1

SCOPE OF STATISTICS IN EXERCISE SCIENCE AND HEALTH

1.1 INTRODUCTION

The use of statistics has become very popular in exercise science and health research because of the availability of many statistical packages. Researchers have begun to use advanced statistical techniques to draw meaningful conclusions. Exercise scientists use statistical techniques to refine their exercise schedule for different categories of people. Using a statistical model helps the researcher to fine-tune his research. The assessment of fitness status is based on the statistical model where different components of health-related fitness are given an appropriate weight to develop a fitness index. By using computer software, the exercise scientists can begin to assess the functional fitness of an individual. Knowledge of statistics empowers research scientists to develop customized fitness prescriptions.

Identification of talent in sports is one of the major thrust areas of research. Knowledge of cause-and-effect relationships provides a scientific basis to develop strategies for talent identification at an early age in different sports. Exercise scientists play an important role in nurturing these young players in different sports. By understanding the nature of different sports, these scientists can develop different exercise programs. By understanding statistical techniques, one can test the appropriateness of the developed schedule. Thus, the use of statistics provides a scientific basis for developing any exercise regimen.

Fitness and health are complementary to each other. Hence, health scientists are always engaged in propagating the need for fitness activities along with proper

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nutritional intake. The main issue is to identify the optimum level of fitness regimen and the nutritional intake for different categories of people. Such knowledge is created by designing an appropriate research experiment and analyzing its findings. By using advanced statistical techniques, one can understand the fitness status and health deficiency of the people in a particular community. Obesity is a menace; hence, health scientists are always interested in identifying the parameters that cause it in different communities. By using statistical modeling, one can identify the lifestyle parameters that are responsible for the increase in the body mass index (BMI) of individuals.

Statistics plays an important role not only in exercise science and health but also in its applied areas such as physical education, sports biomechanics, sports psychology, and sports sciences. For instance, indices can be developed for assessing different parameters such as flexibility, muscular endurance, and muscular strength by using the regression model. Several researchers have developed a methodology for assessing fat percentage on the basis of a few skin folds or bodily circumference by using statistical techniques. One can also use statistical tests in estimating the accuracy of such an assessment. Similarly, researchers in the area of sports biomechanics can use statistical tools to identify the specific muscles used by high performance players. Sports psychologists can identify the specific psychological traits required for being successful in sports. By using some advanced statistical techniques, one can identify the traits that help an individual win in a particular sport. Sports has become very competitive in nature, and scientists now focus on methods to enhance the performance of the players. The researcher can develop a model for maximizing a sportsman's performance by enhancing other parameters to optimal levels. Thus, it is clear that there is tremendous scope for statistics not only in exercise science and health but also in their applied areas.

1.2 UNDERSTANDING STATISTICS

FACTS TO KNOW

Statistics provides authenticity in research findings

The term statistics is used to denote the data as well as the subject. The important thing is the context in and the purpose for which it is used. This text is about statistics; hence, one should understand its definition first. *Statistics* can be defined as an applied science that deals with the collection, compilation, analysis, and interpretation of data. It is also considered a branch of mathematics because most of the statistical techniques are based on mathematical concepts and derivations. A main purpose of statistics is to understand the characteristics of a large group of subjects or entities based on a small subset drawn from it. In other words, one wishes to investigate population characteristics on the basis of the sample drawn from it. The meaning of population depends on the context in which it is used. For instance, if it is required to estimate the BMI of people over 40 years

of age in a locality, then all those whose age is more than 40 years shall constitute the population. On the other hand, if one wishes to understand the fitness culture in the schools of a state, then all the schools will constitute the population. To know the characteristics of the population, one needs to define some parameters on the basis of which its nature can be understood. Two such parameters that are generally used by researchers are mean μ and standard deviation σ, where μ indicates the central value of the dataset and σ is used for understanding the variation of the data in the population. Owing to the large size of the population and various other reasons (as discussed in Chapter 6), these population parameters μ and σ are estimated by the sample statistics and $\overline{x}$, respectively. Thus, the term statistics is also used to denote the function of sample observations.

Research studies on statistics can be broadly classified into descriptive and inferential. In *descriptive* studies, researchers gather data on a group of people or organization to understand their characteristics. For instance, collecting data on the height of the players in a tournament can reveal several interesting features. The mean height can reveal what the average athlete's height is, whereas the range can indicate the maximum variation among the athletes' height. The statistics that are used for descriptive studies are usually mean, standard deviation, variance, coefficient of variation, skewness, kurtosis, and so on.

