A GUIDE TO A SIMPLE RESEARCH PROJECT

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INTRODUCTION

Most O&P practitioners have little or no training in research methods or exposure to them. In some O&P education programs students may get one introductory course in research and are then asked to do a research-related senior project. Also, as these new practitioners enter their required Residency positions they are again asked to do a research project as a requirement of Residency. Since these students and residents generally have no one knowledgeable in research to guide them through their projects the process can be unnecessarily confusing and stressful. The resulting projects may be of a low quality with respect to research content and contribute little to the field of O&P.

Learning about research methodologies can be a formidable undertaking. My Ph.D. program was in Applied Statistics and Research Methods. In my undergraduate and graduate course work I took in excess of 50 research-related courses. I supplemented those courses with approximately 12 years of part- and full-time work in various research positions. Still, there is much in the vast body of knowledge called "research methodology" that I don't know. I can easily understand how overwhelming it would be to be asked to do a research project and have to try to sort through all the information out there on research and try to gain some perspective on it.

It is my hope that this paper will provide students, residents, and interested practitioners with an overview of some of the research methods that will be useful in a simple research project. It is not the intent of this paper to cover topics in great detail. Rather, I have tried to give a broad overview of the important concepts and topics. I have included some references to other resources where more detail is available.

Your research project may end up being no more than an academic exercise, or it may make a badly needed contribution to the scientific body of knowledge in O&P. Its value will probably be in proportion to the amount of work you are willing to put into learning more about research. Hopefully this paper will help you focus you efforts and improve the quality of your project.

<u>JPO Research Forum Articles</u>
In the October 1993 issue of the *Journal of Prosthetics and Orthotics* the editors introduced a series of articles under the heading of the *Research Forum*. These articles were intended to address a need in O&P for more education in research methods. They were also intended to spur more interest among practitioners in research. The initial October 1993 *JPO* issue was fully dedicated to research-related articles. The subsequent JPO issues featured one or more research

articles and continued into 1997.

The Academy Research and Development Committee has reviewed and organized the *Research Forum* articles and other research-related information into an O&P **Research Reference Guide**, which can be found at **www.oandp.org.** It is found in the Members Only section of the Academy's website. *Research Forum* articles are referenced throughout this paper as sources for further investigation of various research topics. Each of the *JPO Research Forum* articles can be accessed and printed out at the academy website **www.oandp.org.**

Also of special interest, in 1995 the *JPO* published a series of three articles under the *Research Forum*. These articles addressed research by new practitioners doing their required residency research project. They are partially titled Residency Research, Parts I, II, and III. These articles are well worth reading and supplement the Introduction section of this paper. Further, a *JPO* article (1997,Vol.9, Num. 1) on Baccalaureate Student Research is also highly relevant to your residency research project.

Also, in the O&P **Research Reference Guide** there are several articles that provide an overview of the research process. These are found under the heading of "The research process: A review of different types of research, and how to get started".

FOCUSING YOUR RESEARCH

Identifying an important question

The real goal or purpose of research is to find the answer to one or more questions. The starting point of any research project is to identify question(s) that you consider to be important enough to warrant your time and energy. If you are relatively new to O&P you might ask several more experienced practitioners to each write five questions that they feel are important to the field. Speakers at conferences may raise unanswered questions in their presentations. Authors of journal articles often identify topics or questions for further exploration.

The more interested you are in a topic the more likely you will do a better job. Try to identify one or more areas of special interest to you. There may be an area of O&P in which you would like to develop some expertise. The requirements of a research project are an excellent way of increasing your level of knowledge in an area of interest to you. You benefit from the research process and the field of O&P may also benefit from your work.

Examples of research questions might include:

1) Which scoliosis brace is more effective in treatment, the Boston or the Charleston Bending brace? (Comparison of two groups).

2) How do stroke patients feel about their AFO's after one month of use?

(Attitude survey, multiple questions).

3) Are age and socioeconomic status important predictors of success in using a prosthesis? (Using patient information to identify those needing additional support and encouragement, regression analysis).

4) What is the average number of return visits for adjustments on pediatric AFO's? (Descriptive statistics for economic planning or quality control).

