  78.0  88.6  50.0  25.6  22.7  33.8  32.5  21.2
## 104   90.9  80.3  80.8  92.8  53.9  32.5  28.0  36.5  35.0  21.0
## 105   90.2  68.0  67.0  81.5  49.5  27.0  23.6  34.0  34.5  20.9
## 106   91.6  80.6  78.0  91.3  55.0  30.7  25.3  35.5  34.0  20.8
## 107  105.2  88.6  94.7  94.7  58.3  36.9  28.8  40.3  39.7  26.3
## 108   97.0  81.1  88.2  93.9  53.5  33.7  28.6  35.0  37.3  23.1
## 109   85.3  70.8  84.9  89.4  55.8  28.7  25.5  38.5  34.2  21.3
## 110   99.6  73.3  82.1  89.3  55.4  36.3  32.5  34.3  34.3  22.3
## 111   94.3  75.9  79.1  92.6  54.4  33.2  27.9  34.8  35.5  23.0
## 112  111.8  86.2  93.5  96.3  59.1  36.3  28.0  38.3  34.7  23.0
## 113   94.3  75.0  82.2  88.0  53.8  36.3  28.9  34.5  33.5  23.0
## 114  106.1 101.0  99.7 105.5  60.2  38.6  30.3  39.5  39.4  25.6
## 115  102.0  90.0  92.3 102.3  60.0  34.6  29.7  38.2  38.3  23.7
## 116   94.8  75.0  79.6  91.6  49.4  30.0  26.5  31.7  30.2  16.4
## 117  102.9  75.9  77.0  93.4  55.0  35.2  28.7  37.0  37.7  24.5
## 118  115.8  96.0  95.9 103.6  62.2  38.2  30.1  41.2  39.4  25.1
## 119  105.4  84.0  90.4  94.8  57.6  38.7  30.2  38.6  38.2  22.8
## 120   87.1  67.1  80.4  85.9  46.8  30.3  25.4  32.7  32.1  20.0
## 121  104.1  82.5  90.1  98.4  57.7  37.9  31.6  37.8  38.3  24.6
## 122   95.8  83.7  84.2  98.4  56.2  33.7  28.0  38.0  39.6  25.8
## 123   98.6  76.7  85.8  93.3  56.0  35.7  27.6  34.7  34.6  20.6
## 124  118.7 105.2 105.0 115.5  69.9  39.4  32.1  42.2  47.7  27.0
## 125  100.9  90.6  93.3  97.7  58.0  34.8  28.0  34.1  35.8  22.2
## 126   98.5  85.7  92.9  98.6  55.5  35.3  28.7  39.3  35.9  23.0
## 127   96.9  82.5  90.8  94.9  54.4  32.8  28.7  39.2  37.0  27.5
## 128  110.7  94.7  92.0 101.3  60.1  37.2  30.9  40.5  40.0  24.2
## 129  108.0 105.2 103.4 108.1  60.5  38.0  30.2  36.9  37.7  21.6
## 130  109.0  86.0  90.2  98.0  59.5  40.0  31.2  38.3  39.0  25.8
## 131  104.2  90.9  92.7 100.2  51.8  30.1  26.8  38.1  36.4  23.2
```

```
## 132  100.5   92.4   92.4   97.0   50.9   32.9   29.0   37.7   37.7   23.4
## 133  105.7   96.5   98.2   97.4   54.3   31.9   28.5   37.7   39.3   24.5
## 134  112.4   98.4  101.5  107.9   67.4   39.2   30.5   42.6   40.7   25.3
## 135   96.2   76.7   83.5   93.9   50.4   32.1   27.7   36.1   32.9   23.2
## 136   97.5   94.8   98.2   98.6   48.3   31.1   27.0   37.7   36.8   24.6
## 137   90.9   80.1   79.8   91.3   56.2   32.9   27.2   36.2   33.0   23.0
## 138  108.4   97.4  103.7  105.3   55.6   36.6   28.4   38.2   36.6   22.9
## 139   94.3   73.7   74.5   88.2   52.3   29.6   26.2   35.2   36.2   21.2
## 140  109.1   76.1   90.1   93.3   51.7   37.0   30.6   36.8   37.7   23.6
## 141  115.0   95.6  101.9  107.9   64.6   37.1   30.0   41.8   39.6   24.7
## 142  104.4  101.0   98.9  103.3   54.4   38.1   29.8   39.7   41.8   25.0
## 143  100.1   84.5   84.5   94.4   54.7   33.9   28.6   38.5   37.6   25.0
## 144  108.4   98.0  101.8  101.5   56.9   38.2   29.9   37.7   39.2   24.9
## 145  107.3  101.6  103.8  110.0   57.8   34.9   28.9   40.3   40.0   23.7
## 146  101.8   87.8   90.2   98.4   55.6   33.1   28.4   38.2   37.7   24.5
## 147   94.5   80.0   85.0   95.0   52.0   31.5   26.5   36.9   36.4   22.9
## 148   91.7   81.8   82.9   98.3   56.3   31.0   25.7   35.0   33.0   22.0
## 149   95.9   84.4   86.8   99.0   55.0   30.5   26.4   36.1   38.4   21.3
## 150  110.5   85.0   83.5   95.7   59.0   39.2   29.9   37.9   37.7   23.8
## 151  104.0   90.0   86.0   96.0   52.5   33.5   29.1   36.0   36.9   23.0
## 152   86.8   72.9   73.4   89.5   51.0   29.8   24.8   32.6   33.1   22.1
## 153  106.7   81.0   80.2   93.7   54.8   35.5   30.6   36.9   37.3   22.7
## 154  102.5   86.5   89.0   97.0   57.0   34.0   28.4   38.0   37.0   22.5
## 155  103.0   93.9   98.6  103.6   60.5   34.4   28.5   40.9   40.8   24.6
## 156   95.0   77.0   78.0   93.0   52.0   32.6   28.4   34.4   34.4   20.0
## 157   99.0   75.0   75.0   90.0   50.6   32.0   27.3   33.8   34.0   22.0
## 158   89.7   80.6   80.8   90.0   55.5   28.9   25.0   34.6   37.4   23.0
## 159  111.5  100.5  107.3  109.5   61.8   37.4   31.6   41.0   39.7   25.4
## 160   94.1   81.2   84.0   91.6   51.5   33.0   27.0   35.2   35.5   23.1
## 161  118.3  103.4  106.2  108.5   60.5   35.4   29.7   42.3   40.8   24.8
## 162  106.5   90.3  101.1  101.6   57.2   35.4   28.6   40.4   37.8   24.9
## 163  110.4   98.0   98.0   99.6   56.7   36.4   29.2   40.9   42.1   26.1
## 164  102.3   86.5   87.7   91.9   55.0   35.0   28.9   38.3   37.8   24.0
## 165   98.5   77.9   87.3   90.8   50.8   35.0   28.4   35.5   35.0   21.0
## 166  111.6   89.1   95.1  104.8   62.7   37.9   31.2   41.1   41.2   27.7
## 167  106.7   93.9  111.8  111.4   62.8   36.2   29.7   42.8   39.3   23.5
## 168  110.4   85.3   82.9   96.5   57.0   39.0   29.8   36.8   36.0   21.6
## 169  114.0   98.5  103.8  108.1   61.3   37.2   31.4   41.9   42.1   26.4
## 170  101.8   79.5   90.1   95.3   54.8   34.2   28.5   36.6   36.2   22.8
## 171  109.6   94.9   94.7  104.3   59.0   35.9   27.8   37.7   36.8   23.2
## 172  100.7   76.5   87.2   96.3   54.2   33.8   27.7   36.4   38.2   23.8
## 173  104.3   88.4   89.6   98.8   54.8   35.5   29.7   37.7   37.0   23.7
## 174  104.2   84.2   84.0   93.2   55.0   33.0   25.4   35.6   36.4   22.8
## 175  107.4   87.6   89.4  106.7   60.9   38.3   31.2   39.0   42.6   25.8
## 176  101.0   83.7   91.1   99.9   56.8   33.5   27.7   38.7   41.8   29.3
## 177  103.0   92.1   91.3  103.8   56.6   33.3   27.7   37.1   37.4   22.6
## 178  107.2   89.9   94.7  107.1   59.2   35.3   26.9   36.6   32.3   22.0
## 179   99.0   88.7   91.0  100.0   57.5   34.0   28.3   40.9   38.8   26.4
## 180  100.3   83.9   89.4  103.9   59.8   36.1   29.4   37.0   36.5   24.3
## 181  100.2   79.5   88.7   95.3   52.5   34.6   25.8   35.6   35.1   21.8
## 182   99.8   84.5   92.6   99.5   59.2   34.3   29.0   36.5   38.5   24.5
## 183  107.5   89.2   88.4  107.0   56.9   35.6   28.5   37.0   37.6   23.0
## 184  110.1   90.7   91.9  101.7   58.0   36.8   29.0   36.9   38.9   24.2
## 185  107.0   88.8   97.5  103.8   61.0   36.7   28.6   38.4   39.5   24.4
```