In inferential studies, a researcher uses those statistical techniques on the basis of which a conclusion about the population characteristics can be drawn from the sample data. Consider a situation where it is necessary to know the impact of a weight training program on back strength. A study may be conducted on a randomly drawn sample of athletes. The data so obtained from the sample may be analyzed by using inferential statistics to draw a conclusion, which can be generalized for the population. The most important aspect of any inferential study is to draw the sample randomly, without which the conclusion drawn about the population characteristics cannot be considered to be authentic. Some statistical techniques used for inferential studies are hypothesis testing, correlation, regression analysis, and so on.

1.3 WHAT STATISTICS DOES?

A main advantage of using statistics in analyzing data is that the reliability of findings can be verified. In addition to this, one can also be sure that the results obtained from the experiment are authentic and, hence, more acceptable to the scientific community. There are ways and means by which one can also test the accuracy of the findings. Let us try and understand what statistics does. A teacher conducts a few statistical tests in which the average performances of the students A and B are given by 55 and 58 marks, respectively. Can it be concluded that the student B is better than student A in statistics. For some it may be, and for others it may not be. But if the difference between their performances is 10 in favor of B, then majority of the people would say that B is better than A but still some may think otherwise. To conclude, all these decisions are subjective in nature and lack authenticity. But if these

two averages are compared by using the statistical test, the difference of 3 marks in their averages may provide 95% confidence to the researcher to believe that B's performance is better than A. What does "the researcher is 95% confident in favor of B" mean? It simply indicates that if you conduct 100 such tests of statistics, at least 95 times B's performance would be better than A's.

1.4 STATISTICAL PROCESSES

A statistical process can be defined as the type of statistical analysis that is used by the researcher in his research study. Before discussing the different types of statistical techniques, let us first see how many types of statistical processes can be encountered in research, and what are the appropriate statistical techniques used in these processes. Broadly, the research processes can be divided into the following five categories.

1.4.1 Descriptive Process

The descriptive process refers to describing the characteristics of a group of individuals, an organization, or a group of similar entities. In such studies, one describes various characteristics of the subjects under study. These studies not only provide interesting information but also help in decision-making. Findings in the descriptive studies may at times provide new topics for research and investigation. The statistics that are used in descriptive studies are known as descriptive statistics. Such statistics are the mean, standard deviation, coefficient of variation, range, skewness, kurtosis, and so on. There are many situations in which descriptive studies may be undertaken. For instance, one may take up a study to prepare a profile of Indian wrestlers. In this case, statistics such as the mean, range, standard deviation, skewness, and kurtosis of different parameters such as height, weight, total body fat, endurance, flexibility, and strength may be computed to understand the different characteristics of Indian wrestlers. Another example of a descriptive study can be the case study of any particular celebrity in sports. In such a case, different descriptive statistics are calculated on the data obtained from the same subject at different points of time.

1.4.2 Comparative Process

All those studies where the researcher is interested in comparing two or more groups come under this category. Often there is interest in comparing the effect of two training programs, the anxiety levels among male and female players, or the IQ of high and low performers in sports. Such studies can be categorized as the comparative process. The statistics that are used in comparative studies are known as comparative statistics. Such statistics are Z, t, F, and chi-square. In comparing more than two groups, analysis of variance is used to analyze the data.

1.4.3 Relationship Process

In the relationship process, the researcher is usually more interested in exploring the relationships among different parameters. For instance, one may be interested in the relationship between the leg length, reaction time, and leg strength with that of the 100 m performance. Similarly, one may like to determine the relationship between the fat percentage and age with cardio respiratory endurance. In such studies, the relationship statistics such as correlation coefficient, partial correlation, and multiple correlation are used to investigate the relationship.

FACTS TO KNOW

In the inferential process the phenomenon that is investigated exists but is unknown, whereas in the predictive process the phenomenon is not known and nor does it exists as well.

1.4.4 Inferential Process

In the inferential process, a conclusion about the population characteristics is drawn on the basis of the information from a sample. Techniques such as statistical estimation and testing of hypothesis are used to draw inferences about the population characteristics. Studies such as estimating students' IQ in a college on the basis of a sample of students, or comparing the agility of gymnasts and basketball players on the basis of two samples obtained from the college gymnasts and basketball players, come under the inferential process. Statistical techniques such as point estimation; interval estimation; s, t, F, and Z tests; and analysis of variance are used to analyze the data in such studies.

