

Summary

Contents

Subject index

< [BACK TO TABLE OF CONTENTS](#)

Experimental research strategy

By: [Mark F. Smith](#)

In: [Research Methods in Sport](#)

Chapter DOI: <https://doi.org/10.4135/9781526433992.n4>

Subject: [Research Methods](#), [Research Projects](#), [Culture, Sport & Leisure](#)

Keywords: [experiments](#); [independent variables](#)

 Hide page numbers

[Page 63]

Experimental research strategy



Learning objectives

By identifying research situations for which an experimental research strategy would be applied, this chapter is designed to help you:

- grasp the basic concepts that underpin an experimental research strategy and identify the relative merits of this approach;
- identify how an experimental type and design impact on the validity of research findings;
- link research design with appropriate data collection and analysis techniques.

[Page 64]

Introduction

For the researcher interested in sporting behaviour and its causes, an experimental research strategy presents an ideal approach. Through observation of the sporting world around us, many research ideas emerge that lend themselves to experiments. By applying the scientific method of inquiry, the experimental strategy enables the researcher to discover the effects of presumed causes. What causes an increase in maximal oxygen uptake after training? Or, what is the effect of topspin on a tennis ball? The key feature of experiments is that, through the deliberate alteration of something, the researcher is able to see what happens to something else. This is something people do all the time, for example, going to the gym to get fitter. The experimental approach, however, differs from this causal relationship, as it makes a deliberate attempt to make observations free from bias.

The purpose of this chapter is to provide clear explanation as to when and how the experimental research strategy should be applied to answer particular research questions. An outline of the key features of the experimental strategy will establish a framework by which the researcher can identify different experimental types and designs. Through the understanding of experimental research methods, appropriate data collection and analysis techniques can form part of the overall strategy. Although it is not the intention of this chapter to

explore statistical techniques relevant to experimental research, an overview of how design and suitable statistical techniques link together will be covered. By the end of the chapter you should have grasped a step-by-step approach to experimental research.

The importance of experimentation in sport research

Through the study and practice of sport, problems emerge that necessitate an experimental research approach in order to find a solution. As covered in [Chapter 1](#), selecting the most suitable research strategy depends heavily on the nature of the research question. The experimental research strategy is a quantitative approach designed to discover the effect of presumed causes. By the very nature of deductive research, the application of the scientific method of inquiry attempts to test theory by subjecting it to different conditions. Experiments in sport provide the researcher with that very opportunity.

Examination of sporting behaviour and attempts to discover the underpinning causes to the effects observed enable the researcher to test theories, such as how we fatigue during exercise, or how we experience peak flow during performance. Aside from the theoretical testing that is an inherent part of experimental research, a practical, more applied perspective also has an important place within sport-related experiments. By discovering the causes of improved aerobic fitness, increased muscle mass or reduced concentration, for example, new training approaches, enhanced performance tools, more specific exercise guidelines or additional assessment strategies may be generated.



Key point 4.1

Experimental research can be defined as research that attempts to identify cause-and-effect relationships between phenomena.

[Page 65]

Establishing causality through experiments

One of the key characteristics of the experimental research strategy is that of cause and effect. Quite simply, the overall purpose of any experiment the researcher conducts is to determine with as much confidence as possible what may have caused an effect. The effect may be an increase in strength, a lowering of heart rate, a quickening of reaction or a slowing of pace. Whatever the effect happens to be, the experimental strategy attempts to determine what the cause was by deliberately altering one thing (e.g. training, recovery, caffeine consumption or intensity). By altering only one thing (i.e. variable), while trying to keep all other things (variables) constant, the researcher can begin to gain confidence that if an effect is seen it is more likely to be due to the thing that was altered. In comparison to qualitative research approaches, covered in later chapters, tightly controlled experiments are the only means by which cause and effect can be established.

It has already been noted that an experimental approach differs from a non-experimental one in that the researcher can establish cause and effect by deliberately altering or manipulating variables, while trying to keep all other variables constant or controlled. Such cause can be thought of as the independent variable and the effect the dependent variable. Experiments require the precise control of all variables except the independent variable.

Characteristics of the experimental approach

The experimental research strategy has a number of characteristics that distinguish it from other research strategies. In the attempt to discover the causation between phenomena, a number of conditions need to be met. These include control, randomisation and manipulation.



Experimental control

The concept of control within the experimental approach can take many different forms and have different usages within this methodological approach. Control refers to eliminating the influence of any extraneous factors or variables that could affect observations made on the outcome (the dependent variable). The purpose of control is to enable the experimenter to isolate the one key variable which has been selected in order to observe its effect on some other variable. Control within an experiment, therefore, allows the researcher to conclude that it is the cause, and nothing else, which is influencing the effect.

Being able to control external variables apart from the one under investigation (the independent variable) will provide confidence that change to the outcome variable was not down to other variables. For the researcher wishing to conduct experimental studies, control may take the form of:

- being in total control of the events that the participants experience;
- controlling the groups so that one does not experience the independent variable;
- controlling the variables so that the consequences of the independent variable can be clearly seen separated from other factors.

[Page 66]



Key point 4.2

'Cause and effect' refers to the link between one event (called the cause, *A*) and another event (called the effect, *B*), which is a direct consequence (the result) of the first (the cause). When determining a cause-and-effect link between two events, probability testing, that is to say, statistical tests, allow for a degree of certainty to be attained. This degree of certainty, or probability score (*P*), provides the researcher with an indication that the effect is a consequence of the cause; so therefore *A* probabilistically causes *B* if *A*'s occurrence increases the probability of *B*.

Randomisation

Randomisation within the experimental research strategy eliminates the influence of extraneous variables acting on one group and not on another. Randomly assigning participants to different groups or treatments provides the researcher with a degree of confidence that each group will be representative of the population from which it was drawn. It therefore has implications for generalising results of the experiment back to the population. Random assignment provides assurance that the extraneous variables are controlled and the bias across groups reduced.