```
## 186  105.6  103.6  100.7  100.6   55.3   33.6   26.9   37.8   37.9   23.9
## 187  103.6   98.5   99.9  103.6   57.5   33.7   29.0   38.7   36.7   24.3
## 188   97.1   82.9   88.1   91.2   51.7   30.7   25.7   33.9   33.4   21.2
## 189  109.8   90.5   92.3   95.2   52.4   35.8   28.7   32.5   36.5   23.7
## 190  103.3   84.5   94.5   98.2   53.7   32.5   27.8   36.0   36.3   22.0
## 191  103.7   86.0   93.8   97.1   53.1   33.9   27.3   35.7   36.6   22.6
## 192  108.5   84.2   88.9   97.5   58.8   36.6   29.9   34.2   34.8   22.0
## 193   97.8   85.7   89.5   94.9   51.7   32.2   26.4   34.4   32.6   22.0
## 194  112.7  112.1  105.9  106.3   56.9   35.7   27.8   37.3   36.6   22.7
## 195  111.4   99.7  102.9  105.8   57.8   36.5   30.5   39.0   41.2   25.7
## 196   95.1   84.7   92.9   96.7   54.6   32.8   25.3   36.6   35.0   23.5
## 197  100.2   80.3   92.4   96.4   53.8   35.7   29.2   38.4   37.0   25.6
## 198  106.3   98.6  111.7  118.7   70.0   37.1   27.8   37.5   39.2   25.7
## 199  109.5   90.0   96.2  104.3   63.5   39.4   29.9   37.4   37.3   24.3
## 200  106.3   86.6   93.9   95.9   53.6   34.4   28.6   35.0   34.1   21.7
## 201   91.5   80.2   85.7   89.2   48.5   28.7   25.0   35.4   32.3   23.0
## 202  104.9  109.2  104.4  101.7   56.4   34.0   29.2   39.3   38.5   24.3
## 203  109.6   88.4   92.0   95.1   52.5   39.4   29.8   34.5   34.0   22.0
## 204  102.5   81.0   84.5  105.0   56.0   31.5   26.5   38.5   36.9   21.3
## 205  101.2   88.8   90.8  101.3   62.5   35.2   28.9   40.6   39.2   23.0
## 206   98.7   78.1   78.6   92.0   56.5   35.7   29.2   36.4   37.0   22.0
## 207   96.0   81.5   80.5   89.5   52.0   30.3   25.0   36.0   35.0   22.4
## 208  104.2   87.6   89.6  100.5   60.7   36.5   31.1   40.7   38.4   22.9
## 209  103.0   92.5   88.5   94.0   55.0   36.0   28.0   36.5   37.0   21.8
## 210  107.0   97.0   95.5  104.5   56.6   34.4   28.9   40.0   38.5   24.0
## 211  101.0   82.0   82.0   98.0   59.0   35.4   29.0   38.0   42.0   23.6
## 212  112.1   99.5   97.8  107.4   60.5   35.5   28.8   42.9   38.7   25.7
## 213  103.4   93.8   92.7  112.2   66.2   34.8   30.1   45.7   43.6   26.9
## 214  100.3   79.1   80.4   94.3   51.0   32.6   27.2   36.1   32.7   22.5
## 215   95.7   85.8   94.7  106.8   60.6   33.6   27.3   37.5   41.8   26.2
## 216  108.0   90.8   92.4  100.3   56.5   36.8   29.3   37.5   36.3   23.4
## 217  101.0   85.4   86.9  101.8   57.0   34.0   27.1   39.4   37.1   23.7
## 218   98.6   91.6  102.1  106.7   57.8   32.3   27.9   41.8   41.5   27.7
## 219  101.6   79.7   82.0   98.4   58.1   36.5   31.0   38.0   38.1   25.3
## 220   99.0   86.1   90.8  101.3   56.0   33.5   28.3   37.7   38.3   25.2
## 221  116.7  113.2  102.9  107.9   57.7   37.4   28.9   37.8   37.4   24.1
## 222  105.0   79.5   85.8   92.7   51.8   36.2   27.0   33.9   28.9   20.3
## 223   95.1   85.4   84.1   94.3   52.7   31.2   25.9   37.4   34.4   24.5
## 224  106.7   97.9   94.7  104.6   60.8   36.2   28.7   37.7   39.4   22.6
## 225  116.6   94.7   93.1  103.3   58.0   42.3   31.9   39.9   39.6   25.5
## 226  103.5   86.1   90.5   96.7   55.2   34.5   27.7   37.3   34.8   22.5
## 227   90.4   84.9   83.7   97.9   51.8   28.0   25.2   37.5   36.0   21.3
## 228  107.5   92.2   88.6   97.5   53.7   34.3   27.6   36.0   37.5   23.3
## 229  100.8   83.7   82.5   97.7   53.3   32.5   27.1   35.4   37.0   22.7
## 230  104.2   97.8   93.6  102.5   58.0   35.8   29.4   39.0   38.1   23.0
## 231  104.9   98.6   99.2  103.3   55.3   35.0   29.3   35.9   36.0   23.5
## 232  112.8   89.5   96.9  100.9   54.9   38.5   28.7   35.9   33.6   22.1
## 233   95.7   82.9   89.6   94.8   51.9   32.2   25.3   33.4   32.8   21.4
## 234  104.9   90.1   90.8   96.6   55.0   32.9   26.5   35.6   37.9   22.5
## 235  109.1   78.9   91.0   98.1   55.7   38.5   30.1   37.2   36.8   23.4
## 236  105.4   80.7   87.4   95.5   56.8   38.3   28.6   35.0   34.3   23.3
## 237  104.3   94.3   99.4  100.4   59.1   35.0   26.7   35.5   35.9   22.6
## 238  100.5   70.2   79.3   92.0   51.7   32.1   26.7   33.2   34.9   23.7
## 239  111.8   83.6   92.7  101.5   59.5   40.4   31.7   36.7   38.3   25.5
```

```
## 240  109.5   91.9   96.5  103.3   57.7   36.5   29.1   34.6   38.8   25.1
## 241  101.2   71.8   82.3   87.6   50.1   34.2   29.2   34.1   33.4   23.1
## 242  103.3   85.0   90.8   97.9   55.2   35.2   29.4   34.9   37.3   23.5
## 243  101.6   85.7   91.0   95.9   50.9   34.0   28.4   35.0   34.3   21.1
## 244  103.1   96.5   99.0  111.8   62.3   34.8   27.5   41.7   37.0   24.3
## 245  104.6   82.4   85.7   99.9   63.3   38.6   32.0   38.4   39.8   25.4
## 246  104.3   86.3   87.8  103.3   59.7   36.4   30.4   39.3   42.0   27.7
## 247   95.9   83.2   88.0  100.6   57.8   34.0   28.2   36.3   39.6   25.2
##     wri.gi age   wgt   hgt sex
## 1     16.5  21  65.6 174.0   1
## 2     17.0  23  71.8 175.3   1
## 3     16.9  28  80.7 193.5   1
## 4     16.6  23  72.6 186.5   1
## 5     18.0  22  78.8 187.2   1
## 6     16.9  21  74.8 181.5   1
## 7     18.8  26  86.4 184.0   1
## 8     18.0  27  78.4 184.5   1
## 9     16.5  23  62.0 175.0   1
## 10    16.9  21  81.6 184.0   1
## 11    16.2  23  76.6 180.0   1
## 12    18.2  22  83.6 177.8   1
## 13    18.0  20  90.0 192.0   1
## 14    16.6  26  74.6 176.0   1
## 15    16.5  23  71.0 174.0   1
## 16    17.5  22  79.6 184.0   1
## 17    17.8  30  93.8 192.7   1
## 18    17.1  22  70.0 171.5   1
## 19    18.5  29  72.4 173.0   1
## 20    18.8  22  85.9 176.0   1
## 21    17.3  22  78.8 176.0   1
## 22    18.0  20  77.8 180.5   1
## 23    16.0  22  66.2 172.7   1
## 24    17.0  24  86.4 176.0   1
## 25    18.2  26  81.8 173.5   1
## 26    19.0  24  89.6 178.0   1
## 27    16.7  21  82.8 180.3   1
## 28    17.8  24  76.4 180.3   1
## 29    16.5  23  63.2 164.5   1
## 30    15.6  19  60.9 173.0   1
## 31    16.6  23  74.8 183.5   1
## 32    17.2  25  70.0 175.5   1
## 33    17.0  23  72.4 188.0   1
## 34    17.2  23  84.1 189.2   1
## 35    16.9  23  69.1 172.8   1
## 36    17.0  20  59.5 170.0   1
## 37    17.0  22  67.2 182.0   1
## 38    16.0  24  61.3 170.0   1
## 39    16.8  22  68.6 177.8   1
## 40    18.7  24  80.1 184.2   1
## 41    17.6  21  87.8 186.7   1
## 42    17.5  23  84.7 171.4   1
## 43    16.7  24  73.4 172.7   1
## 44    17.0  35  72.1 175.3   1
## 45    17.9  29  82.6 180.3   1
```