1.4.5 Predictive Process

The predictive process is used in studies where we try to predict a future event on the basis of the information from a sample. There is a difference between the inferential process and the predictive process. In the predictive process, a phenomenon that does not exist as of now is predicted on the basis of the information from a sample. On the other hand, in the inferential process, a phenomenon about the population that exists but is not known is estimated on the basis of the information from a sample. Consider a study in which it is of interest to know whether a particular student would qualify in a competitive examination on the basis of his mathematical ability, reasoning ability, and IQ scores. In such a study, the predictive process is used because the happening of the event, that is, the result of the competitive examination, is not known at the time of predicton. Statistical techniques such as regression analysis, logistic regression, and discriminant analysis are used to analyze the data in such situations.

1.5 NEED FOR STATISTICS

The following are reasons why students should take a course in statistics and develop mastery of this subject.

1.5.1 To Understand Research Literature

One cannot read much of the literature in research journals without encountering statistical concepts, methods, and techniques. Without understanding the concepts and fundamentals of statistics, it becomes difficult to interpret the findings mentioned in research articles, as a result of which one loses interest in research activities and is discouraged from undertaking research problems.

1.5.2 To Construct a Research Problem

There is a huge difference between abstract thinking and rational thinking. A researcher is required to convert an abstract thought into a feasible research study. This requires knowledge of various statistical designs without which it becomes impossible to frame an experimental study. Further, knowledge of advance statistical techniques gives insight to the researcher in developing the hypotheses for investigation in the study. In the absence of knowledge about various statistical techniques, it is just not possible to develop a meaningful research study.

1.5.3 To Develop a Scientific Temper

Using statistics in decision-making helps an individual to inculcate scientific temper. A scientific temper is required at each and every step in life. It helps an individual to think rationally in any situation. For instance, during a match, a player's decision for any move is based purely upon his earlier experience. A coach plans the training schedule for his trainee on the basis of his previous experience. While taking a shot, the batsman always calculates the risk on the basis of his scientific judgment. Thus, the development of a scientific temper helps an individual to take decisions rationally all the time.

1.5.4 To Assess the Authenticity of Research Findings and to Contradict Unjustifiable Claims

FACTS TO KNOW

Learning statistics sharpens your faculties and helps in developing a good research problem

Several researchers publicly announce findings based on their research work. In order to assess the authenticity of their statements, one can read their research report. But to satisfy oneself about the conformity between their statements and the actual fact, one should be able to understand the statistical techniques used in the report. Many companies make a claim about their product by using the research findings of their scientists. These claims may be tested by conducting an experiment under controlled conditions and analyzing the data. For example, if a fitness lab announces

that their oral tablets reduce 10 lbs weight in 15 days, this claim may be tested by actually conducting an experiment. Normally while making such claims, companies hide certain facts that are required to justify their claims. For instance, they may not reveal for which age group and weight category the finding is true. Thus, knowledge of designing an experiment and various statistical techniques are essential to write-off the unjustifiable claims.

1.5.5 To Develop Indices for Various Characteristics and Performances

Certain concepts in exercise science cannot be directly measured. For instance, to measure the body strength there is no single test. Instead, one may test arm strength, back strength, leg strength, and shoulder strength separately. One may develop a single index for body strength by giving appropriate weight to these components. Similarly, an index can be prepared to measure the flexibility, health-related fitness, or endurance of an individual. To develop such indices, some advanced statistical techniques such as regression analysis and factor analysis can be used. Thus, knowledge of these techniques equips the researcher to take up such studies in exercise science and health.

1.5.6 To Develop Norms on Various Traits

Norms on different test items provide motivation to an individual. In developing norms for parameters such as sit-ups, pull-ups, push-ups, and so on in different age and sex categories, performance of these parameters needs to be converted into a score by using a scale ranging from 0 to 100. Such norms are easily understood by a lay man and can be used as a selection criteria for certain courses and programs. The norms for the test items are developed by assuming normality of the data. In a situation when the data is not normal, a certain transformation is used before using different scaling techniques. Statistical techniques such as percentile scale, T-scale, and weighted scale are used to develop such norms. Thus, the knowledge of these techniques will equip the researcher to take up normative studies for developing norms for different physical, physiological, and psychological traits in people of different age and sex categories.

