The Importance of Summary Statistics and Techniques for Creating Them in R

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Abstract

This document presents a concise overview of summary statistics and their importance in R. Summary statistics - such as mean, median, standard deviation, and frequency counts - capture the key features of a dataset, enabling quick exploration and interpretation. R provides powerful functions and visualization tools to efficiently compute and present these statistics, making them essential for simplifying data, identifying patterns, and supporting informed analysis and decision-making. Practical examples and code are provided to demonstrate these concepts in action. The document also discusses the limitations of summary statistics and considers future directions in their application.

Keywords: summary statistics, R programming, data analysis, descriptive statistics, data visualization, exploratory data analysis, limitations

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Summary statistics are concise numerical measures that capture the essential characteristics of a dataset. They serve as foundational tools in data analysis, providing concise descriptions of large datasets. They help analysts and researchers understand the central tendencies, variability, and overall distribution of data, making complex datasets interpretable and actionable. Without summary statistics, raw data would be overwhelming and difficult to interpret, making it challenging to draw meaningful conclusions or communicate findings effectively.

In R, summary statistics are foundational for data analysis, enabling users to efficiently condense complex data into interpretable values like the mean, median, mode, standard deviation, and quantiles. R offers a rich ecosystem of functions and packages - such as summary(), dplyr::summarise(), and visualization tools like histograms and boxplots - that streamline the computation and presentation of summary statistics for both numeric and categorical data. Their importance lies in simplifying large datasets, revealing patterns and outliers, and laying the groundwork for deeper statistical analyses and informed decision-making.

As the first and often most critical step in any analytical workflow, summary statistics in R empower analysts and researchers to understand, compare, and communicate data-driven insights with clarity and precision.

Summary statistics can be typically divided into:

1. **Descriptive statistics**: Summarize the main features of a dataset (e.g., mean, median, mode). *This will be our focus here.*

2. **Inferential statistics**: Make predictions or inferences about a population based on a sample (not the focus here).

I would like to highlight a book, *Making sense of statistics: A conceptual overview*, (Oh & Pyrczak, 2023) which offers a clear and accessible introduction to key statistical concepts for beginners. The book focuses on building conceptual understanding of both descriptive and

inferential statistics, using simple explanations, practical examples, and step-by-step guidance. It is designed to help in applying statistics to research and interpreting data effectively.

Additonally, watch this **tutorial video** on descriptive statistics in R to get you started.

Key Measures in Summary Statistics

- **Measures of Central Tendency**: Central tendency measures indicate where most values in a dataset fall.
- **Measures of Dispersion**: Dispersion measures describe the spread of data.
- **Measures of Shape and Distribution**: Describe the overall pattern and characteristics of how data values are distributed within a dataset.
- **Visualization tools**: Histogram and boxplot are tools to help understand distribution of data better.
- **Frequency table**: It shows how often each value or category appears in a dataset, making it easy to spot common or rare values and summarize the data.
- **Cross-tabulations** (contingency tables): It shows how two or more categorical variables are related by displaying the count of observations for each combination of categories.

Furthermore, read Modern Statistics with R to understand essential tools and techniques in contemporary statistical data analysis, using the R programming language. The book features numerous examples and over 200 exercises with worked solutions. The online version is freely available and regularly updated, with downloadable datasets for hands-on learning

The YouTube videos referenced here may assist in further understanding the code chunks presented above (Walker, 2023) (Videos, 2024) (Schork, 2021)

Practical Application

Try this exercise to understand how to read data and apply summary statistics functions using the **Star Wars** dataset.

Before we get started, we must install essential packages that might be needed later.

```
if (!require(pacman)) install.packages("pacman")
pacman::p_load(tidyverse)
```

Next, load the Star Wars dataset available in the dylyr package. Read more on dylyr package here (Wickham et al., 2023)

```
library(dplyr)
data(starwars)
```

To begin our analysis, we will display the first 10 rows of the starwars dataset. This provides a quick overview of the data structure and its key variables before we proceed with summary statistics.

```
starwars_tbl <- starwars %>%
  slice_head(n = 10)

kable(starwars_tbl, format = "latex", booktabs = TRUE, caption = "Table 1. Star Wars Dat
  kable_styling(latex_options = "striped", full_width = FALSE)
```

```
# Mean height
starwars %>%
  summarise(mean_height = mean(height, na.rm = TRUE))
```

```
# A tibble: 1 x 1
  mean_height
        <dbl>
1        175.
```

