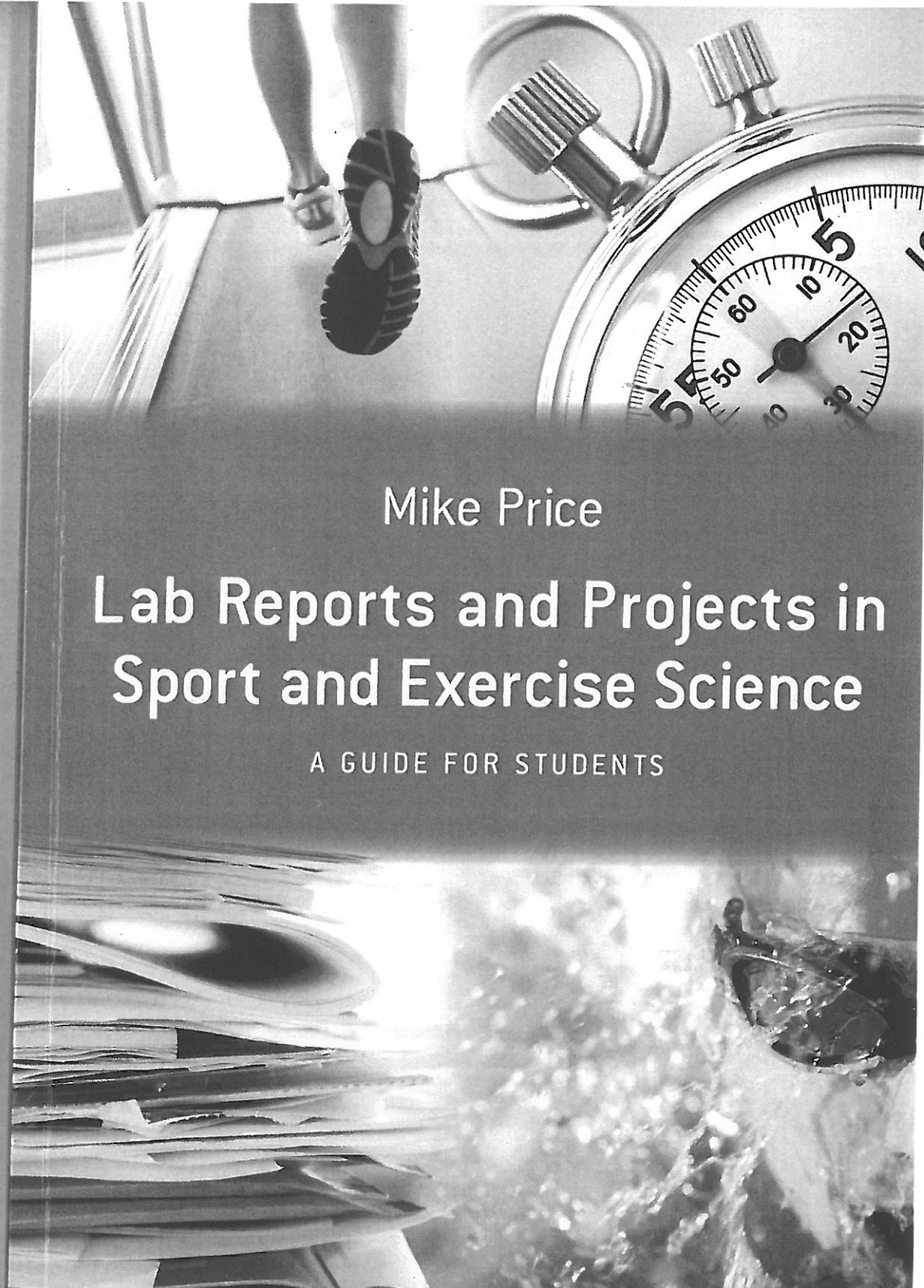




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Lab Reports and Projects in Sport and Exercise Science

A GUIDE FOR STUDENTS

ALWAYS LEARNING

PEARSON

2013.

To determine the significance of a correlation you can obtain the P value directly from the given statistical output (such as correlation in SPSS or via linear regression in Excel) or look up the r values required to achieve significance from statistical tables. For the latter you will require the degrees of freedom (usually $n - 2$ as the data is paired) and the desired level of significance (i.e. $P < 0.05$ or $P < 0.01$). Most research methods and statistics textbooks provide such tables and are relatively easy to use. From these tables you will notice that as the number of data pairs increases (i.e. a greater number of participants) the correlation required for significance decreases. Conversely, if you desire a greater level of significance (e.g. $P < 0.01$ rather than $P < 0.05$) the r value required is also greater.