1.5.7 To Conduct Research

An important reason to understand the concepts of statistics and learn advanced statistical techniques is to equip an individual for research. The knowledge of sampling techniques allows the researcher to select a representative sample that represents the population. Similarly, knowledge of the different statistical designs helps researchers to choose an appropriate methodology for the experiment and identify the proper statistical test to analyze the data. Thus, it is extremely important to have appropriate knowledge of statistical concepts,

methods, and techniques to conduct research in an efficient manner and to draw valid conclusions.

1.6 STATISTICS IN EXERCISE SCIENCE AND HEALTH

No academic discipline can grow without advancement in research; this is true for exercise science and health as well. One of the important dimensions of research is the design of the experiment. Proper statistical design used in a study helps the researcher to isolate the factors responsible for the performance in any event. Further, using appropriate statistical design reduces overall error in the experiment, giving more reliable conclusions. New techniques in different sports can be tested against the existing technique for better results by using an appropriate statistical technique. For instance, in comparing the effectiveness of three different warm-up exercises on a 400 m performance, one may plan a completely randomized design where the subjects may be randomly assigned to three different warm-up exercises. One-way analysis of the variance technique can be used to identify the best warm-up program for the 400 m event. Similar experiments can help to determine the best duration of the warm-up program for the 100 m event. Thus, the development of new techniques and strategies in sports is the result of research experiments conducted over a period of time.

Different statistical techniques are used to solve varieties of research problems in exercise science. For instance, development of test batteries for measuring the concept of motor fitness, athletic fitness, general fitness, and specific fitness in different sports requires factor analysis technique to solve the problem. Similarly, norms construction requires identification of the appropriate scaling procedure. Further, if a coach is interested in the extent of relationships between performance and independent parameters, partial correlation may be used whereas multiple correlation allows him to find the reliability in estimating the performance on the basis of certain known characteristics. To find the optimum training load for different levels of athletes, the experiment can be planned by using the proper statistical design.

To measure qualitative characteristics such as competitive anxiety, attitude toward sports, knowledge of health education, and self concept, questionnaires can be developed. These questionnaires are developed using statistical techniques such as item analysis including difficulty rating and index of discrimination along with the reliability analysis. Further, keys may be developed by using statistical techniques such as factor analysis. Most of the statistical techniques mentioned in this chapter are discussed in detail in different chapters of the book. Thus, we see that any advancement in exercise science and health is not possible without statistical aids.

Every academic discipline has different research requirements; exercise science and health too demand separate attention from a statistical point of view. To give specific focus to the problems in this area this book has been titled *Statistics for Exercise Science and Health with Microsoft® Office Excel®*.

Check Your Progress

Note: Tick the correct answer by using the sign ($\surd$)

		True	False
1.	Statistics is the function of population values	–	–
2.	*t*-statistics is used for testing of hypothesis	–	–
3.	Population is an aggregate of all the items	–	–
4.	Statistics can be used to denote the distribution used in the analysis of data	–	–
5.	If the sample is not random, population characteristics cannot be estimated from the statistics computed from sample observations	–	–
6.	Inferential statistics is used for drawing conclusions about population characteristics	–	–
7.	Descriptive statistics describes population characteristics	–	–
8.	The mean μ and standard deviation σ are known as population statistics	–	–
9.	Statistics describes sample characteristics	–	–
10.	The mean, $\bar{x}$, and sample standard deviation, s, are known as sample statistics	–	–
11.	Statistics provides scientific explanation to research findings	–	–
12.	The statistics t, F, and Z are known as comparative statistics	–	–
13.	Multiple correlation is a predictive statistics	–	–

1.7 COMPUTING WITH EXCEL

1.7.1 Installing Analysis ToolPak

While using Excel for analyzing data you must check that the Add-ins "Analysis ToolPak" is already installed in your Excel. Without its installation, you cannot use the functionality discussed in various chapters of this book. Follow the steps given while installing this ToolPak in your Excel:

