In [1]:
```
#############################################################
## Title  : 'Regression Analysis'                          ##
## Author : 'Bushra Tariq Kiyani'                          ##
## Date   : '27th January, 2023'                           ##
## Output : pdf document                                   ##
## Group  : 5                                              ##
#############################################################
```

In [3]:
```
library(ggplot2)
library(GGally)
library(ggpubr)
library(dplyr)
library(olsrr)
library(reshape2)
```

In [4]:
```
#Loading the Input data
input_data <- read.csv('bodymeasurements.csv')
```

In [5]:
```
#Remove the variable ID
input_data  <- input_data  %>% dplyr::select(-ID)
```

In [6]:
```
#View the input data
head(input_data)
```

A data.frame: 6 × 12

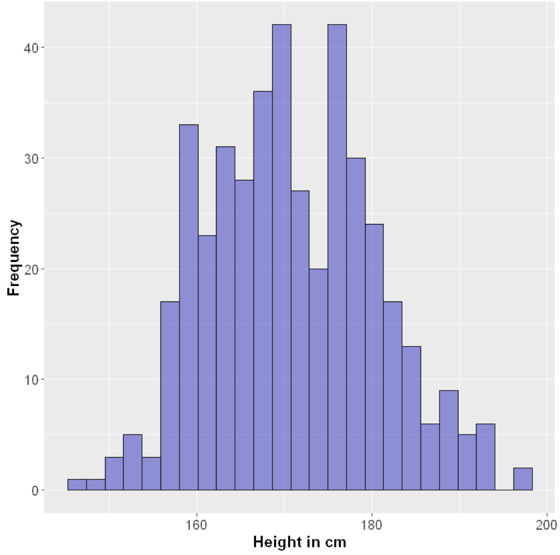
	Age	Sex	Height	Chest	Belly	Thigh	Knee	Calf	Ankle	Biceps	Wrist	Weight
	<int>	<chr>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>
1	21	m	174.0	89.5	71.5	51.5	34.5	36.5	23.5	32.5	16.5	65.6
2	23	m	175.3	97.0	79.0	51.5	36.5	37.5	24.5	34.4	17.0	71.8
3	28	m	193.5	97.5	83.2	57.3	37.0	37.3	21.9	33.4	16.9	80.7
4	23	m	186.5	97.0	77.8	53.0	37.0	34.8	23.0	31.0	16.6	72.6
5	22	m	187.2	97.5	80.0	55.4	37.7	38.6	24.4	32.0	18.0	78.8
6	21	m	181.5	99.9	82.5	57.5	36.6	36.1	23.5	33.0	16.9	74.8

In [7]:
```
#Summarise all continous variables
standard_deviations <- rbind.data.frame(lapply(input_data  %>% dplyr::select(-Sex),sd))
summary_table  <- rbind.data.frame(lapply(input_data  %>% dplyr::select(-Sex),summary))
summary_table  <-  rbind(summary_table, standard_deviations)
row.names(summary_table) <- c("Min", "Q1", "Median", "Mean", "Q3", "Max", "SD")
summary_table  <- t(round(summary_table,3))
summary_table
```

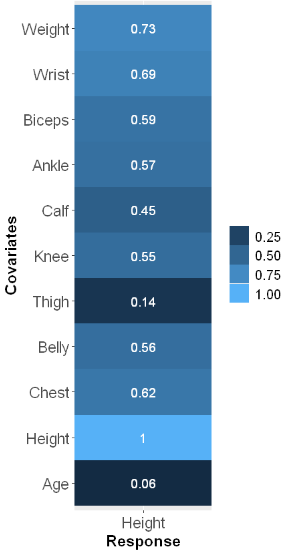
A matrix: 11 × 7 of type dbl

	Min	Q1	Median	Mean	Q3	Max	SD
Age	18.0	22.000	25.00	26.896	31.250	40.0	5.849
Height	147.2	163.200	170.20	170.880	177.800	198.1	9.398
Chest	72.6	84.775	90.95	92.221	99.825	116.7	9.600
Belly	57.9	67.500	74.10	75.283	82.000	113.2	9.904
Thigh	46.3	53.700	56.30	56.822	59.500	75.7	4.431
Knee	29.0	34.300	35.90	36.005	37.700	45.7	2.544
Calf	28.4	34.000	35.80	35.880	37.700	45.0	2.756
Ankle	16.4	20.900	21.90	22.025	23.100	29.3	1.847
Biceps	22.4	27.275	30.35	30.828	34.125	42.4	4.267
Wrist	13.0	14.875	15.90	15.967	17.000	19.6	1.351
Weight	42.0	57.300	66.80	67.822	75.625	105.2	12.739