A final way to determine the strength of a relationship is using the r^2 value, as mentioned earlier in the section on scatter plots (Section 4.2.3). This is simply the r value multiplied by itself and indicates the amount of variation in one variable explained by the other variable (for further explanation see any research methods or statistics textbook). A correlation of $r = 0.97$ provides an r^2 of 0.94 (meaning 94% of the variation is accounted for, 6% is unaccounted for), whereas a correlation of $r = 0.62$ provides an r^2 of 0.38. Here there is much weaker relationship with a lot more of the variation between variables being unaccounted for.

4.4.1.iii Describing the results of correlation analysis

From the correlation table above (Table 4.8) you can see that the correlation is large. The relationship between variables also turns out to be significant. Complete Exercise 4.6 by describing the correlation.

Exercise 4.6: Describing correlation results

Describe the results from the correlation outputs provided above. You should consider reporting the size of the r value, whether it is statistically significant and the direction of the relationship (i.e. does one value increase as the other decreases?). Use mean and standard deviation values in your description. Written examples are provided in Appendix 3C.

Description:

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4.4.2 T-tests

T-tests are used to determine the difference between the means of two values. These may be for the same participants undertaking the same tests on two occasions (e.g. electromyography activity during a maximal dead lift before and after a period of weight training), different participants performing the same tests (e.g. motivation to train in elite and non-elite athletes) or comparing a group's score to an established criterion or standard (e.g. cholesterol measurements in a group of athletes compared to national averages). These examples represent the use of paired (dependent) t-tests,

unpaired (independent) t-tests and differences between a sample and population mean, respectively. The first two tests are much more common than the last.

4.4.2.i Main output from t-tests

The key parameter you will obtain from your t-test output is the 't' value and its associated significance (P value). The majority of studies simply report whether the difference between variables was significant, i.e. was the value less than or equal to $P = 0.05$? You do not have to report the whole results table. Look at any journal article that has used a t-test analysis and observe how the authors have presented their data. An example t-test output from Excel is shown in Table 4.10. These results are obtained from a hypothetical study examining motivation to train in elite and non-elite athletes. A 'Motivation to train questionnaire' was completed by each athlete. The questionnaire produced values between 0 and 25, with higher values representing greater motivation.

Within the results table for t-tests you will usually have significance values for both one-tailed and two-tailed tests. If you already know, from your literature review and hypothesis, the likely direction of the comparison then you should concentrate on the one-tailed value. For example, maximal strength in elite weightlifters compared to non-elite. If you do not know the possible direction, such as pre-match anxiety levels in male and female hockey players, then concentrate on the two-tailed result. For our example we could assume that elite athletes would be more motivated to train – although this may not always be the case!

4.4.2.ii Describing results from t-tests

Table 4.10 shows a typical t-test output from Microsoft Excel for the example of motivation to train in elite and non-elite athletes. The resultant t statistic is shown as $t = 5.95$. If you are checking significance by using statistical tables this value would

Table 4.10 Example t-test output from Excel (using the two-sample assuming equal variances option). The output is shown as it would appear in Excel

t-test: two-sample assuming equal variances		
	<i>Elite</i>	<i>Non-elite</i>
Mean	20.2	12.1
Variance	5.733333	12.76667
Observations	10	10
Pooled variance	9.25	
Hypothesised mean		
Difference	0	
df	18	
t stat	5.955238	
P(T<=t) one-tail	6.18E-06	
t critical one-tail	1.734064	
P(T<=t) two-tail	1.24E-05	
t critical two-tail	2.100922	

All you need to know for this output is that the difference between both one- and two-tailed tests is significant

have to be equal to or greater than the critical value within the tables for it to be significant (i.e. 1.73 for a one-tailed test and 2.10 for a two-tailed test at the $P < 0.05$ level of significance). As our value is greater than the critical value our means are statistically significantly. However, the table shows the actual P values for both one-tailed ($P = 6.18\text{E-}06$) and two-tailed ($P = 1.24\text{E-}05$) tests so you don't have to consult any further statistical tables. In Table 4.10 the P values are expressed to the power of E-06 and E-05. This format is mathematical shorthand and indicates the number of zeros following the decimal point before you get to '124' for the one-tailed test or '618' for the two-tailed test. In other words $P = 0.00000618$ and $P = 0.0000124$, respectively. The use of 'E' means that the output does not have to show all the zeros – if a response is highly significant there can be quite a lot of these. Generally, if the result is reported as 'E-' it is likely to be significant. Other statistical software, such as PASW (previously SPSS), may just show $P = 0.000$. Table 4.10 also shows the degrees of freedom (df) for the test. When describing t-test results you may see the actual t value provided along with the degrees of freedom (df) in brackets such as ' $t_{(18)} = 5.95$ ' for the example shown in Table 4.10.

From the t-test outputs in Table 4.10 you can see that both the one- and two-tailed comparisons are significant. Complete Exercise 4.7 by describing the t-test results.