1. After starting the Excel in your system, click the sequence of commands.

Office button ⟶ Excel Options ⟶ Add-Ins

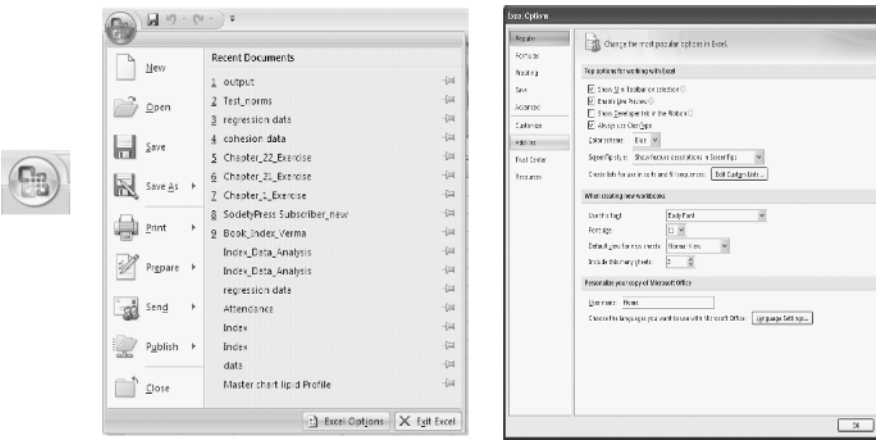


Figure 1.1 (a–c) Sequence of commands in installing Analysis ToolPak.

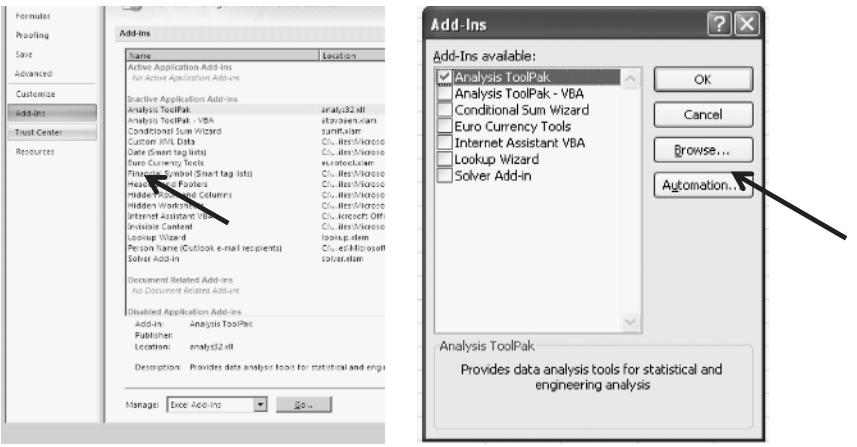


Figure 1.2 (a,b) Options for installing Analysis ToolPak.

While clicking these commands, you will see the following screens in sequence as shown in Figure 1.1(a–c).

2. After clicking the **OK** in Figure 1.1(c) you will get the screen as shown in Figure 1.2(a). By scrolling choose the option **Analysis ToolPak** and then select the option **Excel Add-Ins**. Click **OK** to get the screen as shown in Figure 1.2(b). Select the **Analysis ToolPak** and then click **OK** to get it installed.
3. Restart the Excel to use the functionality of Analysis ToolPak.

	A	B
1	*SLong_Jump*	
2		
3	Mean	64.5
4	Standard Error	1.087811
5	Median	64.5
6	Mode	65
7	Standard Deviation	3.439961
8	Sample Variance	11.83333
9	Kurtosis	-0.71601
10	Skewness	0.081888
11	Range	11
12	Minimum	59
13	Maximum	70
14	Sum	645
15	Count	10
16	Largest(1)	70
17	Smallest(1)	59

Figure 1.3 Dataset in the column B which is required to be formatted.

1.7.2 Formatting Cell Entries in Excel

Most of the time when you compute various statistics using Excel, it shows you long scores in fraction such as 1.087811258, 3.43996124, 11.83333333, and −0.716014396. This disturbs the whole formatting. You can format the cell entries by the following command sequence. Let us consider the following output generated in Excel while computing descriptive statistics as shown in Figure 1.3.

Let us see how scores in the second column as shown in Figure 1.3 can be formatted.

Select the second column by clicking the mouse on the column label B and right click the mouse to get the option **Format Cells** as shown in Figure 1.4

Clicking the option **Format Cells** in Figure 1.4 will take you to Figure 1.5 to decide on the number of decimal places in your output. Select 2 or anything else as per your requirement. Let other options be selected by default. Click **OK** to get your desired formatted output as shown in Figure 1.6.

After choosing the option in Figure 1.5, the final output looks like what is shown in Figure 1.6.

1.7.3 Initiating Computation with Excel

Excel can be used for simple as well as advanced computing. One must understand its basics to exploit its full potential. The following example will make you learn how to add, subtract, multiply, divide, and compute mathematical expressions.