Table 1

Table 1. Star Wars Data

name	height	mass	hair_color	skin_color	eye_color	birth_year	sex	gender
Luke Skywalker	172	77	blond	fair	blue	19.0	male	masculin
C-3PO	167	75	NA	gold	yellow	112.0	none	masculin
R2-D2	96	32	NA	white, blue	red	33.0	none	masculin
Darth Vader	202	136	none	white	yellow	41.9	male	masculin
Leia Organa	150	49	brown	light	brown	19.0	female	feminine
Owen Lars	178	120	brown, grey	light	blue	52.0	male	masculin
Beru Whitesun Lars	165	75	brown	light	blue	47.0	female	feminine
R5-D4	97	32	NA	white, red	red	NA	none	masculin
Biggs Darklighter	183	84	black	light	brown	24.0	male	masculin
Obi-Wan Kenobi	182	77	auburn, white	fair	blue-gray	57.0	male	masculin

```
# Median height
starwars %>%
  summarise(median_height = median(height, na.rm = TRUE))
```

```
# A tibble: 1 x 1
  median_height
          <int>
1           180
```

```
# Mode height


starwars %>%
  filter(!is.na(height)) %>%
```

```
  count(height, sort = TRUE) %>%
  slice_max(n = 1, order_by = n) %>%
  select(mode_height = height)
```

```
# A tibble: 1 x 1
  mode_height
        <int>
1         183
```

Now, let's apply other summary functions.

```
# Select relevant variables
starwars_selected <- starwars %>%
  select(height, mass, gender, birth_year, species)

# Tidy summary for numeric variables
starwars_selected %>%
  summarise(
    mean_height = mean(height, na.rm = TRUE),
    sd_height = sd(height, na.rm = TRUE),
    mean_mass = mean(mass, na.rm = TRUE),
    sd_mass = sd(mass, na.rm = TRUE)
  )
```

```
# A tibble: 1 x 4
  mean_height sd_height mean_mass sd_mass
        <dbl>     <dbl>     <dbl>   <dbl>
1        175.      34.8      97.3    169.
```

```r
# Frequency table for gender (tidyverse style)
starwars_selected %>%
  count(gender, name = "frequency")
```

```
# A tibble: 3 x 2
  gender    frequency
  <chr>         <int>
1 feminine         17
2 masculine        66
3 <NA>              4
```

```r
# Proportion table for gender (tidyverse style)
starwars_selected %>%
  count(gender, name = "frequency") %>%
  mutate(proportion = frequency / sum(frequency))
```

```
# A tibble: 3 x 3
  gender    frequency proportion
  <chr>         <int>      <dbl>
1 feminine         17     0.195
2 masculine        66     0.759
3 <NA>              4     0.0460
```

```r
# Comprehensive tidy summary using skimr
skim(starwars_selected)
```

Table 2

Data summary

Name	starwars_selected
Number of rows	87
Number of columns	5
Column type frequency:	
character	2
numeric	3
Group variables	None

Variable type: character

skim_variable	n_missing	complete_rate	min	max	empty	n_unique	whitespace
gender	4	0.95	8	9	0	2	0
species	4	0.95	3	14	0	37	0