Exercise 4.7: Describing t-tests results

Describe the results from the t-test output provided above. You should consider reporting whether the P value (and t value if appropriate for your study area) is statistically significant. If the result is significant, state which variable is greater/smaller, depending on the research question. Please note that reporting greater motivation to train in the elite or lower motivation in non-elite athletes is essentially the same result, so try not to duplicate the findings. Use mean and standard deviation values in your description. Written examples are provided in Appendix 3C.

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4.4.3 Combination of correlation and t-test analysis

For some data sets it is useful to undertake both correlation and t-test analyses (providing you have paired data). This is particularly so for examining how repeatable responses are. For postgraduate students it is good practice to know the repeatability of each exercise test or measure that you use. We have already used the example of $\dot{V}O_{2\max}$ values being produced from an established exercise protocol and a new exercise protocol (Section 4.2.3.i). Here, you would hope that when tested twice using the same test, on separate days with sufficient recovery between tests, that similar values would be achieved. You would expect those participants who performed well on the first trial to also perform well on the second trial (giving a high correlation, Figure 4.10,

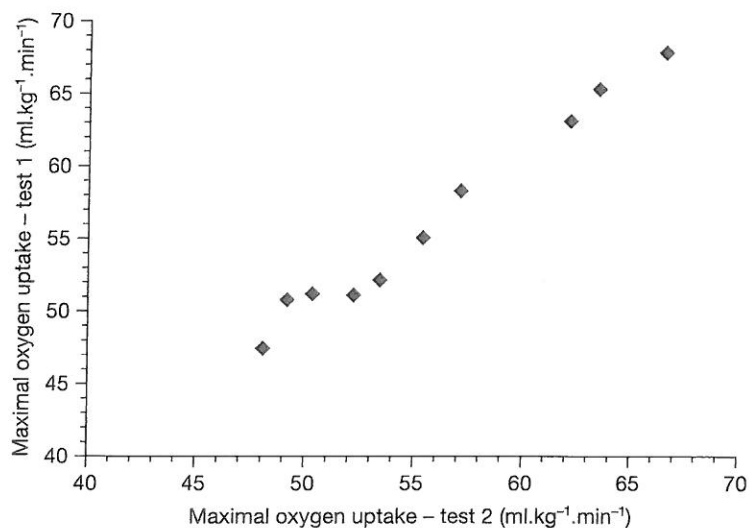


Figure 4.10 Maximal oxygen uptake during two exercise protocols

Table 4.11 t-test output from Microsoft Excel for maximal oxygen uptake during exercise on two separate occasions. The two-tailed significance is considered here (bold row) as we are not sure which test value would be correct

t-test: two-sample assuming equal variances		
	Test 1	Test 2
Mean	55.77	56.24
Variance	40.62233	49.16044
Observations	10	10
Pooled variance	44.89139	
Hypothesised mean		
Difference	0	
df	18	
t stat	-0.15686	
P(T ≤ t) one-tail	0.438552	
t critical one-tail	1.734064	
P(T ≤ t) two-tail	0.877104	
t critical two-tail	2.100922	

$r = 0.989$; $P < 0.05$) with no difference between the values (as determined from a t-test, see Table 4.11). If you are interested in the repeatability of test data you should research techniques such as Limits of Agreement (Bland and Altman, 1986, 1995).

In reporting the results you could state the following:

There was no difference between trials for $\dot{V}O_{2\max}$ ($P < 0.05$) and a significant correlation observed between trials ($P < 0.05$).

Alternatively you could write:

There was no difference between trials for $\dot{V}O_{2\max}$ ($t_{(18)} = -0.15$; $P < 0.05$) with a significant correlation observed between trials ($r = 0.989$; $P < 0.05$).

Exercise 4.8: Combining difference and relationship analysis

Consult a range of journal articles that examine the reliability or validity of the procedures involved in your project. These studies will potentially have used both t-test and correlation analyses. For each study complete Table 4.12. Include enough detail within the 'Main aim' column so that you can see why the authors have used the given statistical test. In the 'Written description' column comment on how the authors have reported their data.

Table 4.12 Summary of study results combining difference and relationship analysis

<i>Statistical test used</i>	<i>Authors</i>	<i>Main aim</i>	<i>Written description</i>
t-test			
Correlation			
t-test and correlation combined			

4.4.4 Analysis of Variance (one-way analysis of variance)

Most students are confident with the use and reporting of correlations and t-tests. It is after this point when the analysis gets more complex that many students feel a little bemused, such as with analysis of variance. Analysis of variance (ANOVA) is an extension of the t-test but this time the key value is the F ratio and its associated significance. Let's first review when to use ANOVA.