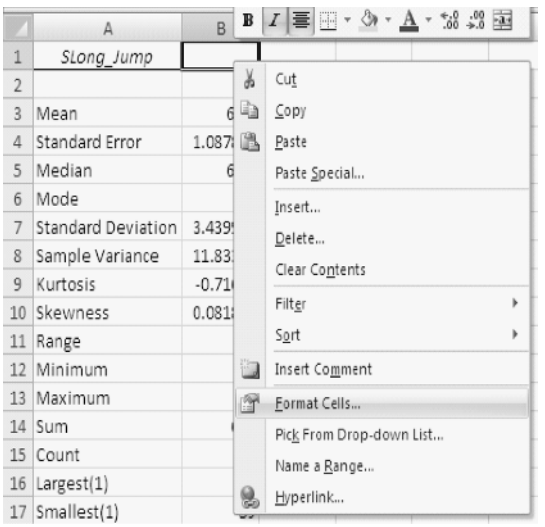


Figure 1.4 Choosing the option for formatting data.

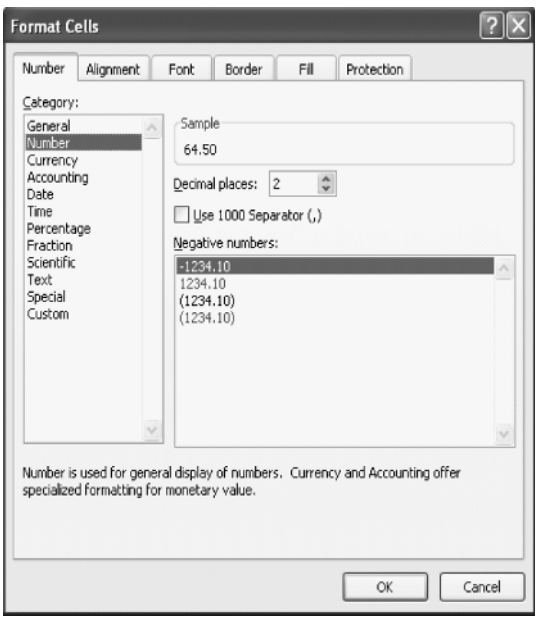


Figure 1.5 Choosing the option for deciding decimal places and other specifications.

	A	B
1	*SLong_Jump*	
2		
3	Mean	64.50
4	Standard Error	1.09
5	Median	64.50
6	Mode	65.00
7	Standard Deviation	3.44
8	Sample Variance	11.83
9	Kurtosis	-0.72
10	Skewness	0.08
11	Range	11.00
12	Minimum	59.00
13	Maximum	70.00
14	Sum	645.00
15	Count	10.00
16	Largest(1)	70.00
17	Smallest(1)	59.00

Figure 1.6 Final output in a formatted form.

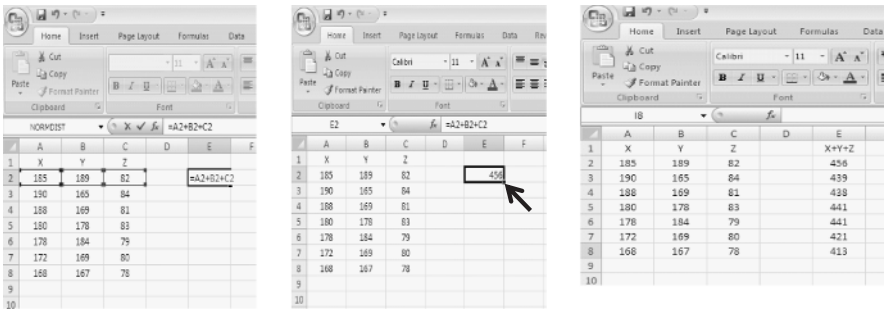
Example 1.1 Following are the data on height (cms), weight (lbs), and arm length (cms) obtained on male athletes in a college.

Height (X)	185	190	188	180	178	172	168
Weight (Y)	189	165	169	178	184	169	167
Arm length (Z)	82	84	81	83	79	80	78

Compute the following:

i. $X+Y+Z$
ii. $X-Y$
iii. $X \times Y$
iv. $\sum X$, $\sum Y$, and $\sum Z$
v. $\sum X^2$, $\sum Y^2$

Solution: To compute the above-mentioned expression, first, the three sets of scores should be typed column-wise in the Excel sheet.