Consider an experiment in which half the participants are in an exercise condition and the other half are in a no-exercise condition. Suppose that the participants are also different in a third factor, such as annual income. If the researcher wished to investigate the causal relationship between exercise and anxiety, for example, randomly assigning participants into the conditions would eliminate the influence of income differences between the conditions. Not randomly assigning participants to groups means that annual income may have an impact on anxiety, which could mask any causal relationship between exercise and anxiety. Ensuring that participants are assigned to different groups in a random way increases the internal validity of the experiment.



Key point 4.3



One of the easiest ways to assign participants randomly to groups is by allocating a number to each one, so say 1–20, and then asking a friend to call out a number between 1 and 20. You could either place the first ten numbers called into one group and the next ten numbers to another, or every other number. Although basic, this provides a quick and effective way of randomly assigning participants into your groups.

Experimental manipulation

If you create change within a controlled setting and then observe the resulting effect, you may be able to establish what the true cause of the change was. The implication of change in this context

[Page 67]

therefore is extremely important and distinguishes the experimental approach from other research strategies. This approach deliberately introduces change, which forms the core of the experiment, and such change is termed manipulation. Consider the flight of a football for one moment. The flight of the ball off the boot can make a number of different shapes, which are all caused by single or, more likely, multiple factors. These include the design of the boot, the boot material, the location of impact, the angle of impact and the speed of impact.

From an experimental perspective, the researcher may start by changing or manipulating these in isolation, keeping all other factors constant to see how they alter ball flight. Changing the material, for example, from leather to a rubberised compound may cause less ball spin off the boot and therefore reduce slice. Alternatively, changing the location of impact on the boot through relocation of the laces, for example, may cause the ball to travel faster for the same impact speed. Through manipulation and control, the researcher can begin to identify what causes alterations and therefore develop new approaches.

If researchers wished to explore the impact of agility-specific drills on a group of junior hockey players, they could apply manipulation to their study. The researchers could manipulate the type of practice (e.g. agility versus non-agility), the group (e.g. boys versus girls), or both. If, however, they were interested in how different types of music alter 5k running performance in elite runners they could manipulate the type of music (e.g. fast versus slow) that the runners listen to. Manipulation in this context refers to the purposeful change in one variable so that the effect on one or more other variables can be observed. This process allows the researcher the opportunity to begin testing theories and existing models, make improvements and predict future events or occurrences. With research questions wishing to determine whether any meaningful change exists between groups, conditions and/or across periods of time, the manipulation of one factor or variable can provide the researcher with an opportunity to determine the extent of an effect.



Reflection point 4.1

Validity is an important issue when it comes to applying the experimental approach to research. The two types that probably have the most impact on your research at this stage of your understanding are internal and external validity. [Table 4.1](#) gives explanations and some practical examples that will help your comprehension. These will be mentioned again throughout the chapter so it is important you understand what they mean and how they can impact on your research findings.

Another way to view manipulation within the experimental approach is through the deliberate administration of a treatment to a group in order to observe the response. The word treatment basically refers to something that the researcher imposes on to participants. For example, researchers may administer a co-ordination practice drill to one group and no practice drill to another to see how the drill changes the response – the junior players' hockey performance. Or they may administer a training programme, a sport drink or a different piece of sports equipment to a group. The main aim therefore is to attempt to keep all aspects of the situation constant except one; that being the one thing the researcher wishes to investigate or change (the effect the treatment has on a group of objects or participants).

This approach allows the researcher, in a very controlled way, to establish whether a meaningful effect caused by the treatment impacts those involved in the research.

Table 4.1 The meanings and applications of validity

Validity type	Description	Example
Internal validity	Provides the researcher with a level of confidence that the independent variable caused a change in the dependent variable	Julie conducted a laboratory experiment to investigate the impact of sound on reaction time. She ensured that as many factors as possible were kept constant for all assessments apart from the one she was interested in – sound. In this instance Julie had a <i>high level of internal validity</i> as any change in reaction time would be a consequence of the type of sound and no other factor
External validity	Concerns the degree to which the conclusions in the research study would hold for other persons in other places and at other times	Henry conducted a field-based experiment to investigate the impact of membership promotion type on recruiting new gym goers. He wished to ensure that his study was set in as natural an environment as possible so that he could generalise his findings. He recognised that due to the research setting and the <i>high degree of external validity</i> he was unable to control for many factors and this would lower his confidence in concluding that the promotional type caused change in new gym members

[Download Table as .xlsx](#)

[Download Table as .csv](#)

[Download Table as .pdf](#)

To find out more about the meaning and application of validity within the experimental strategy a number of resources can be consulted. Research Methods Knowledge Base (2006) offers a no-nonsense explanation regarding validity in research. Alternatively, for a more thorough grounding, the textbook of Christensen et al. (2014) *Research Methods, Design, and Analysis* and Cozby and Bates's textbook, *Methods in Behavior Research* (2012) offer a clear overview of the definition and practical implications of validity when the experimental strategy is applied.



Learning activity 4.1

Read through each of the research projects (below) devised by students studying courses relating to sport and exercise science. Try and identify the independent variable and dependent variable for each study by highlighting each in a different colour. *Remember, the independent variable is what you wish to manipulate or change and the dependent variable is what you will be measuring.*

- Two groups (basketball vs. volleyball) completed a standing vertical jump to assess vertical distance (in metres) jumped.
- Three groups of pistol shooters (novice, intermediate and expert) were assessed for reaction time (milliseconds) during a manual tracking task.
- One group of darts players were assessed for accuracy (millimetres) before, during and after ingestion of caffeine.
[Page 69]
- Four groups of school children (ages 4–6, 7–9, 10–12, 13–15 years) completed three tests (trials 1, 2 and 3) to assess peak heart rate ($\text{beats} \cdot \text{min}^{-1}$) recorded during the hop, skip and jump game.
- Two groups of postgraduate sport science students completed seven 1.5-mile runs and had their rating of perceived exertion recorded immediately before, mid-way and on completion of each run.
- One group of well-trained cyclists completed five indoor 40-km cycling time trials during which power output (watts) was recorded at 10-km intervals.
- Six groups of second-year sport science students completed four tests during which motivation to work was assessed before and after hypnosis.