```
## 46     18.9  25  88.7 182.9   1
## 47     16.8  23  84.1 188.0   1
## 48     17.7  20  94.1 177.2   1
## 49     16.3  25  74.9 172.1   1
## 50     15.8  29  59.1 167.0   1
## 51     16.9  23  75.6 169.5   1
## 52     17.9  23  86.2 174.0   1
## 53     17.3  36  75.3 172.7   1
## 54     16.4  25  87.1 182.2   1
## 55     15.0  24  55.2 164.1   1
## 56     15.8  20  57.0 163.0   1
## 57     15.3  52  61.4 171.5   1
## 58     17.7  50  76.8 184.2   1
## 59     17.5  46  86.8 174.0   1
## 60     16.5  51  72.2 174.0   1
## 61     16.1  28  71.6 177.0   1
## 62     17.2  48  84.8 186.0   1
## 63     17.5  35  68.2 167.0   1
## 64     16.9  23  66.1 171.8   1
## 65     17.5  23  72.0 182.0   1
## 66     17.4  62  64.6 167.0   1
## 67     16.7  21  74.8 177.8   1
## 68     17.2  26  70.0 164.5   1
## 69     17.7  33 101.6 192.0   1
## 70     16.1  36  63.2 175.5   1
## 71     17.9  41  79.1 171.2   1
## 72     16.6  40  78.9 181.6   1
## 73     15.6  27  67.7 167.4   1
## 74     17.5  27  66.0 181.1   1
## 75     17.0  23  68.2 177.0   1
## 76     15.8  31  63.9 174.5   1
## 77     15.8  26  72.0 177.5   1
## 78     15.4  23  56.8 170.5   1
## 79     16.3  24  74.5 182.4   1
## 80     18.0  24  90.9 197.1   1
## 81     16.0  34  93.0 180.1   1
## 82     18.0  21  80.9 175.5   1
## 83     16.5  25  72.7 180.6   1
## 84     16.7  34  68.0 184.4   1
## 85     16.2  31  70.9 175.5   1
## 86     16.6  40  72.5 180.6   1
## 87     17.3  21  72.5 177.0   1
## 88     17.3  33  83.4 177.1   1
## 89     16.4  25  75.5 181.6   1
## 90     16.6  29  73.0 176.5   1
## 91     17.0  27  70.2 175.0   1
## 92     16.5  44  73.4 174.0   1
## 93     16.3  26  70.5 165.1   1
## 94     16.0  22  68.9 177.0   1
## 95     18.6  37 102.3 192.0   1
## 96     16.2  38  68.4 176.5   1
## 97     16.2  20  65.9 169.4   1
## 98     16.5  21  75.7 182.1   1
## 99     17.0  24  84.5 179.8   1
```

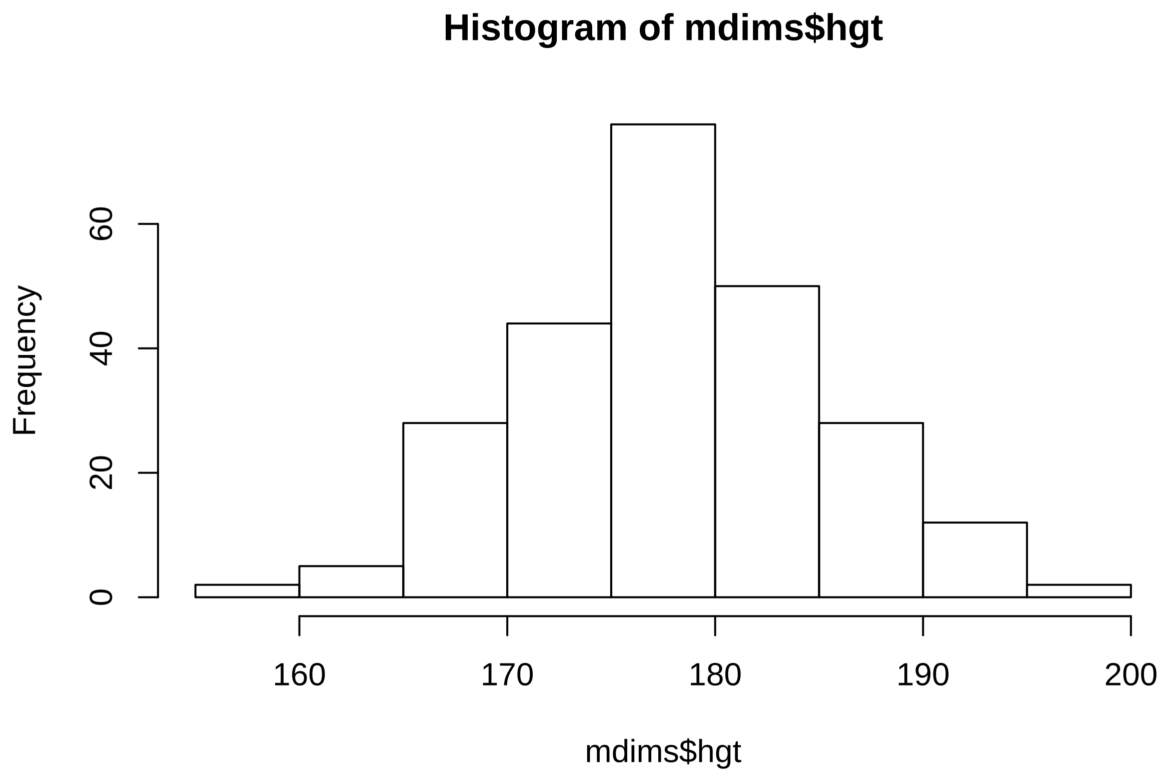
```
## 100   17.7  45  87.7 175.3   1
## 101   17.8  25  86.4 184.9   1
## 102   17.5  22  73.2 177.3   1
## 103   14.6  29  53.9 167.4   1
## 104   16.4  37  72.0 178.1   1
## 105   16.0  20  55.5 168.9   1
## 106   16.4  20  58.4 157.2   1
## 107   18.1  32  83.2 180.3   1
## 108   16.7  23  72.7 170.2   1
## 109   15.6  25  64.1 177.8   1
## 110   18.4  27  72.3 172.7   1
## 111   16.3  21  65.0 165.1   1
## 112   16.1  27  86.4 186.7   1
## 113   17.1  25  65.0 165.1   1
## 114   18.3  38  88.6 174.0   1
## 115   18.0  44  84.1 175.3   1
## 116   16.1  27  66.8 185.4   1
## 117   17.3  37  75.5 177.8   1
## 118   17.7  28  93.2 180.3   1
## 119   18.2  33  82.7 180.3   1
## 120   15.3  25  58.0 177.8   1
## 121   18.1  21  79.5 177.8   1
## 122   17.6  30  78.6 177.8   1
## 123   16.0  26  71.8 177.8   1
## 124   19.2  27 116.4 177.8   1
## 125   16.3  33  72.2 163.8   1
## 126   17.4  29  83.6 188.0   1
## 127   17.9  27  85.5 198.1   1
## 128   17.6  34  90.9 175.3   1
## 129   18.3  42  85.9 166.4   1
## 130   19.5  29  89.1 190.5   1
## 131   16.3  41  75.0 166.4   1
## 132   17.0  43  77.7 177.8   1
## 133   17.1  43  86.4 179.7   1
## 134   17.5  29  90.9 172.7   1
## 135   17.0  27  73.6 190.5   1
## 136   18.4  62  76.4 185.4   1
## 137   16.8  33  69.1 168.9   1
## 138   18.1  45  84.5 167.6   1
## 139   16.2  30  64.5 175.3   1
## 140   18.5  20  69.1 170.2   1
## 141   18.2  22 108.6 190.5   1
## 142   19.6  51  86.4 177.8   1
## 143   17.7  34  80.9 190.5   1
## 144   17.6  44  87.7 177.8   1
## 145   18.1  46  94.5 184.2   1
## 146   17.1  34  80.2 176.5   1
## 147   17.0  32  72.0 177.8   1
## 148   15.5  28  71.4 180.3   1
## 149   16.4  31  72.7 171.4   1
## 150   17.1  29  84.1 172.7   1
## 151   18.0  42  76.8 172.7   1
## 152   16.3  29  63.6 177.8   1
## 153   16.8  31  80.9 177.8   1
```