The first aspect of ANOVA that often confuses students is when to use it. Consider the number of comparisons that you have. For example, if we were interested in the long jump distance (dependent variable) of different groups of athletes, and there were just two groups of athletes (e.g. elite vs. non-elite), then there would be only two sets of data and you would probably use a t-test. If you had a scenario where there was the possibility of using more than one t-test (e.g. long jump distance in three groups of athletes (e.g. under-19, under-21 and senior athletes) resulting in three possible comparisons (i.e. under-19 vs. under-21; under-19 vs. seniors; under-21 vs. seniors)

Exercise 4.13: Producing your own written description

Using the pointers in Exercise 4.12 produce a written description for your own ANOVA data. For extra practice you could also consider writing a results section for each of the typical lab class examples used throughout this book.

Written description for your own data:

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4.5 Don't be afraid of error messages!

Most statistics packages or spreadsheets with statistics options normally provide error messages if something is not quite right with the data set-up or analysis procedures. Although these are designed to help you they may seem daunting at first glance and mean little to you. However, with a little thought you can usually work out what the problem is. For example, Excel will tell you that 'Output will overwrite existing data' if the output region for the statistics analysis will cover something else already on your spreadsheet. In this instance all you have to do is to direct your output to a different cell or area on your spreadsheet or to a new spreadsheet. Also, as noted earlier, for two-way analysis of variance in SPSS you may get the message 'No post hoc results for group as fewer than three groups'. This just means that there are only two groups to compare for main effects, the results for which you would already have from your two-way ANOVA output. If you had three or more groups to compare this would not appear.

4.6 Common errors in results sections

There are a number of common errors that many students display when writing their results sections. The following are the most common to be avoided. Doing so will not only help to improve the flow of your results section but also your marks for this section.

4.6.1 Discussing results

Within your results section you should only present and describe the results. It is very common for students to try and explain or discuss their results within the results section. Try to avoid this as you have a discussion section specifically for this purpose.

4.6.2 Reporting variables not described in the methods

You need to ensure that all of the results you present have been adequately described in the methods. Conversely, you also need to ensure that all of the variables described in the methods are reported in the results. Otherwise, what was the point of measuring them? Even if variables do not result in any significant differences a single sentence may be all that is required to inform the reader of the main finding.

4.6.3 Duplicating data in tables and figures

Avoid duplicating your data by presenting results in both figure and table formats. The description of your data should be sufficient to provide the key responses and any specific values of interest.

4.6.4 Poor description of the results

Poor written descriptions do not help demonstrate the key findings of the study. Always make sure that you have reported the key statistical results and any values which aid this description. In addition, the actual statistical outputs from each test (i.e. the output tables) are seldom required in written reports. You may need these tables within your project lab file as evidence of data analysis or even as appendices (check your coursework guidance) but they are not usually contained within the results section per se. A common error is when your data may look as if it would yield a strong correlation but you have not actually undertaken a correlation analysis. Here many students state that 'there is a positive correlation' but if you have not done the analysis it is better to state that there is 'a linear relationship'.

4.6.5 Unclear reporting of statistics

If you are not confident with the statistical analysis it is likely that you will also not be confident in reporting the key findings of each test. Try to keep the message simple. Focus on stating whether the results for each test were significant in conjunction with reporting whether the P values were greater or less than 0.05. Also make sure that you have the greater than (>) and less than (<) symbols written correctly. Confusing these symbols could have important implications on your results and demonstrate a lack of understanding of statistics. It is becoming more common for authors to report the actual P value rather than simply ' $P < 0.05$ ' or ' $P > 0.05$ '.

4.6.6 Repeating the statistical tests used

You do not have to repeat the statistical tests undertaken as this will have been described in the methods section.

4.6.7 Inconsistent reporting of values and units

As noted in the methods it is important to use the correct units for all variables and an appropriate number of decimal places. It is also important not to forget to state the standard deviation values with each mean value reported.

4.6.8 Lack of reference to figures and tables

If you have figures and tables in your report it is important to state which figure your particular description relates to (see the example written descriptions earlier in this

chapter). If figures and tables are not labelled clearly the flow of the results from the perspective of the readers or assessors will be affected.

4.7 Chapter summary and reflection

This chapter considered different ways of analysing and presenting your results. Different types of figure may be more effective than others in displaying the key findings of your study. The main statistical tests for different types of research design were also considered. This chapter also considered how to write your results section through a series of exercises relating to each statistical test. To assess your understanding of results sections answer the following summary questions:

- What is the purpose of a results section?
- What are main ways of expressing your key findings?
- How do your results reflect your research question or hypothesis?
- What are the common errors when writing results sections?

4.8 Further activities

Go to the website of a journal that you regularly read or are aware of. Find the author guidelines and consider the advice given for writing results sections.

Use the critical appraisal tools in the introduction chapter to evaluate your own results section.

Consult your lab schedule and ensure that you understand the expected results for each variable you have measured.