- One group of MSc sport coaching students completed three statistics exams with anxiety assessed before, 30 minutes during and 1 hour after each test.

Types of research experiment

For researchers undertaking experiments, it is a necessary part of the strategy to decide upon an experimental approach that will match the objectives of the research study. This means that they need to develop a plan that includes the research design type and the data collection and analysis methods. Before we discuss the different research designs, it is worth considering the three types of experiments and how they can be linked to sport research. The three are: true, quasi- and natural experiments.

True experiments

So far in this chapter we have focused on an experimental type that permits the researcher to control, in principle, all extraneous factors and variables except one – the one that is manipulated. Such an experimental approach is known as a true experiment and is considered the strongest approach of all experimental types. Providing a high degree of internal validity, the true experiment provides the researcher with the greatest level of confidence that any change observed in the dependent variable is a consequence of the independent variable and nothing else. In order to ensure internal validity, therefore, true experiments tend to occur in artificial settings, such as the sport and exercise science laboratory. However, the attempt to attain a high degree of internal validity will impact on the external validity of the study. This means that a true experiment may not reflect a real-life situation; the artificial environment distorts the real-life nature of observations.

The ability to move experiments outside the laboratory (e.g. on to the football pitch or within a school playground) allows for a more natural setting (field experiment). When the external validity of the study is increased, the findings may have more ecological significance, but control of many extraneous factors may not be possible. Such an approach can still be referred to as a true experiment but may be less ideal. As with a controlled laboratory experiment, the independent variable is still deliberately manipulated. However, it is not possible to have such tight control over all variables. If researchers wished to conduct a study in a natural setting, therefore, they must be aware of the external factors that, in addition to the independent variable, could change the dependent variable. The researcher must decide whether the benefit of increasing external validity, by setting the research in a more natural environment, outweighs the reduction in internal validity.

[Page 70]



Research focus 4.1

In a study by Bloms et al. (2016), a true experimental approach was selected to examine the effects of caffeine ingestion on squat jump height and jump execution in collegiate athletes. The study deployed a single-blind, randomised, cross-over design, where athletes consumed either caffeine ($5 \text{ mg} \cdot \text{kg}^{-1}$) or a placebo. In this study the independent variable was the condition to which the athletes were exposed (supplement vs. placebo) whilst the dependent variable (what was measured) was their performance (peak force and height) produced during three vertical and countermovement jumps.

In total, 25 athletes, aged between 18 and 23 years, were randomly assigned to one of the two conditions. Of all the athletes, 16 were not regular consumers of caffeine, whilst nine of the participants consumed caffeine on a regular basis in the form of coffee, energy drinks or pre-workout supplements. The treatments (either caffeine or placebo condition) were provided to the athletes 60 minutes before their jump assessments. Once they had completed their jumps, a period of 1 week passed, following which all athletes returned to the testing facilities and the other treatment was given to them (cross-over design). They then repeated the jump assessments as they had done on their first visit.

The results of the study indicated that, when exposed to a caffeine dose equivalent to $5 \text{ mg} \cdot \text{kg}^{-1}$ body weight, jump parameters significantly increased compared to the placebo condition. The execution of the squat and countermovement jump following the experimental treatment enhanced both height and execution of jumping.

Quasi-experiments

There are occasions when it is not possible to control, in principle, the influence of all extraneous variables as in the true experiment. Such an experimental type is known as a quasi-experiment. As with the true experimental type described above, this approach allows the researcher to examine the impact of an independent variable on a dependent variable, but causal inference is much more difficult. In most research instances, the use of a quasi-experimental approach results from the inability or lack of need to assign participants randomly into groups. This may be the case, for example, when the researcher wishes to compare particular groups (e.g. one school class against another).



Research focus 4.2

In a study by Larsen and colleagues (2016), a quasi-experimental approach was taken to assess the feasibility of standardising an exercise prescription for cognitive improvement, without reducing the fitness benefits of exercise. This between-group design started with a non-randomised sample of 49 females (mean age 48 years) who self-allocated themselves to one of three groups based on their own class time preferences. The three independent groups (independent variables) were treadmill-based walking, floor/step aerobics or stretching classes that took place over a period of 7 weeks. For this approach a number of dependents were measured. These included a cognitive test battery to measure executive function, attention, processing speed and a learning test (memory and recall). In addition, a single-stage submaximal treadmill walking assessment was used to measure cardiorespiratory fitness

[Page 71]

(maximal oxygen consumption). All participants completed these assessments at pre-intervention, mid-point during the intervention and following completion of the classes. Throughout the course of the experiment, the number of participants reduced from 49 to 27 by the post-exercise class assessment (aerobics = 8; treadmill = 9; stretching = 10).

Findings revealed that those participants who self-selected the floor/step aerobics class may experience greater cognitive gains, whilst still finding cardiorespiratory fitness benefits. Given that groups were determined based on class time preference, rather than a randomised allocation, this quasi-experimental approach may have resulted in bias towards a particular exercise intervention.

Natural experiments

A third type is known as a natural experiment and involves naturally occurring events rather than naturally occurring groups. This means that the researcher does not manipulate the independent variable like the true experiment; rather, a deliberate change is introduced that occurs naturally within the research setting for which the researcher is not responsible. Natural experiments, by their very nature, have low internal validity due to the inability of the researcher to control extraneous factors during the study. Because of this, the results of natural experiments are often difficult to generalise back to the population from which the study sample was drawn.





Research focus 4.3

In a study by Grandjean et al. (2002), a natural experimental approach was taken to examine an unintended 'experiment' on world-class gymnasts at the 2000 Olympics. During the women's all-around final, the vault apparatus was initially set 5 centimetres too low, potentially undermining the athletes' self-confidence. The 18 gymnasts who vaulted early in the competition became an unknowing experimental group. The remaining 18 vaulted after the error was corrected, becoming a randomised control group. For this between-group pre-post-test design there was only one independent variable: group. Both groups had pre-test scores (from preliminary rounds) and post-test scores (from the final) on each of the four apparatuses: vault, bars, beam and floor. From analysis of the data it is clear that the vault error had little, if any, effect on later performances or on the final standings. The researchers concluded that elite athletes in a closed-skill sport apparently learn to concentrate so well that most can recover from a mishap and refocus successfully for the next effort.