Variable type: numeric

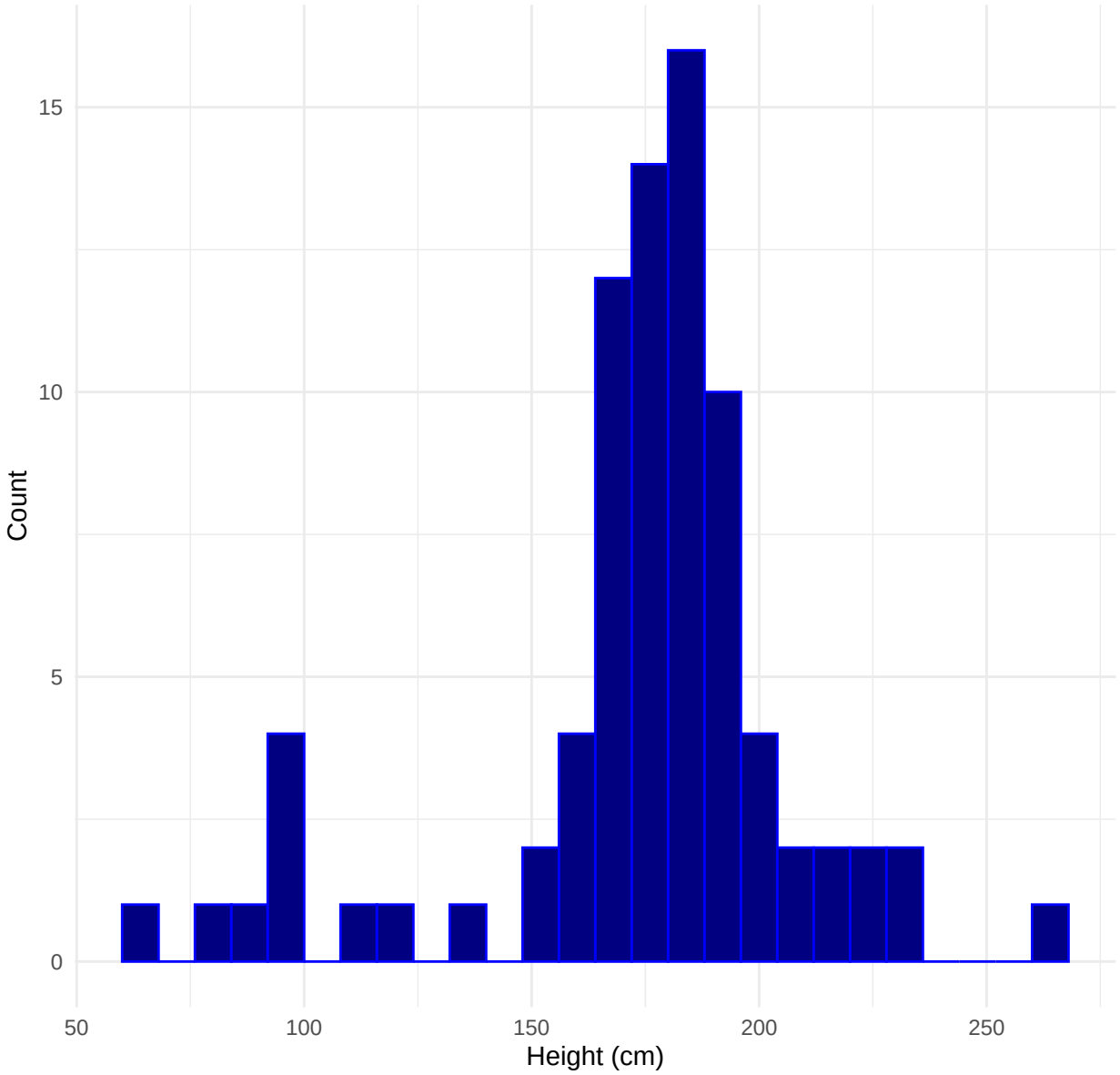
skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
height	6	0.93	174.60	34.77	66	167.0	180	191.0	264	
mass	28	0.68	97.31	169.46	15	55.6	79	84.5	1358	
birth_year	44	0.49	87.57	154.69	8	35.0	52	72.0	896	

Let's look at a visual pattern of the height of different characters in Star Wars.

```
starwars %>%
  ggplot(aes(x = height)) +
  geom_histogram(binwidth = 8, fill = "navy", color = "blue") +
  labs(
    title = "Figure 4. Histogram of Height of Characters in Star Wars",
    x = "Height (cm)",
    y = "Count"
  ) +
  theme_minimal()
```

```
Warning: Removed 6 rows containing non-finite outside the scale range
(`stat_bin()`).
```