```
## 154   17.4  30  80.9 182.9   1
## 155   17.1  27  85.5 170.2   1
## 156   16.5  25  68.6 167.6   1
## 157   17.0  24  67.7 175.3   1
## 158   16.4  33  66.4 165.1   1
## 159   18.4  45 102.3 185.4   1
## 160   16.3  37  70.5 181.6   1
## 161   17.1  44  95.9 172.7   1
## 162   17.9  34  84.1 190.5   1
## 163   19.5  55  87.3 179.1   1
## 164   17.3  43  71.8 175.3   1
## 165   16.6  24  65.9 170.2   1
## 166   18.1  22  95.9 193.0   1
## 167   16.8  38  91.4 171.4   1
## 168   17.3  24  81.8 177.8   1
## 169   17.9  29  96.8 177.8   1
## 170   17.3  25  69.1 167.6   1
## 171   16.5  37  82.7 167.6   1
## 172   18.2  30  75.5 180.3   1
## 173   18.3  26  79.5 182.9   1
## 174   15.9  35  73.6 176.5   1
## 175   18.8  29  91.8 186.7   1
## 176   18.0  30  84.1 188.0   1
## 177   17.1  37  85.9 188.0   1
## 178   17.1  34  81.8 177.8   1
## 179   18.1  28  82.5 174.0   1
## 180   18.7  27  80.5 177.8   1
## 181   16.3  32  70.0 171.4   1
## 182   17.3  28  81.8 185.4   1
## 183   17.5  22  84.1 185.4   1
## 184   17.9  44  90.5 188.0   1
## 185   16.8  25  91.4 188.0   1
## 186   17.1  49  89.1 182.9   1
## 187   17.7  54  85.0 176.5   1
## 188   16.7  49  69.1 175.3   1
## 189   17.5  60  73.6 175.3   1
## 190   17.7  42  80.5 188.0   1
## 191   17.5  52  82.7 188.0   1
## 192   18.1  23  86.4 175.3   1
## 193   16.4  33  67.7 170.5   1
## 194   16.4  46  92.7 179.1   1
## 195   18.8  43  93.6 177.8   1
## 196   17.1  56  70.9 175.3   1
## 197   17.9  21  75.0 182.9   1
## 198   15.9  18  93.2 170.8   1
## 199   17.2  21  93.2 188.0   1
## 200   17.1  45  77.7 180.3   1
## 201   16.2  22  61.4 177.8   1
## 202   17.4  55  94.1 185.4   1
## 203   17.0  42  75.0 168.9   1
## 204   16.6  29  83.6 185.4   1
## 205   17.5  40  85.5 180.3   1
## 206   17.2  24  73.9 174.0   1
## 207   16.7  62  66.8 167.6   1
```

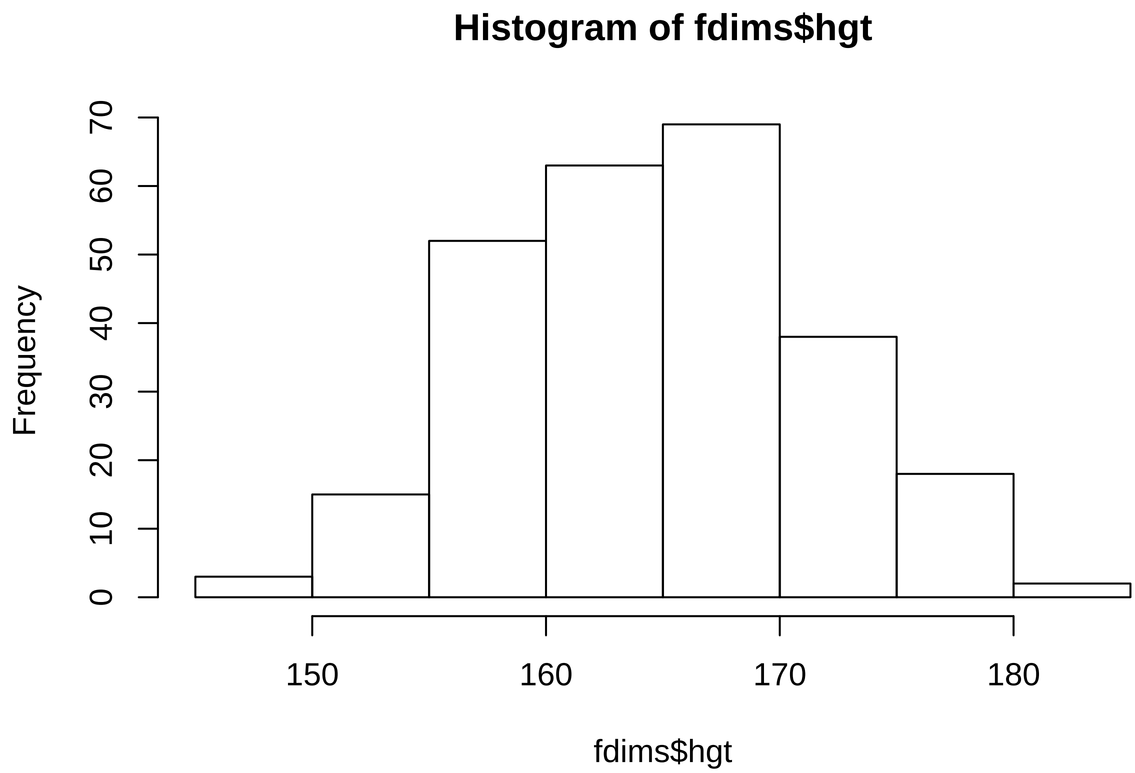
```
## 208   17.9  26  87.3 182.9   1
## 209   17.5  35  72.3 160.0   1
## 210   17.0  37  88.6 180.3   1
## 211   17.5  34  75.5 167.6   1
## 212   17.1  25 101.4 186.7   1
## 213   17.0  30  91.1 175.3   1
## 214   17.9  32  67.3 175.3   1
## 215   17.8  27  77.7 175.9   1
## 216   16.7  42  81.8 175.3   1
## 217   16.6  44  75.5 179.1   1
## 218   18.1  46  84.5 181.6   1
## 219   17.7  19  76.6 177.8   1
## 220   17.4  43  85.0 182.9   1
## 221   17.1  28 102.5 177.8   1
## 222   15.8  39  77.3 184.2   1
## 223   17.1  30  71.8 179.1   1
## 224   17.5  36  87.9 176.5   1
## 225   18.9  48  94.3 188.0   1
## 226   16.4  48  70.9 174.0   1
## 227   15.1  53  64.5 167.6   1
## 228   16.7  45  77.3 170.2   1
## 229   16.6  39  72.3 167.6   1
## 230   17.0  43  87.3 188.0   1
## 231   18.1  65  80.0 174.0   1
## 232   17.1  45  82.3 176.5   1
## 233   16.3  37  73.6 180.3   1
## 234   17.8  55  74.1 167.6   1
## 235   19.6  33  85.9 188.0   1
## 236   17.3  25  73.2 180.3   1
## 237   17.3  35  76.3 167.6   1
## 238   18.4  28  65.9 183.0   1
## 239   19.4  26  90.9 183.0   1
## 240   18.9  43  89.1 179.1   1
## 241   18.3  30  62.3 170.2   1
## 242   17.3  26  82.7 177.8   1
## 243   16.3  51  79.1 179.1   1
## 244   16.7  30  98.2 190.5   1
## 245   18.1  24  84.1 177.8   1
## 246   18.4  35  83.2 180.3   1
## 247   17.0  37  83.2 180.3   1
```

1. Make a histogram of men's heights and a histogram of women's heights. How would you compare the various aspects of the two distributions?

```r
hist(mdims$hgt)
```




```
hist(fdims$hgt)
```




```
fivenum(mdims$hgt)
```

```
## [1] 157.20 172.90 177.80 182.65 198.10
```

```
fivenum(fdims$hgt)
```

```
## [1] 147.2 160.0 164.5 169.5 182.9
```

```
#The Tukey five-number summary shows the median, range and inter-quartile range for the men's and women
```

The normal distribution

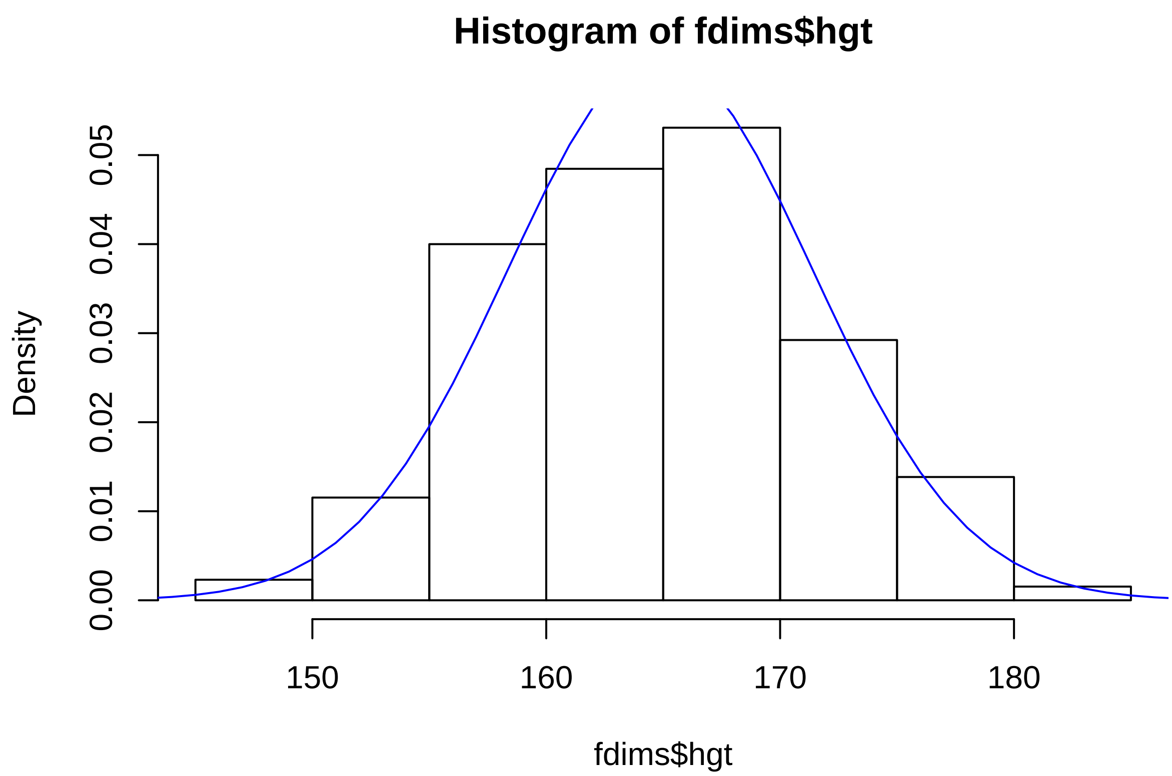
In your description of the distributions, did you use words like *bell-shaped* or *normal*? It's tempting to say so when faced with a unimodal symmetric distribution.

To see how accurate that description is, we can plot a normal distribution curve on top of a histogram to see how closely the data follow a normal distribution. This normal curve should have the same mean and standard deviation as the data. We'll be working with women's heights, so let's store them as a separate object and then calculate some statistics that will be referenced later.

```
fhgtmean <- mean(fdims$hgt)
fhgtsd   <- sd(fdims$hgt)
```

Next we make a density histogram to use as the backdrop and use the `lines` function to overlay a normal probability curve. The difference between a frequency histogram and a density histogram is that while in a frequency histogram the *heights* of the bars add up to the total number of observations, in a density histogram the *areas* of the bars add up to 1. The area of each bar can be calculated as simply the height *times* the width of the bar. Using a density histogram allows us to properly overlay a normal distribution curve over the histogram since the curve is a normal probability density function.Frequency and density histograms both display the same exact shape; they only differ in their y-axis. You can verify this by comparing the frequency histogram you constructed earlier and the density histogram created by the commands below.