Learning activity 4.2

On reviewing the previous section you should now be more aware of how each experimental type has both advantages and disadvantages when it comes to considering the internal and external validity of the research. Now read carefully the studies outlined below and attempt to allocate the most appropriate

[Page 72]

experimental type to each. Remember that there may be more than one answer, so consider how the chosen experimental type and the associated degree of validity may impact on the accuracy of any inferences made as well as the applicability of the findings.

Study one

What does it take to win the London Marathon? An examination of champions' performance times over the last ten events.

Experimental type: _____

Study two

The effectiveness of seated leg exercises on lower-limb anterior cruciate ligament recovery time.

Experimental type: _____

Study three

The impact of ankle strapping on medial and lateral heel stability during the pedal cycle.

Experimental type: _____

Study four

The effect of multi-lateral versus unilateral reverse running on blood lactate recovery curves.



Designing the experiment

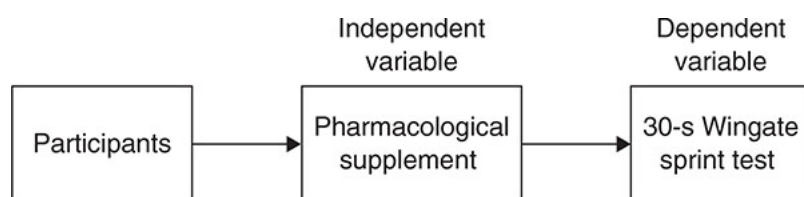
When considering the design of an experiment it is important for researchers to keep in mind the impact of diminished internal validity on the ability to support the conclusion that the independent and dependent variables were causally linked. If the degree of internal validity within the selected design is threatened, that's to say, it is low, then it is difficult to be confident that the independent variable caused any change in the dependent variable. Based on this premise, the researcher needs to be aware that the selected research design, based on the research question, can have a significant impact on the conclusions and inferences made.

Simple quasi-experimental designs

Probably the simplest experimental design is the *one-group post-test design*. This is considered quasi-experimental as it lacks an important element of a true experiment: a control or comparison group. For this approach the dependent variable is measured once in a single group (i.e. within-group) following a treatment (Figure 4.1). Consider a single group being given a pharmacological supplement over the course of 6 weeks and then having their exercise ability assessed. Although some valuable scientific data are produced, the omission of a pre-test before the treatment means that it is very difficult to know if the treatment changed the participants' ability or the change was a consequence of other extraneous factors not controlled for. Therefore, without a control group, it would be hard to say whether the same effects would have happened in the absence of the treatment. As a consequence, the internal validity associated with such a design is considered very low.

[Page 73]

Figure 4.1 A single one-group post-test quasi-experimental design.



[Download Image as .jpg](#)

Advancing the first design further, it is sometimes the case that the researcher wishes to evaluate change in a dependent variable within the same group across two occasions (Figure 4.2). By measuring participants before and after the introduction of a treatment a comparison can be obtained. This type of within-group approach is aptly named the *one-group pre-post-test design* and can be referred to as a repeated-measures design. This approach, although not featuring a control group, is still considered quasi-experimental, but internal validity is increased as the researcher now has a pre-test comparison to make observations against. Let's suppose the researcher wanted to investigate whether a 4-week plyometric strength-training programme increased the ability to throw a shot put from athletes' dominant side. A group of participants would be selected and they would complete the pre-test throw, then they would be given the plyometric training programme to complete. After the 4 weeks their performance would be reassessed (i.e. post-test).

Unlike the previous two quasi-experimental designs, the non-equivalent control group design employs a separate control group (i.e. between-group or independent group design), but the participants in the two conditions are not equivalent (Figure 4.3). Take the example of a sports nutritionist who wanted to investigate the impact of a dietary programme on weight management. All overweight members of a local health club, as recorded on their personal record sheets, were identified and recruited to the study. Those members who actively volunteered became the experimental group and those who did not, by default, became the control group. Although this approach provided a control group for comparison, because of the selection differences between groups, problems arose because those who volunteered may have differed in some important way from those who did not. This design would therefore make it difficult to know whether any change in the dependent variable was a consequence of the independent variable or not.

Figure 4.2 An illustration of a within-group pre-post-test design.

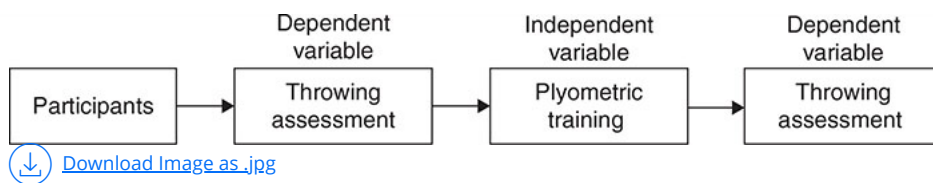
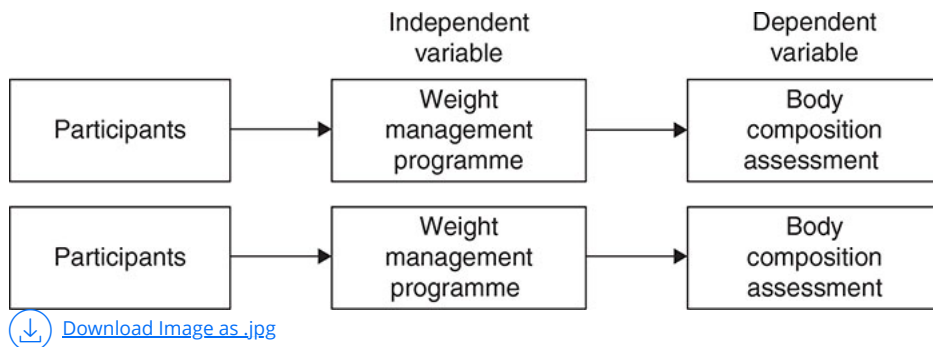
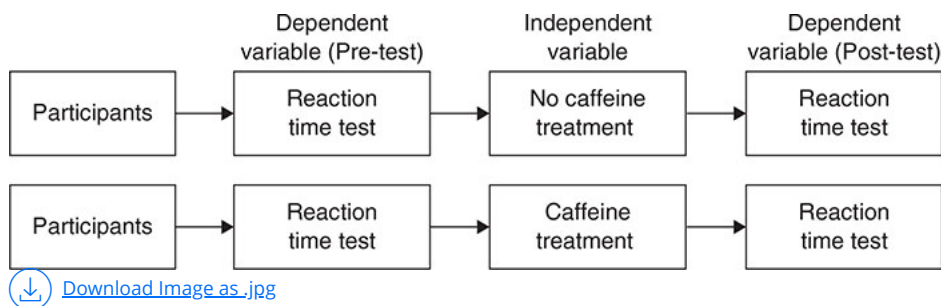