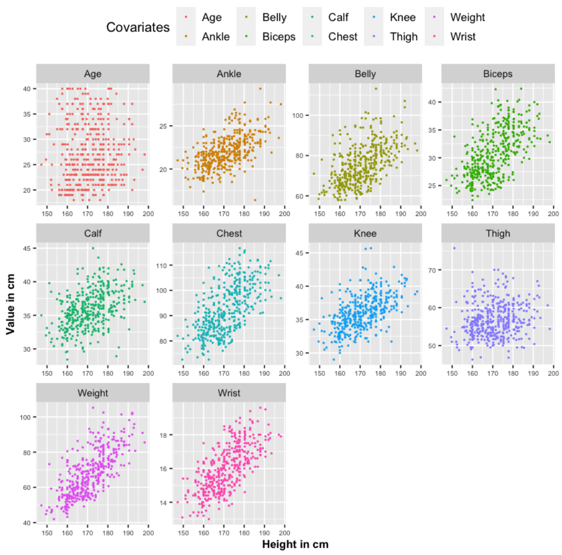
In [8]:
```
#Histogram to see the frequency distribution of the variable Height
ggplot(input_data, aes(x=Height))+
  geom_histogram(color="black", fill="#0002AF", alpha = 0.4, bins = 25)+
  xlab("Height in cm") + ylab("Frequency") +
  theme(axis.text=element_text(size=12), axis.title=element_text(size=14 , face = "bold"))
```



In [10]:
```
corr_mat <- round(cor(input_data  %>% dplyr::select(-Sex)),2)
melted_corr_mat <- melt(corr_mat) %>% dplyr::filter(Var1 == "Height")
Corr_HM  <- ggplot(data = melted_corr_mat, aes(x=Var1, y=Var2,
                                               fill=value)) + geom_tile(aes(width = 1.5, height=1)) +
xlab("Response") + ylab("Covariates") + guides(fill=guide_legend(title="")) +
theme(legend.text = element_text(size=12),  axis.text=element_text(size=14), axis.title=element_text(size=14 , face = "bold"))+
geom_text(aes(label = value),
          color = "white", size = 4)
Corr_HM
```



In [8]:
```
#Correlation scatter plot for height vs all variables
input_corr <- input_data  %>% dplyr::select(-Sex) %>%
              tidyr::gather(key = "Covariates", value = "value",-Height)

corr_plot  <- ggplot(input_corr, aes(x = Height, y = value, col = Covariates)) +
  geom_point(size = 0.3) +
      facet_wrap(~Covariates, scales = "free") +
      xlab("Height in cm") + ylab("Value in cm")  +
      theme(axis.text=element_text(size=6),
            axis.title=element_text(size=10 , face = "bold"),
            legend.title = element_text(size=12),
            legend.text = element_text(size=10),
            legend.position = "top",
            legend.direction = "horizontal"
           )
corr_plot
```



In [9]:
```
#Linear regression model
full_model  <-  lm(Height ~ ., data = input_data)
summary(full_model)
```

```
Call:
lm(formula = Height ~ ., data = input_data)

Residuals:
     Min       1Q   Median       3Q      Max 
-13.9956  -2.5388   0.1734   2.7092  14.0613 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 211.23128    6.96030  30.348  < 2e-16 ***
Age           0.01769    0.03802   0.465   0.6420    
Sexm          6.38037    0.98056   6.507 2.23e-10 ***
Chest        -0.14534    0.06964  -2.087   0.0375 *  
Belly        -0.67402    0.05946 -11.335  < 2e-16 ***
Thigh        -0.58815    0.10001  -5.881 8.45e-09 ***
Knee          0.09616    0.17084   0.563   0.5738    
Calf         -0.67324    0.14570  -4.621 5.12e-06 ***
Ankle         0.10198    0.20798   0.490   0.6242    
Biceps       -1.01355    0.15004  -6.755 4.88e-11 ***
Wrist         0.52087    0.39333   1.324   0.1861    
Weight        1.40384    0.06858  20.469  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.249 on 412 degrees of freedom
Multiple R-squared:  0.8009,	Adjusted R-squared:  0.7956 
F-statistic: 150.6 on 11 and 412 DF,  p-value: < 2.2e-16
```