(a) (b) (c)

Figure 1.7 (a–c) Steps in computing $X+Y+Z$.

i. Computing $X+Y+Z$
To find the value of this expression, do the following:
   a. Type the formula = **(*A*2+*B*2+*C*2)** in the cell $E2$ as shown in Figure 1.7(a). $A2$, $B2$, and $C2$ are the cell addresses of the first athlete's data on the three variables X, Y, and Z, respectively.
   b. Click Enter key after the command to get the first subject's data on three variables added in the $E2$ location as shown in Figure 1.7(b). Kindly note that unless the = sign is typed, Excel will not understand this as a formula.
   c. Drag the black dot located in the right corner at the bottom of the cell $E2$ downward to compute the expression for other subjects as shown in Figure 1.7(c).

ii. Computing $X-Y$
This can be computed by using the formula = ***A*2−*B*2**. Other processes shall remain the same as discussed in the first problem. This computation is shown in column E of Figure 1.8.

iii. Computing $X \times Y$
This can be computed by using the formula = ***A*2**B*2**. In Excel, star(*) is used as the operator for multiplication. Other processes remain the same. This computation is shown in column F of Figure 1.8.

iv. Computing $\sum X$, $\sum Y$, and $\sum Z$
These expressions can be quickly computed by using the $\sum$ command in the header of Excel. To get the sum of the data in a column, place the cursor just below the data set and click $\sum$ command in the header. Clicking the enter key will give you the value of the sum of that variable. This has been shown in Figure 1.8.

v. Computing $\sum X^2$, $\sum Y^2$
These expressions can be computed by using the following formula = ***A*2^2**. The cap "^" command is used to find the power of the variable and can be

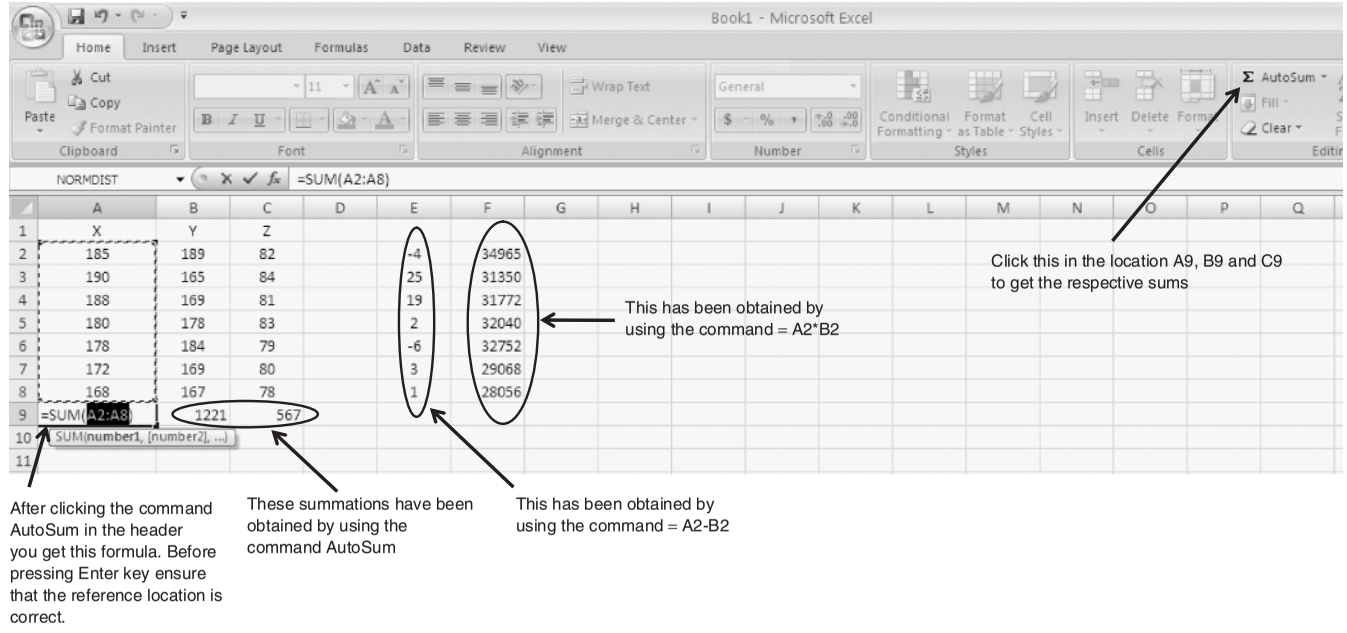
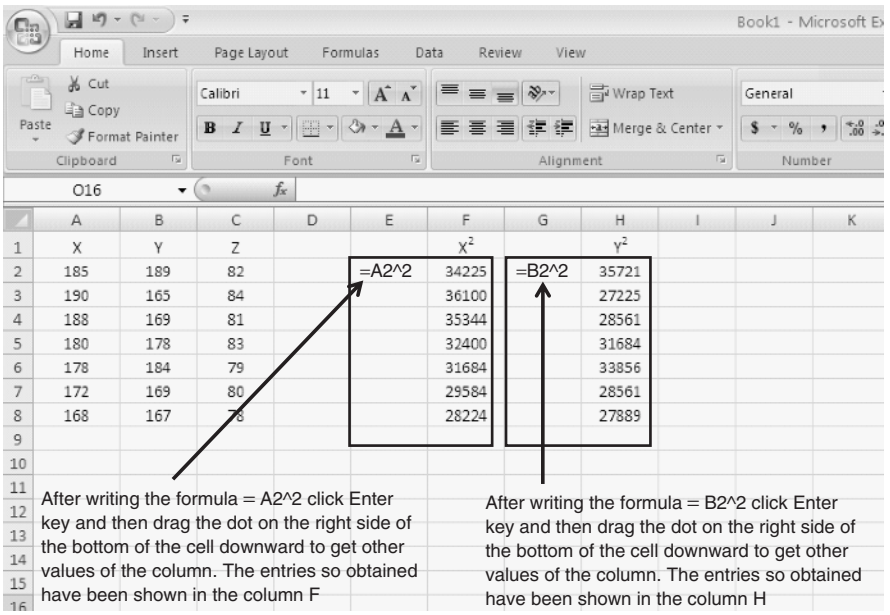