Figure 4.3 A between-group non-equivalent control group design with one independent variable (i.e. weight management programme).



[Page 74]

Figure 4.4 A between-group non-equivalent control group pre-post-test design with two independent variables (i.e. group and treatment condition).



To some extent, the design presented in [Figure 4.3](#) can be extended to incorporate a pre-post-test component ([Figure 4.4](#)). Although an extremely useful quasi-experimental design, this is still not as robust as a true experiment, as the participants have not been randomly assigned, therefore introducing bias. As illustrated in [Figure 4.4](#), although the change in the dependent variable can be assessed across each group, the groups may, by way of selection process, have characteristics that impact on that change (e.g. originate from an office where a high amount of coffee is drunk).

Simple true experimental designs

From the designs presented so far, quasi-experimental designs lack suitable participant randomisation and often appropriate control. With non-randomised allocation and the lack of control or comparative group, the threat to internal validity is increased and inference made difficult. Eliminating selection differences through the random assignment of participants to groups as well as the inclusion of a between-group factor provide a control or comparison group, and the researcher can begin to improve the degree of internal validity and ensure more confidence in the causal relationships between the independent and dependent variables.

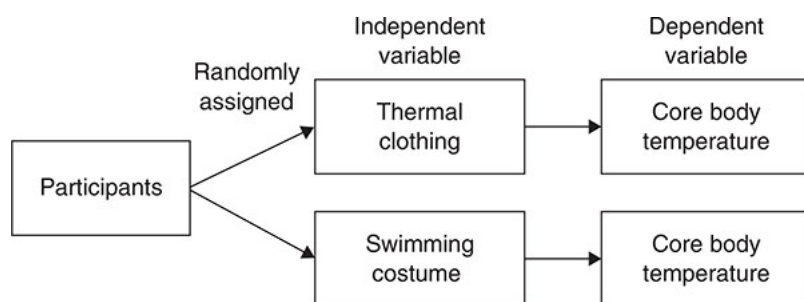
Similar to the post-test-only design ([Figure 4.1](#)), the between-group post-test design involves the random assignment of participants into either an experimental or control/comparative group. Used to eliminate any systematic bias, randomisation of participants in such design will reduce the impact of extraneous variables on the dependent variable. This is also known as an unrelated design because the two groups are not related to each other; they are separate and treated as two distinct groups. In the example illustrated in [Figure 4.5](#), one randomly assigned group wore thermal clothing during 30 minutes of cold-water submersion, while the control wore only their swimming costume. After the time was completed each group's core temperature was recorded.

As has already been noted regarding the one-group post-test design, this approach allows the researcher the opportunity to measure the dependent variable only once in each group and neglects any pre-test assessment. This thereby lowers the internal validity of the study. If the researcher had measured core temperature in each group before submersion then a pre-submersion value could be compared with post-submersion value. If the researcher were therefore to find that both groups' core temperature changed by the same amount as a

consequence of the 30-minute submersion, then they would have a high degree of confidence that the thermal clothing had no or little impact on the maintenance of core body temperature.

[Page 75]

Figure 4.5 An illustration of a between-group post-test design with one independent variable (i.e. clothing condition).



[Download Image as .jpg](#)

Take another research example. Suppose a researcher wished to investigate the impact of high-intensity fatiguing exercise on muscle activation patterns. By randomly allocating participants to two groups (experimental and control) the researcher firstly recorded all participants' lower-limb electromyographic patterns during a flexion and extension movement on an isokinetic dynamometer. Following this, the experimental group completed a 30-second Wingate test and the control group remained static on the ergometer. After the 30-second test each once again performed the flexion and extension movement and the electromyogram was recorded (Figure 4.6).

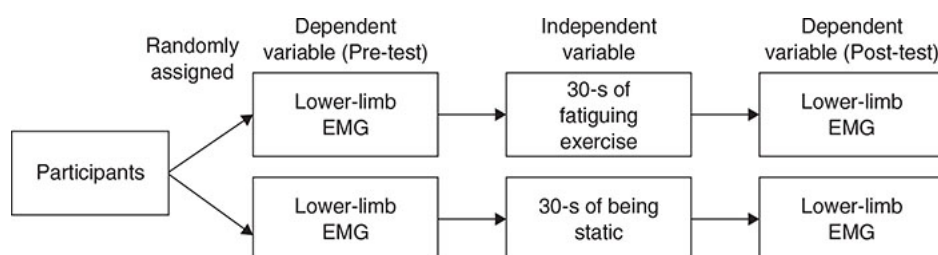
Repeated-measures design

Consider an experiment investigating the relationship between hydration status and cognitive functioning in competitive sailors. In independent group designs (i.e. within-group), as outlined and illustrated above, participants would be randomly assigned to one of two groups (i.e. dehydrated state or euhydrated state) and once in this state they would undertake a cognitive functioning test. In a repeated-measures design, the same individuals participate in all the conditions, meaning that participants are repeatedly measured on the dependent variable after being in each condition.