```
hist(fdims$hgt, probability = TRUE)
x <- 140:190
y <- dnorm(x = x, mean = fhgtmean, sd = fhgtsd)
lines(x = x, y = y, col = "blue")
```



After plotting the density histogram with the first command, we create the x- and y-coordinates for the normal curve. We chose the `x` range as 140 to 190 in order to span the entire range of `fheight`. To create `y`, we use `dnorm` to calculate the density of each of those x-values in a distribution that is normal with mean `fhgtmean` and standard deviation `fhgtsd`. The final command draws a curve on the existing plot (the density histogram) by connecting each of the points specified by `x` and `y`. The argument `col` simply sets the color for the line to be drawn. If we left it out, the line would be drawn in black.

The top of the curve is cut off because the limits of the x- and y-axes are set to best fit the histogram. To adjust the y-axis you can add a third argument to the histogram function: `ylim = c(0, 0.06)`.

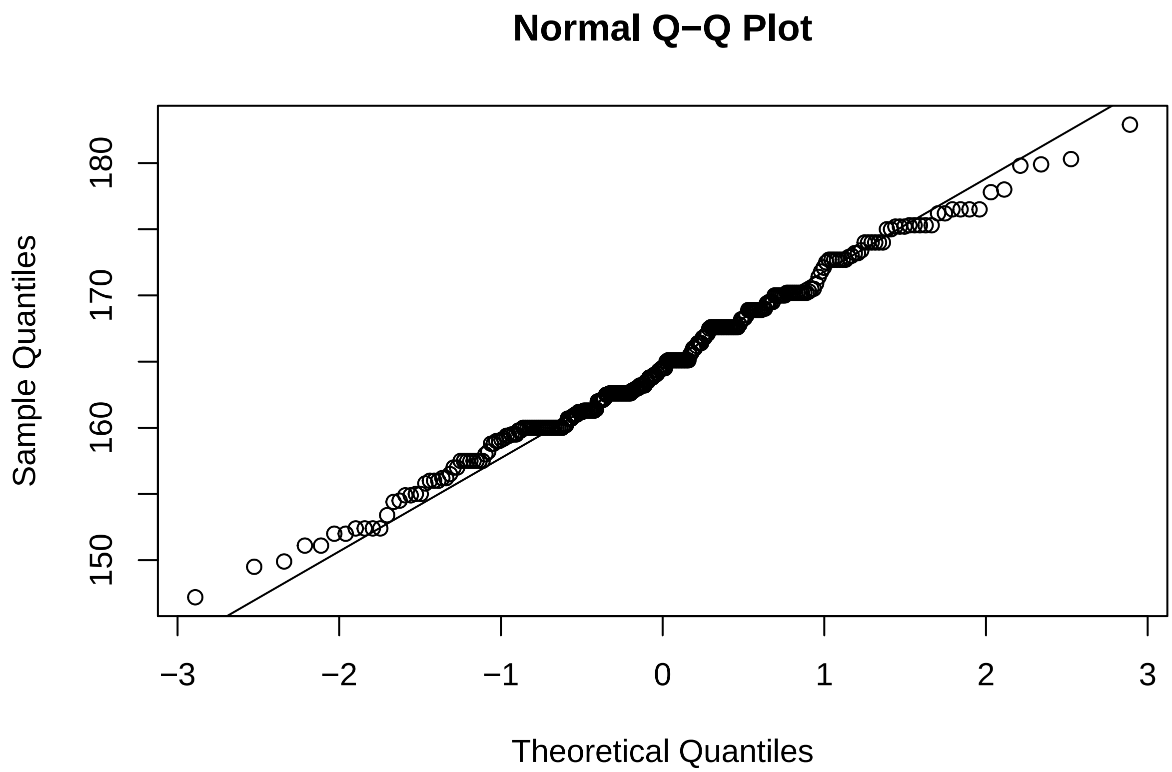
2. Based on the this plot, does it appear that the data follow a nearly normal distribution?

Yes, based on this plot, the data does appear to follow a nearly normal distribution.

Evaluating the normal distribution

Eyeballing the shape of the histogram is one way to determine if the data appear to be nearly normally distributed, but it can be frustrating to decide just how close the histogram is to the curve. An alternative approach involves constructing a normal probability plot, also called a normal Q-Q plot for “quantile-quantile”.

```
qqnorm(fdims$hgt)
qqline(fdims$hgt)
```



A data set that is nearly normal will result in a probability plot where the points closely follow the line. Any deviations from normality leads to deviations of these points from the line. The plot for female heights shows points that tend to follow the line but with some errant points towards the tails. We're left with the same problem that we encountered with the histogram above: how close is close enough?

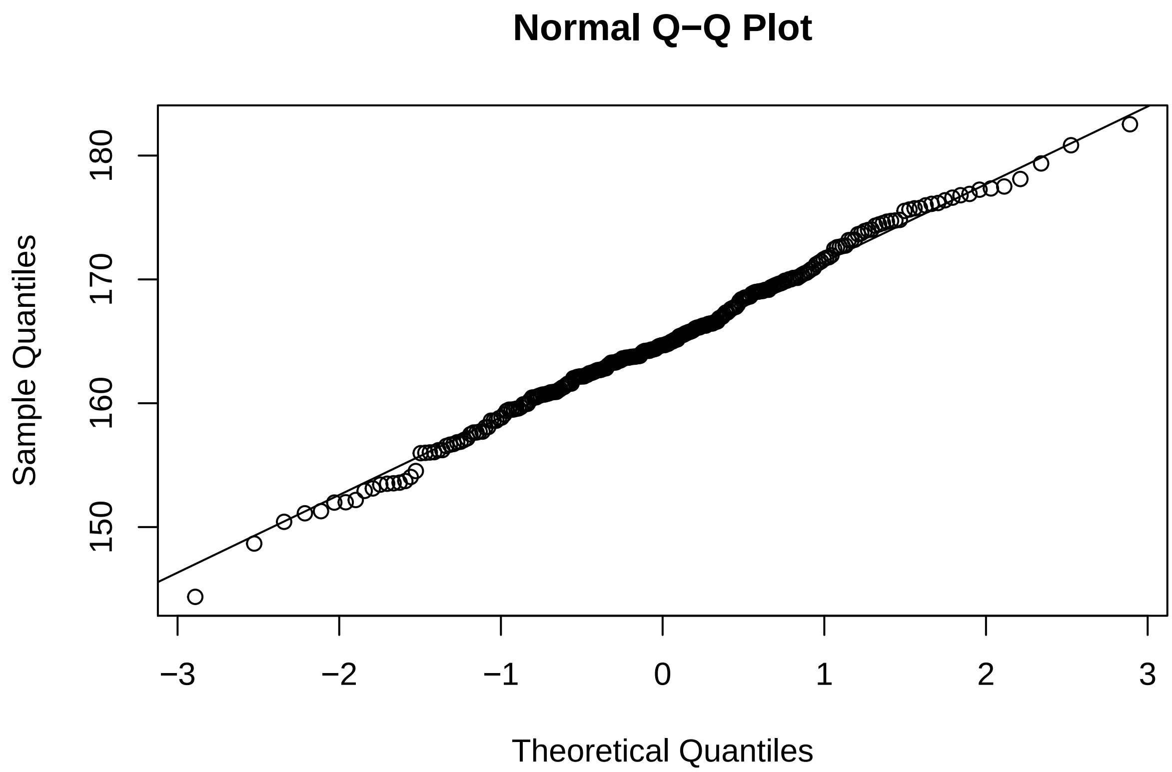
A useful way to address this question is to rephrase it as: what do probability plots look like for data that I *know* came from a normal distribution? We can answer this by simulating data from a normal distribution using `rnorm`.

```
sim_norm <- rnorm(n = length(fdims$hgt), mean = fhgtmean, sd = fhgtsd)
```

The first argument indicates how many numbers you'd like to generate, which we specify to be the same number of heights in the `fdims` data set using the `length` function. The last two arguments determine the mean and standard deviation of the normal distribution from which the simulated sample will be generated. We can take a look at the shape of our simulated data set, `sim_norm`, as well as its normal probability plot.

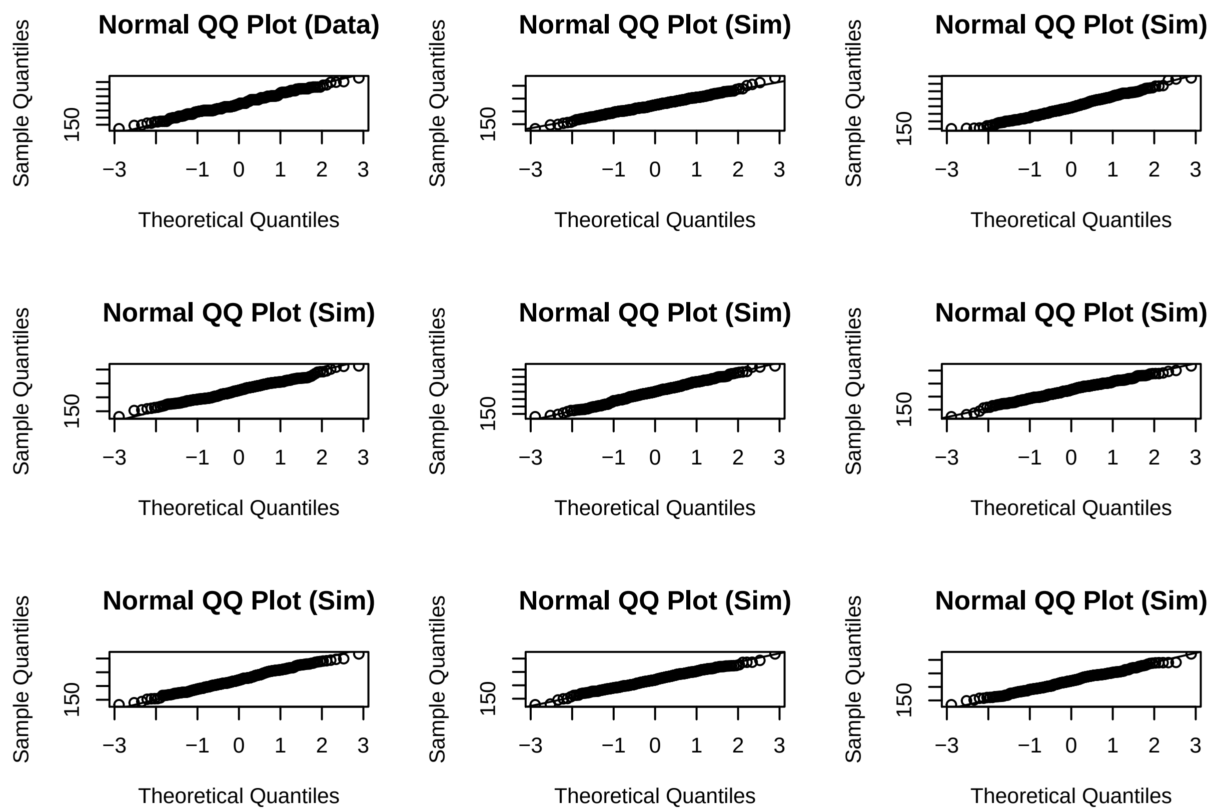
3. Make a normal probability plot of `sim_norm`. Do all of the points fall on the line? How does this plot compare to the probability plot for the real data?