In [10]:
```
#Finding the best subsets using least squares estimator
best_subsets  <- ols_step_best_subset(full_model)
```

In [11]:
```r
#Listing the best subsets
best_subsets  <- best_subsets  %>% mutate(Model = mindex, Number_of_covariates = n,
                                     Covariates = predictors, Rsquared = rsquare, Adj.Rsquared = adjr,
                                     AIC = aic, BIC = sbc)  %>%
                          select(Model, Covariates, Adj.Rsquared, AIC, BIC)
best_subsets
```

A ols_step_best_subset: 11 × 5

	Model	Covariates	Adj.Rsquared	AIC	BIC
	<int>	<chr>	<dbl>	<dbl>	<dbl>
11	1	Weight	0.5272616	2789.499	2801.648
51	2	Thigh Weight	0.6630077	2646.977	2663.176
181	3	Belly Thigh Weight	0.7422729	2534.269	2554.518
505	4	Belly Thigh Biceps Weight	0.7652275	2495.706	2520.004
841	5	Sex Belly Thigh Biceps Weight	0.7860804	2457.254	2485.602
1360	6	Sex Belly Thigh Calf Biceps Weight	0.7940634	2442.113	2474.511
1710	7	Sex Chest Belly Thigh Calf Biceps Weight	0.7956268	2439.864	2476.311
1949	8	Sex Chest Belly Thigh Calf Biceps Wrist Weight	0.7965996	2438.820	2479.317
2029	9	Sex Chest Belly Thigh Knee Calf Biceps Wrist Weight	0.7963231	2440.373	2484.920
2046	10	Sex Chest Belly Thigh Knee Calf Ankle Biceps Wrist Weight	0.7959514	2442.121	2490.718
2047	11	Age Sex Chest Belly Thigh Knee Calf Ankle Biceps Wrist Weight	0.7955636	2443.898	2496.545

In [12]:
```r
#best_subset using AIC
best_subsets  %>% filter(AIC == min(best_subsets$AIC))
```

A ols_step_best_subset: 1 × 5

Model	Covariates	Adj.Rsquared	AIC	BIC
<int>	<chr>	<dbl>	<dbl>	<dbl>
8	Sex Chest Belly Thigh Calf Biceps Wrist Weight	0.7965996	2438.82	2479.317

In [13]:
```r
#best_subset using BIC
best_subsets  %>% filter(BIC == min(best_subsets$BIC))
```

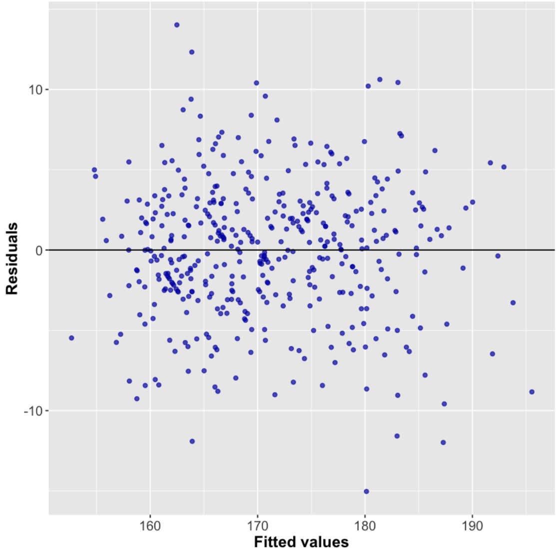
A ols_step_best_subset: 1 × 5

Model	Covariates	Adj.Rsquared	AIC	BIC
<int>	<chr>	<dbl>	<dbl>	<dbl>
6	Sex Belly Thigh Calf Biceps Weight	0.7940634	2442.113	2474.511