[Page 76]

The advantages of this approach over others are that fewer research participants are needed and costs can be kept to a minimum. In addition to these more obvious strengths, the repeated-measures approach can be extremely sensitive to finding statistically significant differences between groups.

Figure 4.6 A between-group pre-post-test design with two independent variables (i.e. group and activity condition). EMG, electromyogram.



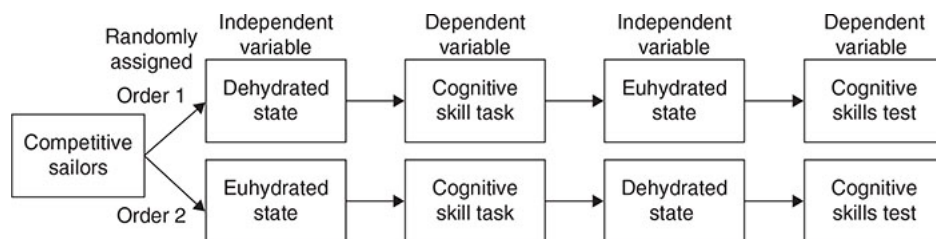
[Download Image as .jpg](#)

A major problem with this approach, however, stems from the fact that the order in which the conditions are presented could impact on the dependent variable. In the example above, suppose that all participants experienced the dehydrated condition before the euhydrated condition. Although a change in the dependent variable following the manipulation may be a consequence of the hydration status of the participants, it may also be a result of an order effect. Performance in the cognitive function tests may improve due to learning of test or becoming more familiar with the procedures. There is also the chance of a fatigue effect caused by insufficient time between the two conditions.

There are two approaches to dealing with such problems. To counteract any potential fatigue effect, the researcher can create a procedure in which the time interval between conditions is of sufficient length. The balance between being too short and too long needs careful consideration both in terms of impact of the dependent variable as well as participant availability. The second relates to the order of conditions. In repeated-measures design this can be resolved by *counterbalancing* the order of conditions. As shown in Figure 4.7, the

participants would be randomly allocated to two groups. Each group would undertake both conditions but in a different order: group one undertakes order 1 and group two undertakes order 2. In essence, all participants are doing exactly the same, but the order has changed. By applying this approach to the repeated-measures design it is possible to reduce the impact an order effect may have on the dependent variable.

Figure 4.7 A counterbalanced within-group repeated-measures design with one independent variable (dehydration status).



[Download Image as .jpg](#)



Key point 4.4

A counterbalanced approach is a method of controlling for order effects in a repeated-measures design by either including all orders of treatment presentation or randomly determining the order for each participant.

An understanding of the basic structure of experimental designs, the impact such design has on the threat to internal validity and the link between the research question and the within-, between- or repeated-measures approach enables the researcher to use these models as building blocks to create more elaborate approaches to experimental research design. Irrespective of what design is created, however, the issues relating to the control of extraneous variables that may impact on the ability to

[Page 77]

conclude causal links between the independent variable and dependent variable will always be the researcher's challenge.

It is important to remember that each design has its strengths and weaknesses that will impact on the researcher's selection decisions. The choice of a pre-test, a control group and the randomisation of participants will influence the validity of the study and affect the ability to determine causality confidently.



Reflection point 4.2

The simple experimental designs presented within this chapter act as a starting point for the evolution of more complex experiments. By understanding the building blocks of basic research design within an experimental research strategy, you can be led to more elaborate research questions.

Increasing the number of independent variables or levels, as they are sometimes referred to, the researcher can begin to understand much more about the cause-and-effect relationships between independent variables and dependent variables.

Experimental designs, such as a 2x2 factorial design that combines both within- and between-group models, are not uncommon in undergraduate research. This approach involves two independent variables/levels (e.g. sex and vertical jump score), each consisting of two groups or conditions (e.g. sex (male and female) and vertical jump score (pre-training and post-training)), hence 2x2. In this

design the first level (sex) is a between-group factor and the second (jump score) is a within-group factor. If you know this information about the experimental design you will be able to determine, in advance of data collection, the most suitable statistical test to use (see [Figure 4.8](#) on page 80).

If you want to find out more about complex experimental designs, such as the factorial design, then look at the recommendations listed in the Further reading section, later in this chapter.



Learning activity 4.3

Without looking back through this chapter, try and recall the three key characteristics of the experimental research strategy. Once you have done this and entered them into the grid below, re-read the two research summaries in [Research focus 4.1](#) and [4.2](#) and evaluate each against the three characteristics. For each one indicate below whether the characteristics are met or not by placing a tick or cross in the corresponding space.

Characteristic	Bloms et al. (2016)	Larsen et al. (2016)
----------------	---------------------	----------------------

1:		
----	--	--

2:		
----	--	--

3:		
----	--	--

[Page 78]

Collection of data in experiments

A further component of the experimental research strategy, and one that comes after the selection of the research design, concerns decisions about the data collection methods – methods that require the researcher to select appropriate instruments or techniques that are then implemented via a set procedure or protocol to ensure efficient and effective data collection.

Presentation of the independent variable

An important starting point for the researcher is to consider how the independent variable will be presented and how the dependent variable will be measured. In some studies, researchers become involved in the presentation of the independent variable, and their active participation is required in the administration of the variable which is to be manipulated. Consider the researcher's involvement in a study that implements a training programme, sandwiched between two 5 maximum repetition tests. In this instance the researcher may be fully involved with the presentation of the independent variable to the participants, monitoring and recording testing and training to ensure accurate accounts are made. This approach has advantages as the researcher is able to ensure familiarity and consistency in the presentation of the independent variable. The limitation, however, is that researcher bias can impact on the presentation. This may have an unwanted effect on the dependent variable.

One way around this is to present the independent variable in a way that reduces bias. Consider a study that aims to identify the effect of caffeine compared to placebo on 2000-metre rowing performance. In this instance researchers may choose firstly not to inform the participants as to which solution they are receiving (i.e. single-blind). The value of this approach is that the participants will not be influenced by knowing that one is the caffeine and the other a placebo. To advance this further, researchers may also wish to remove their own influence by also becoming 'blind' to the solutions each participant is receiving. Known as a 'double-blind' approach, a third person would organise the solutions, labelling each *A* and *B*, devising a testing schedule and then providing it to the researcher. In this way, the researcher presenting the independent variable cannot impose bias on to the procedure or participants in the study.