```
qqnorm(sim_norm)
qqline(sim_norm)
```



Even better than comparing the original plot to a single plot generated from a normal distribution is to compare it to many more plots using the following function. It may be helpful to click the zoom button in the plot window.

```
qqnormsim(fdims$hgt)
```



4. Does the normal probability plot for `fdims$hgt` look similar to the plots created for the simulated data? That is, do plots provide evidence that the female heights are nearly normal?

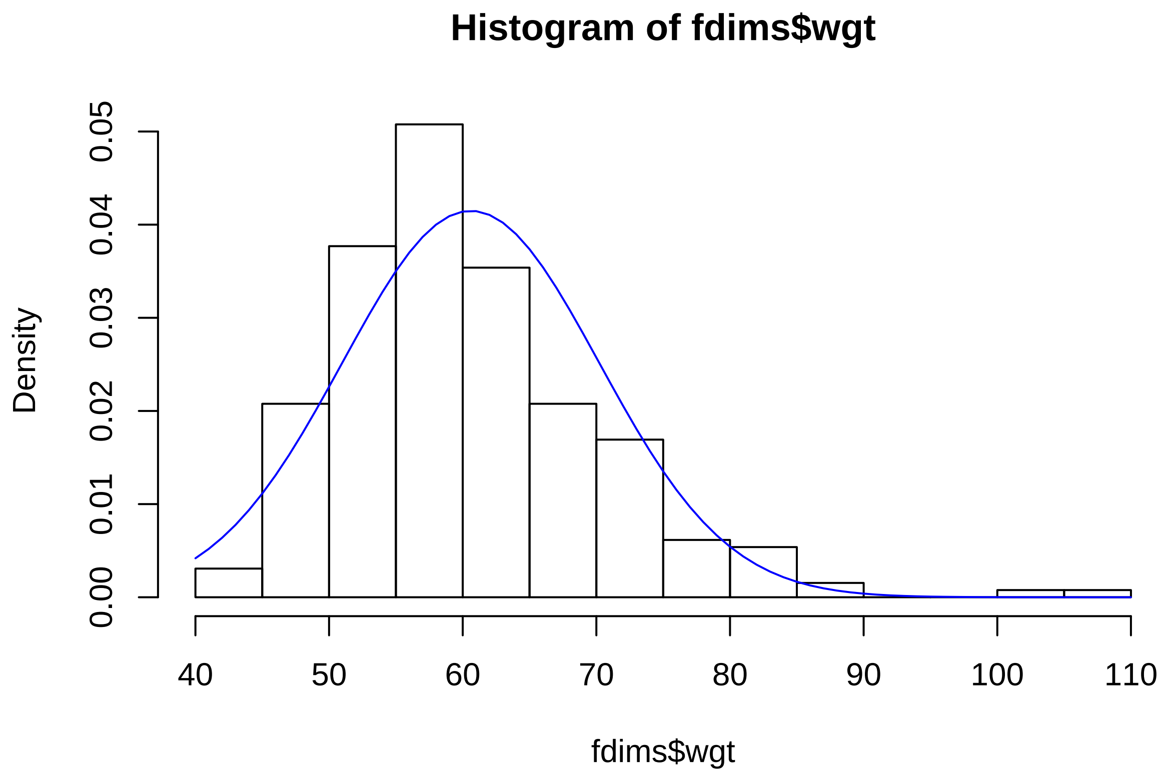
Yes, the normal probability plot for female heights does look similar to the plots created for the simulated data, which provides further evidence that the female heights are nearly normal.

5. Using the same technique, determine whether or not female weights appear to come from a normal distribution.

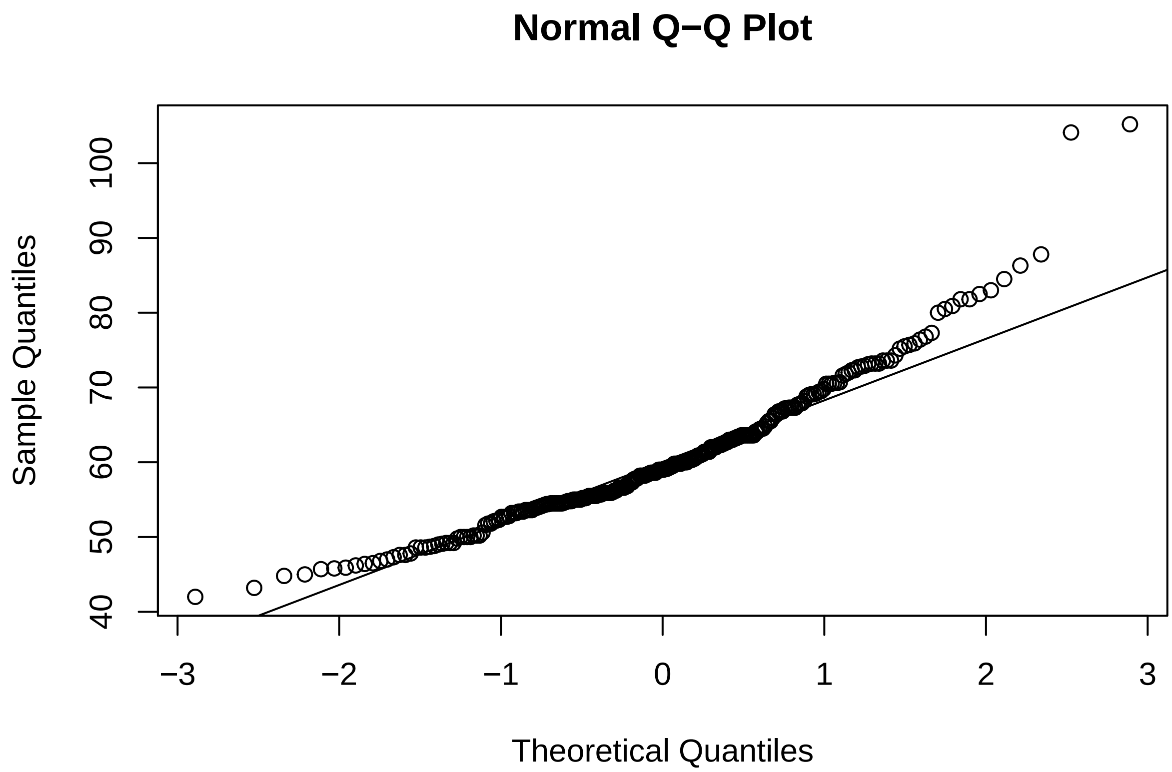
```
#fdims$wgt
fivenum(fdims$wgt)
```

```
## [1]  42.0  54.5  59.0  65.7 105.2
```

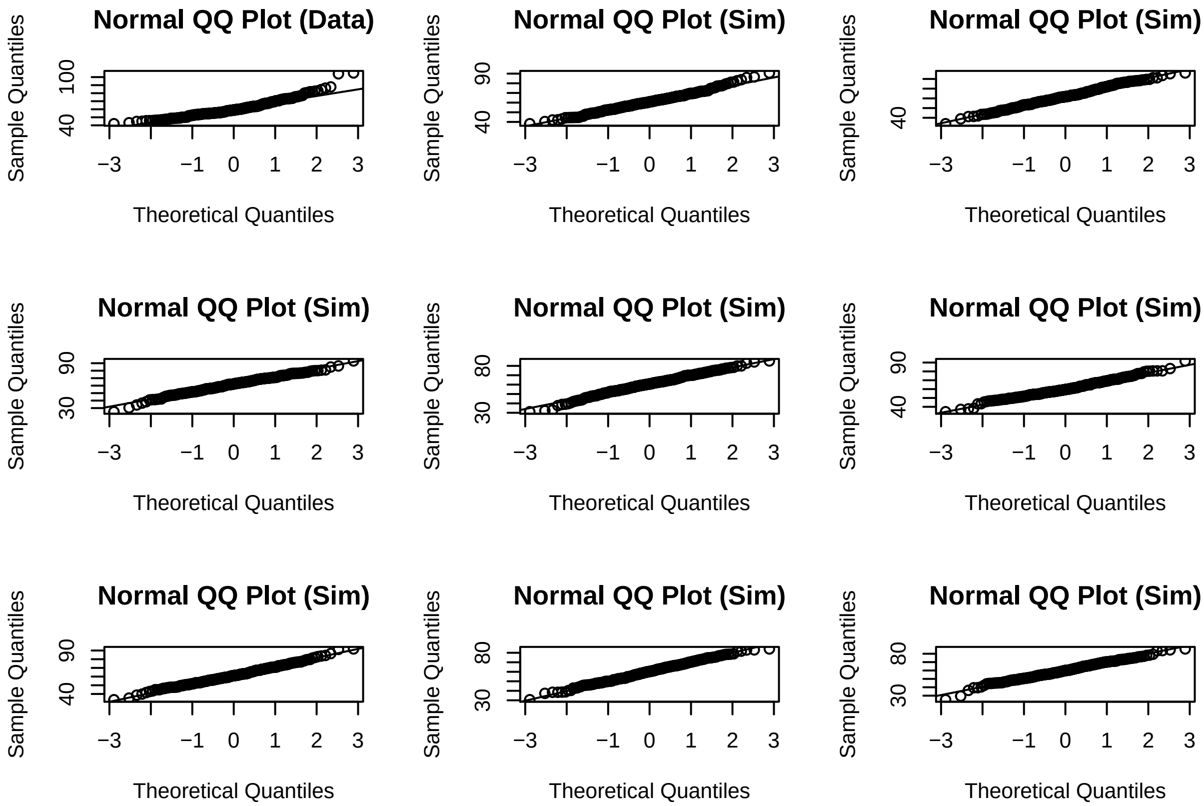
```
fwgtmean<-mean(fdims$wgt)
fwgtsd<-sd(fdims$wgt)
hist(fdims$wgt, probability = TRUE)
x <- 40:110
y <- dnorm(x = x, mean = fwgtmean, sd = fwgtsd)
lines(x = x, y = y, col = "blue")
```