Figure 4. Histogram of Height of Characters in Star Wars



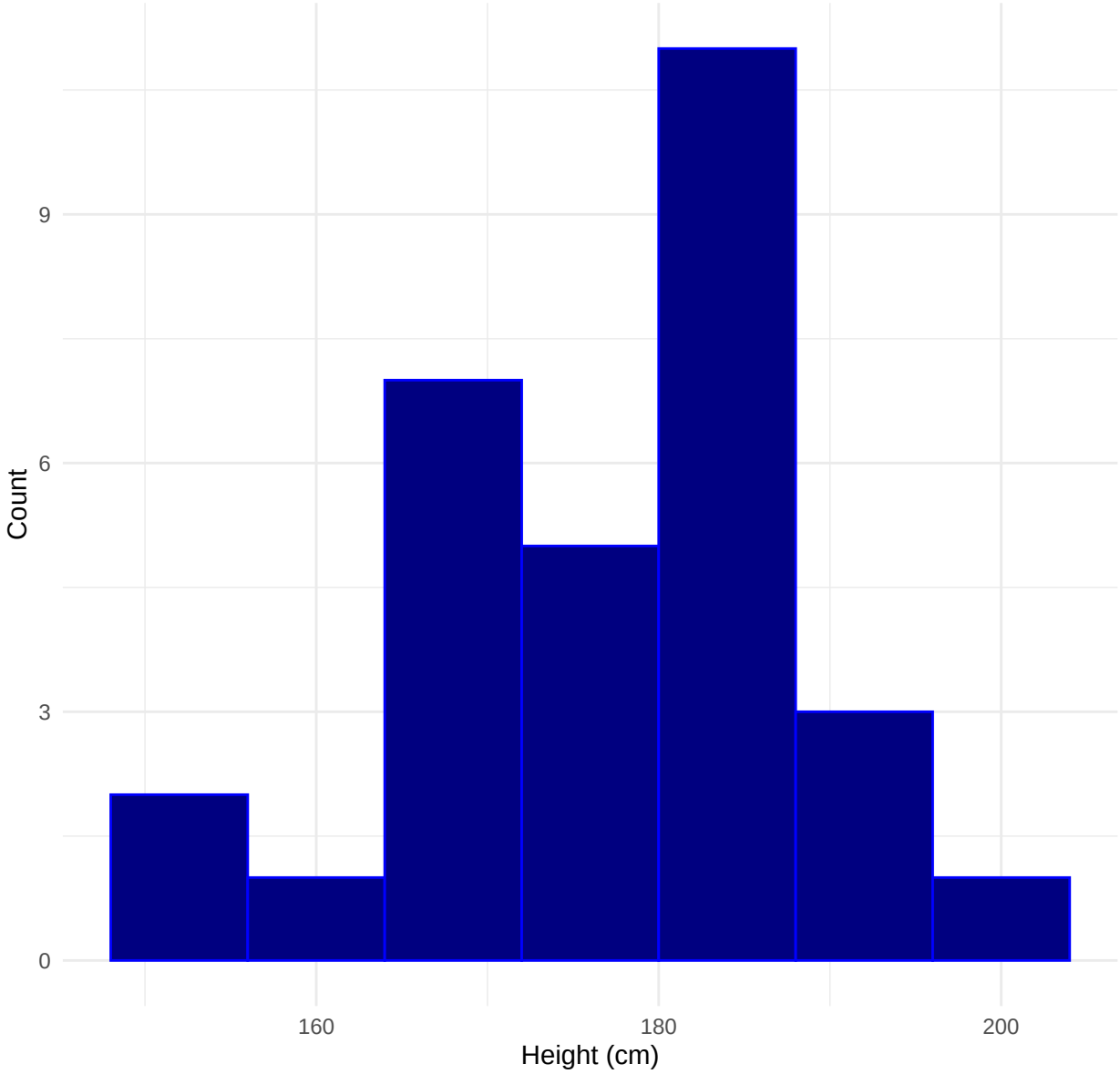
Now, we filter the species to get visual pattern of the height of different *human* characters in Star Wars.

```
starwars %>%
  filter(species == "Human") %>%
  ggplot(aes(x = height)) +
  geom_histogram(binwidth = 8, fill = "navy", color = "blue") +
```

```
  labs(
    title = "Figure 5. Histogram of Height of Human Characters in Star Wars",
    x = "Height (cm)",
    y = "Count"
  ) +
  theme_minimal()
```

```
Warning: Removed 5 rows containing non-finite outside the scale range
(`stat_bin()`).
```

Figure 5. Histogram of Height of Human Characters in Star Wars



Furthermore, this YouTube video Return of the Star Wars dataset may be an interesting resource to help you better understand the dataset.

Limitations

Summary statistics are essential for providing a quick and accessible overview of a dataset, but they have several important limitations. In the book *Naked Statistics* (Wheelan, 2013), the author highlights key limitations of statistics, warning that statistical measures can be easily

misapplied, misinterpreted, or manipulated to mislead people. He explains that while statistics help summarize complex data, this simplification can lead to information loss and oversights, especially when descriptive statistics are mistaken for complete truth. He emphasizes that statistics are only as reliable as the data and methods behind them, and that issues like bias, poor sampling, or careless analysis can produce misleading or false conclusions.

Looking ahead, summary statistics are evolving to address larger and more complex datasets. Advances in computational methods, artificial intelligence, and visualization are making summaries more interactive and adaptive to big data challenges (Datatas, 2025; Fan et al., 2014; Garden, 2023). As data science progresses, summary statistics will remain foundational but must be used alongside advanced analytics to ensure accurate and meaningful insights.

Conclusion

Summary statistics are a key starting point for any data analysis, helping us quickly understand and interpret data. In R, these statistics—like the mean, median, and standard deviation—give a clear overview of the data and help spot problems or unusual values. R makes it easy to calculate these numbers for all the data or for different groups, using built-in functions and packages like dplyr.

As (Lane, 2013) explains, using R to automate summary statistics saves time and helps organize your analysis. This basic step is important before moving on to more advanced methods. By mastering summary statistics in R, you can find useful patterns, make better decisions, and clearly share your results in research or business.

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Jelin George, 28May2025, Cologne