Measurement of the dependent variable

The selection of instruments and their associated procedures for the measurement of the dependent variable will be dictated by what behaviour the researcher wishes to measure. The researcher in sport has a wide and varied range of clinical and non-clinical measurement tools available, spanning broad areas of physiology, biomechanics and psychology. Sport-specific ergometry, video capture systems, cardiorespiratory devices, sport-specific questionnaires, field-based assessment tools and force platform technology are among only a few different instruments that, when applied in a reliable and accurate manner, can produce a sensitive measure of the dependent variable.

The dependent variable in experiments typically falls into three broad categories: self-report behavioural and physiological. Self-reporting measures are used to measure quantifiably such things as attitudes, emotional states, confidence and motivation levels, or perceived ratings of exertion.

Rating scales (e.g. Likert scales) with assigned descriptions are the most common and allow the researcher to convert ratings into numerical responses. Behavioural measures are direct observations

[Page 79]

of sporting behaviour, often using video or notational tools and, as one can imagine, are endless in number. These can be verbal and non-verbal and are recorded to produce numerical quantification of behaviours (e.g. time spent in different zones on court). The final measure is physiological in nature and refers to the recording of bodily responses. Indicators from a physiological perspective may include temperature, heart rate, oxygen uptake, blood markers (e.g. lactate), blood pressure and lung function. From a biomechanical viewpoint, measures may include measures of ground reaction force or movement kinematics.

It is sometimes desirable for the researcher to measure more than one dependent variable in order to build up a more concrete view of the sporting behaviour in question. For example, measuring participants' endurance capacity on a treadmill may require the measurement of velocity, oxygen uptake, heart rate, rating of perceived exertion and blood markers. What this approach creates is the question of importance and order. When more than one dependent variable is measured, the order in which measurements will occur and their associated importance need to be recognised. All dependent variables in the example above may have been of equal value and collected all at the same time period. There may be cases when one measurement leads on to the next and the researchers should be aware of the impact on each subsequent measure as well as their overall importance to the study.

Linking design with an analysis approach

The analysis of numerical data collected from experiments provides the researcher with the opportunity to decipher the meaning behind the numbers. Analysing experimental data using statistical analysis methods often incites unnecessary fear among many novice researchers. In reality, once the experimental design is decided upon, the selection of data analysis techniques, whether basic descriptive statistics or more complex procedures, is relatively straightforward. What is important – and most novice researchers do not do this well – is to decide on the analysis method prior to data collection. The point of undertaking statistical analysis on the collected data is that the researcher can determine whether differences across groups or conditions are due to chance or a consequence of a cause. Remember, the whole point of the experimental approach is discovery of cause and effect. Does the independent variable, which is the one that the researcher manipulates, affect the dependent variable? Subjecting the data to statistical analysis reveals to the researcher the likelihood of any effect measured being caused by the independent variable and not just by chance occurrences.

What tends to confuse most when it comes to data analysis is not so much the mechanics of statistical analysis but rather the process of matching the research design, which is related to the research question, to the type of analysis that needs to be performed. A wide range of software packages now makes it easy for the researcher to put data in, press a few buttons and get something back. It may not always be the case that this is understood, but the mechanics are simplified.

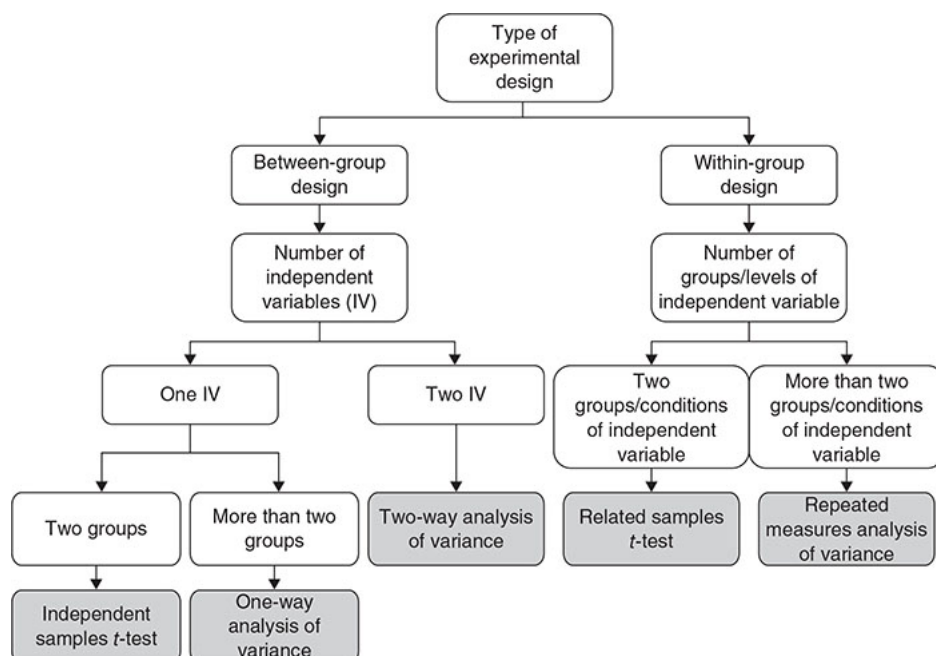
As illustrated in [Figure 4.8](#), the relationship between research design and statistical analysis tests can be seen. Specific tests are best suited to analysis data collected using specific types of design. Whether a between-group or within-group design, one independent variable or more, or a number of different groups to compare, the decision tree process allows the researcher to consider the type of statistical analysis test whilst designing their study.