```
qqnorm(fdims$wgt)
qqline(fdims$wgt)
```




```r
sim_norm_fwgt <- rnorm(n = length(fdims$wgt), mean = fwgtmean, sd = fwgtsd)
#qqnorm(sim_norm_fwgt)
#qqline(sim_norm_fwgt)
qqnormsim(fdims$wgt)
```




```r
cat("Based on the above, it seems that female weights do not come from a nearly normal distribution. The
```

```
## Based on the above, it seems that female weights do not come from a nearly normal distribution. They
```

Normal probabilities

Okay, so now you have a slew of tools to judge whether or not a variable is normally distributed. Why should we care?

It turns out that statisticians know a lot about the normal distribution. Once we decide that a random variable is approximately normal, we can answer all sorts of questions about that variable related to probability. Take, for example, the question of, "What is the probability that a randomly chosen young adult female is taller than 6 feet (about 182 cm)?" (The study that published this data set is clear to point out that the sample was not random and therefore inference to a general population is not suggested. We do so here only as an exercise.)

If we assume that female heights are normally distributed (a very close approximation is also okay), we can find this probability by calculating a Z score and consulting a Z table (also called a normal probability table). In R, this is done in one step with the function `pnorm`.

```r
1 - pnorm(q = 182, mean = fhgtmean, sd = fhgtsd)
```

```
## [1] 0.004434387
```

Note that the function `pnorm` gives the area under the normal curve below a given value, `q`, with a given mean and standard deviation. Since we're interested in the probability that someone is taller than 182 cm, we have to take one minus that probability.

Assuming a normal distribution has allowed us to calculate a theoretical probability. If we want to calculate the probability empirically, we simply need to determine how many observations fall above 182 then divide this number by the total sample size.

```
sum(fdims$hgt > 182) / length(fdims$hgt)
```

```
## [1] 0.003846154
```

Although the probabilities are not exactly the same, they are reasonably close. The closer that your distribution is to being normal, the more accurate the theoretical probabilities will be.

6. Write out two probability questions that you would like to answer; one regarding female heights and one regarding female weights. Calculate those probabilities using both the theoretical normal distribution as well as the empirical distribution (four probabilities in all). Which variable, height or weight, had a closer agreement between the two methods?

1) What is the probability that a young adult female is shorter than 150 cm?
2) What is the probability that a young adult female is heavier than 65 kgs?

```
pnorm(q = 150, mean = fhgtmean, sd = fhgtsd)
```

```
## [1] 0.01152955
```

```
sum(fdims$hgt < 150) / length(fdims$hgt)
```

```
## [1] 0.01153846
```

```
1 - pnorm(q = 65, mean = fwgtmean, sd = fwgtsd)
```

```
## [1] 0.3236397
```

```
sum(fdims$wgt > 65) / length(fdims$wgt)
```

```
## [1] 0.2615385
```

As expected, female heights tend to follow the theoretical normal distribution more closely, while female weights show a greater deviation, on account of the right-skewed nature of the data. The actual data shows a longer right tail than the theoretical normal distribution.

On Your Own

- Now let's consider some of the other variables in the body dimensions data set. Using the figures at the end of the exercises, match the histogram to its normal probability plot. All of the variables have been standardized (first subtract the mean, then divide by the standard deviation), so the units won't be of any help. If you are uncertain based on these figures, generate the plots in R to check.

  a. The histogram for female biiliac (pelvic) diameter (`bii.di`) belongs to normal probability plot letter *B*___.

  b. The histogram for female elbow diameter (`elb.di`) belongs to normal probability plot letter **C**.

  c. The histogram for general age (`age`) belongs to normal probability plot letter *D*___.

  d. The histogram for female chest depth (`che.de`) belongs to normal probability plot letter *A*___.

- Note that normal probability plots C and D have a slight stepwise pattern.
  Why do you think this is the case?

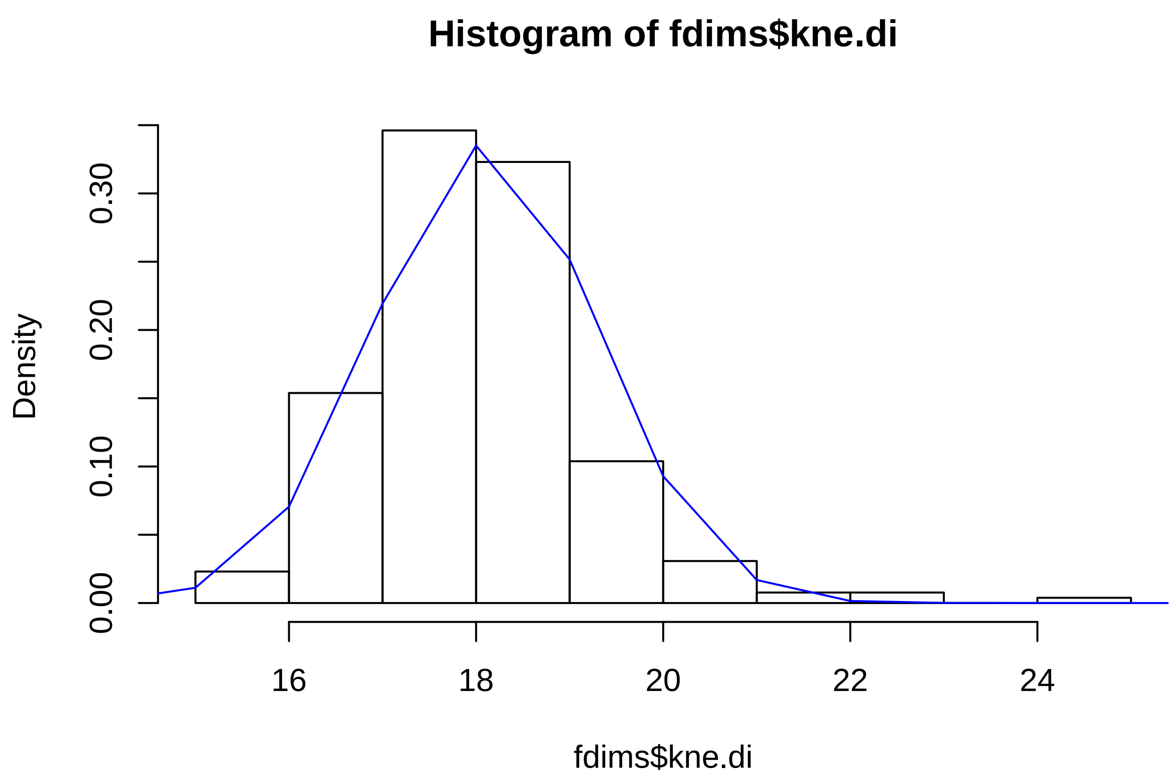
  This is probably because these two measurements are more discrete in nature rather than continuous. For example, age is expressed in years, so the data "jumps" from year to year.

- As you can see, normal probability plots can be used both to assess normality and visualize skewness. Make a normal probability plot for female knee diameter (`kne.di`). Based on this normal probability plot, is this variable left skewed, symmetric, or right skewed? Use a histogram to confirm your findings.

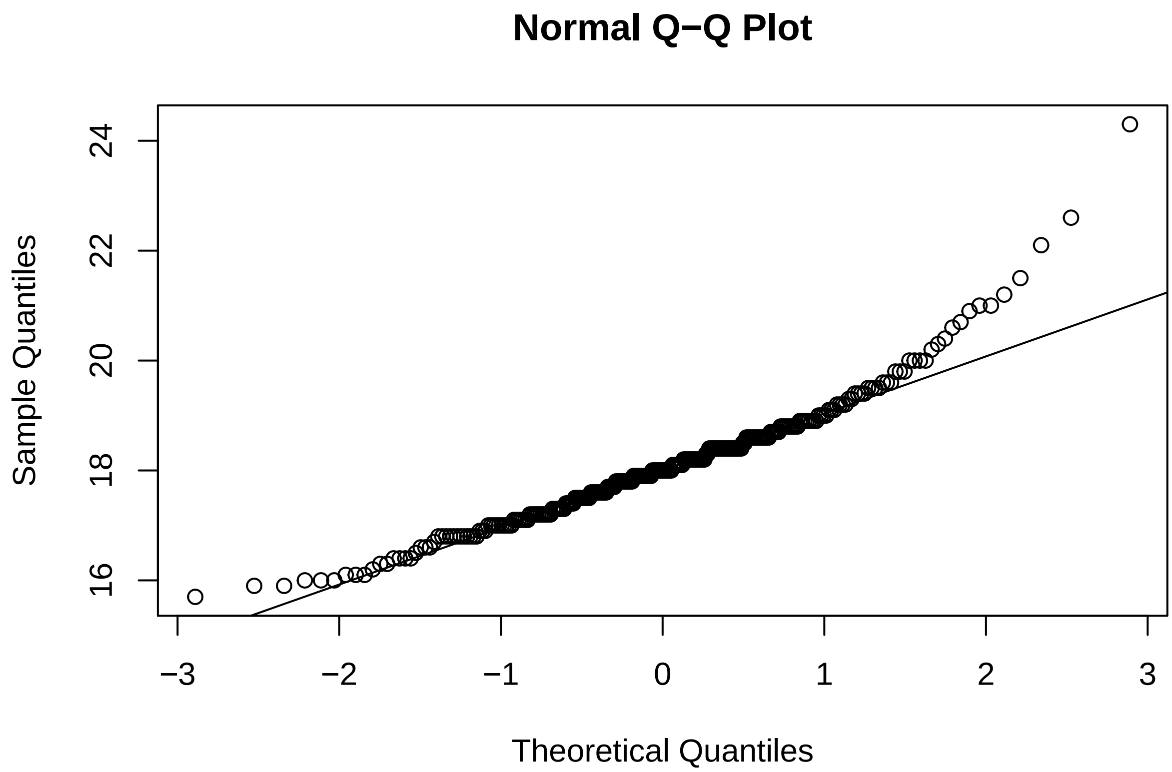
```r
#fdims$kne.di
fivenum(fdims$kne.di)
```