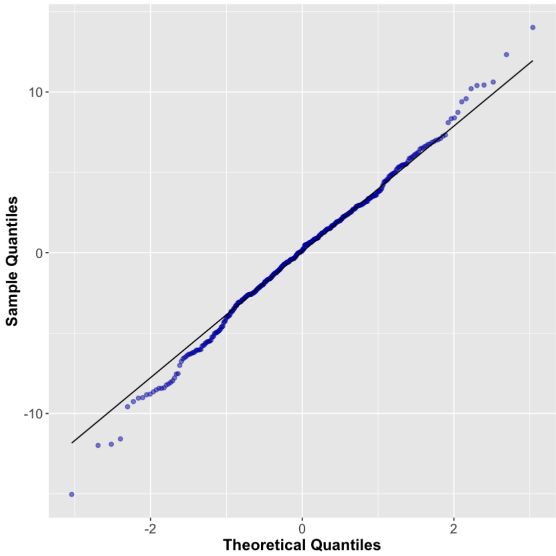
In [14]:
```r
# Fitting the model, based on the based subset selection using BIC
best_subset_model  <- lm(Height ~ Sex + Belly + Thigh + Calf + Biceps + Weight, data = input_data)
summary(best_subset_model)
```

```
Call:
lm(formula = Height ~ Sex + Belly + Thigh + Calf + Biceps + Weight, 
    data = input_data)

Residuals:
     Min       1Q   Median       3Q      Max 
-15.0336  -2.5824   0.1241   2.6957  14.0164 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 213.72083    4.33769  49.271  < 2e-16 ***
Sexm          6.60926    0.94766   6.974 1.21e-11 ***
Belly        -0.72749    0.05296 -13.737  < 2e-16 ***
Thigh        -0.59827    0.09257  -6.463 2.87e-10 ***
Calf         -0.52786    0.12726  -4.148 4.07e-05 ***
Biceps       -1.10825    0.11774  -9.413  < 2e-16 ***
Weight        1.41574    0.05788  24.461  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.265 on 417 degrees of freedom
Multiple R-squared:  0.797,	Adjusted R-squared:  0.7941 
F-statistic: 272.8 on 6 and 417 DF,  p-value: < 2.2e-16
```

In [15]:
```
#Residual plot for standardized residuals vs Fitted best subset model
ggplot(best_subset_model, aes(x = .fitted, y = best_subset_model$residuals)) +
  geom_point(size = 1.5, color = "#0002AF", alpha = 0.7) +
  geom_hline(yintercept = mean(best_subset_model$residuals), color = "black", linewidth = 0.5) + xlab("Fitted values") + ylab("R
      theme(axis.text=element_text(size=12), axis.title=element_text(size=14 , face = "bold"))
```



In [16]:
```
# QQ plot for the standardized residuals
ggplot(input_data, aes(sample = best_subset_model$residuals)) +
       stat_qq(distribution = stats::qnorm, color = "#0002AF", alpha = 0.5) +
       stat_qq_line() +
       xlab("Theoretical Quantiles") +
       ylab("Sample Quantiles") +
          theme(plot.title = element_text(face = "bold",hjust = 0.5, size = 12),
                axis.text=element_text(size=12),
                axis.title=element_text(size=14, face = "bold"),
                legend.text = element_text(size = 12))
```



In [17]:
```
#Extracting the coefficient values and p-values
coefficient_values  <- t(rbind(round(best_subset_model$coefficients,3)))
p_values  <- t(rbind(round(summary(best_subset_model)$coefficients[ , 4],10)))
```

In [18]:
```
#Finding the confidence intervals for the estimated coefficients
conf_intervals  <- as.data.frame(round(confint(best_subset_model, level = 0.95),3))
colnames(conf_intervals)  <- c("lower","upper")
conf_intervals['Confidence_interval']  <- paste0("[",conf_intervals$lower," , ", conf_intervals$upper, "]")
conf_intervals  <- conf_intervals  %>% select(Confidence_interval)
```

In [19]:
```
#Displaying the output
parameters  <- cbind(coefficient_values, conf_intervals, p_values)
colnames(parameters)  <- c("Estimated coefficients", "Confidence intervals", "P_values")
parameters
```

A data.frame: 7 × 3

	Estimated coefficients	Confidence intervals	P_values
	<dbl>	<chr>	<dbl>
(Intercept)	213.721	[205.194 , 222.247]	0.00000e+00
Sexm	6.609	[4.746 , 8.472]	0.00000e+00
Belly	-0.727	[-0.832 , -0.623]	0.00000e+00
Thigh	-0.598	[-0.78 , -0.416]	3.00000e-10
Calf	-0.528	[-0.778 , -0.278]	4.07118e-05
Biceps	-1.108	[-1.34 , -0.877]	0.00000e+00
Weight	1.416	[1.302 , 1.53]	0.00000e+00