To provide practical examples to illustrate the effectiveness of the decision process, let's consider an earlier quasi-experimental design (Figure 4.5) that was constructed to investigate the effect of clothing on body temperature following 30 minutes' submersion in cold water. In this design, participants were allocated to one of two groups (thermal clothing or swimming costume). In this between-group design there were therefore two groups that did not experience the other condition during the experiment. The independent variable for this study was the type of clothing worn. By applying these three basic design features to our decision tree, that is: (1) between-group design; (2) one independent variable; and (3) only two groups, the resultant statistical test will be an independent *t*-test.

[Page 80]

Figure 4.8 Decision tree for selecting appropriate statistical tests based on experimental research design. IV, independent variable.



[Download Image as .jpg](#)

Next consider the example illustrated in Figure 4.7. In this study, the researcher wished to examine the impact of hydration status on cognitive functioning. The design was a repeated-measures approach where the same participants took part in all conditions. This design can be considered a within-group design. There was one independent variable, the hydration status, which comprised two conditions (dehydrated and euhydrated). By again applying the basic design features to our decision tree, that is: (1) within-group design; and (2) two conditions, the resultant statistical test will be a related *t*-test.



Learning activity 4.4

Refer back to the three Research focus boxes (4.1, 4.2, 4.3) earlier on in the chapter. Applying your understanding of experimental research design gained from this chapter and working logically through

[Page 81]

the decision tree illustrated in Figure 4.8, attempt to determine which statistical test you would use. It may help to consider the following:

- Is the design a within- or between-group design?
- How many independent variables are there?
- How many groups or conditions are being compared?

Based on the experimental design, the statistical test would be:

Research focus 4.2: Larsen et al. (2016)

Based on the experimental design, the statistical test would be:

Research focus 4.3: Grandjean et al. (2002)

Based on the experimental design, the statistical test would be:



Chapter review

Throughout this chapter we have investigated when and how to apply the experimental research strategy in order to examine a wide range of sporting behaviours. Examination of the importance of internal and external validity in experiments helps to verify the cause-and-effect relationship between measured variables. In constructing the experiment, selecting the most appropriate design will allow the researcher to draw accurate and truthful conclusions while allowing for a degree of generalisability. Whether a between-, within- or a combined-group approach is required, being able to make the link to the most suitable statistical technique will guide the researcher to make the right analysis and interpretation. By using a range of sport-related research examples throughout this chapter you should now be able to:

[Page 82]

- ☒ recall a definition for the term experiment and explain why it is different from non-experimental approaches;
- ☒ list the strengths and weaknesses of this strategy and identify how it can be used to answer specific research problems;
- ☒ name the three core experimental types and provide sport and exercise science-specific examples for each;
- ☒ construct a suitable research design based on a range of sport-related research questions.

Further reading



Christensen, LB, Johnson, B and Turner, LA (2014) *Research Methods, Design, and Analysis*. 11th ed. London: Pearson Education. Part IV.

Advancing on from the basics, part IV of this textbook will offer you a much more thorough grounding within experimental research approach and design construction. Set out in a clear manner, each chapter ends with internet site recommendations, practical tests and learning activity challenges.

Cozby, PC and Bates, SC (2012) *Methods in Behavior Research*. 11th ed. New York: McGraw Hill Higher Education.

Montgomery, DC (2012) *Design and Analysis of Experiment*. 8th ed. New York: John Wiley.

These valuable books should be on the shelf of everyone wishing to undertake experimental research. The key themes outlined within this chapter are further advanced, and complex research designs are clearly examined to help students understand and apply these approaches to their own research projects.

Keeble, S (1995) *Experimental Research 1: An Introduction to Experimental Design*. The Open Learning Foundation, Churchill Livingstone.

This is an extremely practical text with lots of useful learning activities. It will guide you through a more detailed perspective on the experimental approach with particular reference to experimental design.

Field, A (2017) *Discovering Statistics Using IBM SPSS*. 5th ed. SAGE Publications.

Ntoumanis, N (2001) *A Step-by-Step Guide to SPSS for Sport and Exercise Studies*. London: Routledge.

Both of these textbooks provide the reader with a thorough grounding in statistical data analysis. They provide practical illustrations on how to conduct and interpret the SPSS findings. Whether you are a first-time user or are more experienced at using SPSS, you will find these books of particular value.

Keeble, S (1995) *Experimental Research 2: Conducting and Reporting Experimental Research*. The Open Learning Foundation, Churchill Livingstone. Higher Education.

The second volume in the series takes you through reporting experimental research, which is particularly useful when you come to write up your experimental project work.

< [Chapter 3](#)
[Systematic review research strategy](#)

[Chapter 5](#)
[Correlational research strategy](#) >

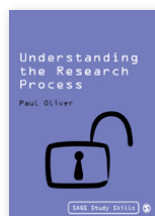
Read next in Sage Academic Books



 Academic Books

Books

Doing Research in Sport and Exercise: A Student's Guide



 Academic Books

Books

Understanding the Research Process



 Academic Books

Books

Applying for Research Funding: Getting Started and Getting Funded



 Academic Books

Basic Research Entry to Social Research

Smith, Mark F.
January 29, 2025

Oliver, Paul
December 20, 2013

Ries, Joanne B., et al.
June 19, 2012

Guthrie, Gerard
December 20, 201

1 2

More like this in Sage Knowledge



Reference

Handbooks

The SAGE Handbook of
Participatory Research and
Inquiry

March 11, 2022



Reference

Handbooks

The SAGE Handbook of
Qualitative Research Design

March 31, 2022



Reference

Handbooks

The SAGE Handbook of Social
Science Methodology

January 30, 2014



En

The SAGE Encyclopedia of
Social Science
Methods

September 15, 201

1 2

Sage Recommends

We found other relevant content for you on other Sage platforms.



About

[About Sage Knowledge](#)

[About Sage Publishing](#)

[Accessibility](#)

[Author Guidelines AI/LLM](#)

[CCPA](#)

[Permissions](#)

[CCPA – Do Not Sell My Personal Information](#)

[Privacy policy](#)

[Terms of use](#)

Information for

rs



[Frequently Asked Questions](#)
[Instructors](#)
[Librarians](#)
[Students and researchers](#)
[Trial Login](#)

Stay in Touch
[Contact us](#)

Copyright © 2025 by Sage Publications