```
## [1] 15.7 17.3 18.0 18.7 24.3
```

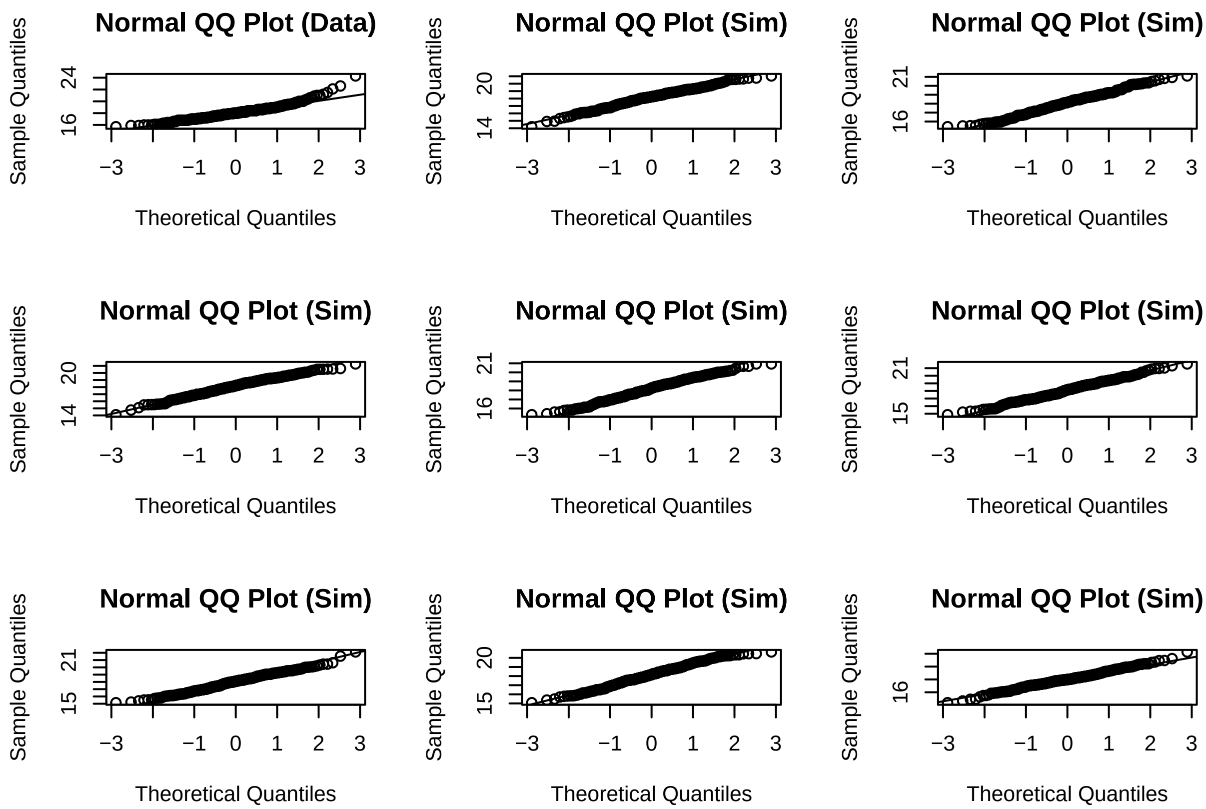
```r
fknemean<-mean(fdims$kne.di)
fknesd<-sd(fdims$kne.di)
hist(fdims$kne.di, probability = TRUE)
x <- 10:28
y <- dnorm(x = x, mean = fknemean, sd = fknesd)
lines(x = x, y = y, col = "blue")
```




```r
qqnorm(fdims$kne.di)
qqline(fdims$kne.di)
```




```r
sim_norm_fkne <- rnorm(n = length(fdims$kne.di), mean = fknemean, sd = fknesd)
#qqnorm(sim_norm_fkne)
#qqline(sim_norm_fkne)
qqnormsim(fdims$kne.di)
```




```
cat("Based on the above, it seems that female knee widths do not come from a nearly normal distribution
```

```
## Based on the above, it seems that female knee widths do not come from a nearly normal distribution. T
```

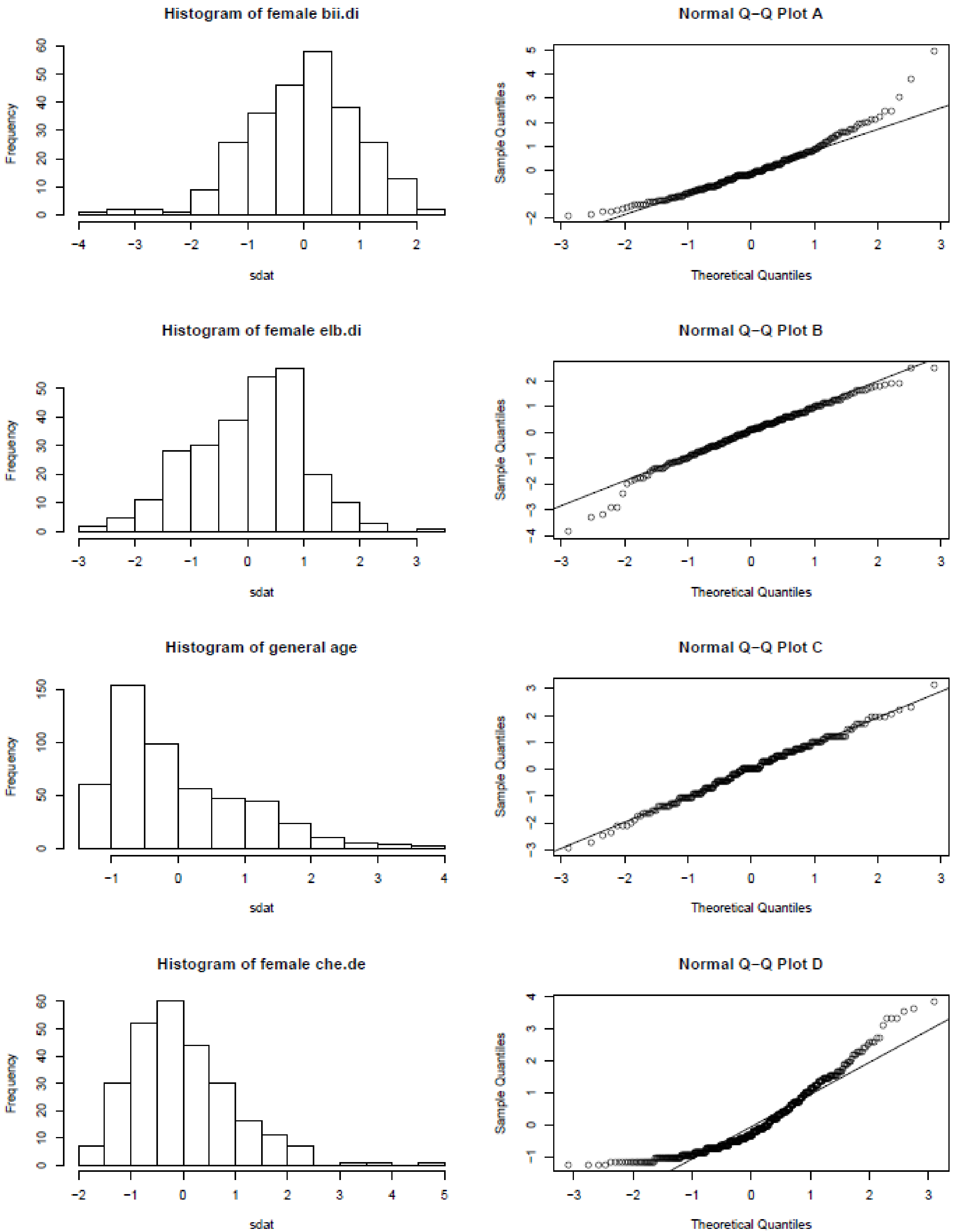


Figure 1: histQQmatch