Figure 1.8 Computing process in subtraction, multiplication, and addition.



	A	B	C	D	E	F	G	H	I	J	K
1	X	Y	Z			X^2		Y^2			
2	185	189	82		=A2^2	34225	=B2^2	35721			
3	190	165	84			36100		27225			
4	188	169	81			35344		28561			
5	180	178	83			32400		31684			
6	178	184	79			31684		33856			
7	172	169	80			29584		28561			
8	168	167	78			28224		27889			
9											
10											
11											
12											
13											
14											
15											
16											

Figure 1.9 Computing process in sum of squares.

created by using the key available in the keypad. These computations have been shown in Figure 1.9.

IMPORTANT DEFINITIONS

Statistics may be defined as an applied science that deals with the collection, analysis, and interpretation of data.
Population can be defined as the collection of individuals, objects, events, or item of interest.
A ***sample*** is a subset of a population.
Parameters are the statistical constants that are used to describe the characteristics of the population and are denoted by Greek letters such as μ and σ.
Statistic is a function of sample observations and is denoted by roman letters such as $\bar{x}$ and s.

The objective of statistics is mainly to study the population characteristics based on the sample observations obtained from the population of interest.

KEY TERMS

statistic	understanding statistics	statistical processes
parameters	population	

CHAPTER EXERCISE

1. Give two examples in sports for each of the data types: nominal, ordinal, interval, and ratio.
2. Classify each of the following as nominal, ordinal, interval, or ratio data.
   i. The time required to score a century in a cricket match.
   ii. Scores in a basketball match.
   iii. The ranking of volleyball players by the judges.
   iv. The marks of students in a class.
   v. Height of a player.
   vi. The number of hours a sportsman practices.
   vii. Student's categories: 1, General; 2, SC/ST; 3, OBC; 4, Handicapped.
   viii. Rating of players on a five-point scale based on playing ability.
   ix. The reaction time of an athlete.
   x. Assessment of anxiety on a five-point scale.
3. Elaborate a situation where a researcher in exercise science may organize a descriptive study.
4. Give a specific example of data that might be gathered from each of the following areas: training methods, coaching, yoga, fitness, and talent identification.
5. Suppose you are the head of a teaching organization that runs exercise science courses. Give an example of how you could use descriptive statistics to make better administrative decisions. Give an example of how you could use inferential statistics to make better management decisions.
6. What do you mean by statistical process? Discuss different types of statistical processes with suitable examples in the field of exercise science.
7. Explain the need for statistics in research.

ANSWERS

Check Your Progress

1. F	3. F	5. T	7. F	9. T	11. T	13. T
2. T	4. T	6. T	8. F	10. T	12. T	

Chapter Exercise

2. i. Ratio
   ii. Ratio

iii. Ordinal
iv. Ratio
v. Ratio
vi. Ratio
vii. Nominal
viii. Interval
ix. Ratio
x. Interval

FURTHER READING

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