LITERATURE REVIEW

Once you have identified one or more questions of interest or, at least a topic of interest, then it is essential to do a thorough literature review. The purpose of the literature review is to bring yourself up to speed on what is known in the field about your research question or topic. You may find that your question has already been satisfactorily answered by other research in the field. In this case there may be no point in continuing on with this question/topic. However, one study is not necessarily a definitive answer. It may be important that additional studies be done to further validate or dispute the existing research. If several studies all find the same answer to a question then the research findings are probably reliable and valid.

The goal of a literature review is not just to find 20 or 30 articles on the subject, rather, the object is to get a thorough and accurate picture of what is known. What is the state-of-the-art knowledge on your question or topic? The more focused your research question is then, probably, the easier your literature review will be. If you have only identified a general topic or a more general question at this point, you may well find hundreds of related journal articles and be overwhelmed by the literature review process. As you proceed in reading existing articles they may help you better focus your question or questions. Your review may cause you to see the problem in a different light or may help you identify a question of more importance or interest.

Existing literature is abound with poor articles and questionable research. The goal is to sort through the literature on your topic and identify the key articles that are reliable and accurately represent the knowledge on the topic. With minimal research education and experience it may be difficult for you to determine if an article is one of the key articles on a topic. Start with journal articles whose specific purpose is to provide a state-of-the-art literature review on your topic or related topics. Literature review articles are often written by leading experts in the field at the request of a journal editor. These authors are best qualified to identify key articles and accurately summarize what is known on the topic. They can save you a tremendous amount of work and greatly improve the quality of your project.

If you cannot find any literature review articles, the next step is to examine the smaller literature review sections of related journal articles. Every good journal article will do a brief review of related articles. By reading several articles on a research topic, key articles should start to be identified as they are referenced repeatedly.

A good literature review is a service to your colleagues and a contribution to the field. A poor or misleading literature review is a disservice to the field and only adds to the confusion of knowledge in the field. Spend the time to do a good job on your literature review and come away feeling good about it. In the O&P **Research Reference Guide** you will find two articles of interest under the category of "Literature review: How to seek out and critically review published information".

Sources to assist you in your literature review

If you live in a town where you have access to a good medical library this would be the best place to conduct a literature review. The library will probably have all the medical journals you need and good search capabilities for locating the articles related to your topic. If you don't have access to a medical library there are still some on-line sources you can access over the internet.

Medline - This is the premiere literature search site for journal articles in the health professions. It provides search capabilities for over 9 million journal articles in the medical field. The search gives you a bibliographic list of articles related to the topic of your search. While it does not give you full text of the articles on-line, you can obtain the full text of an article through a related service called Loansome.Doc. Medline can be accessed through Internet Grateful Med on the internet at website **http://ign.nlm.nih.gov.** Medline is run by the National Library of Medicine.

JPO Online - This provides access to approximately 10 years of articles from the *Journal of Prosthetics and Orthotics*. The site provides full text searches as well as a print-out of any article, if desired. The *JPO* section is easily accessed via the main O&P site at **http://www.oandp.org**.

RECAL - This is a literature database specifically for Orthotics, Prosthetics, and Rehabilitation Engineering. It provides bibliographic listings and full text retrieval for related articles, worldwide. The main database can be accessed over the internet for a fee or can be purchased annually on cd-rom for the PC. Information on RECAL's services can be found at **http://www.recal.org.uk**. You may be able to get your residency site to try this service via the internet or to purchase the cd-rom for a year. This would be a great training resource.

MISCELLANEOUS - Two other websites may be helpful in your literature review even though they do not specifically target just journal articles.

> NIH Search Engine - The National Institute of Health provides a search engine that accesses information at approximately 100 NIH-related sites. The quality of information provided by this site is very high. The site is at **http://search.info.nih.gov**.
>
> Fedstats Search Engine- - This is an excellent site to find statistics provided by 70 federal agencies to supplement your literature review, publication, or presentation. The site is at **http://www.fedstats.gov/index.html**.

THE POPULATION AND THE SAMPLE

Once you have done a literature review and have one or more research questions clearly in focus, then you need to identify a target population for your research. The target population is the group of people you would like the results of your study to apply to. The scope of the population you define is limited by the time and funding you have for your research. For example, if you were doing a study of transtibial amputees, ideally you might want to apply your findings to all transtibial amputees in the United States. Since you have no hope of getting data on all those amputees or of getting a list of all transtibial amputees in the U.S., you would need to redefine your population based on which amputees you can get access to in order to do your study. A well-funded study might redefine the population as all transtibial amputees in Texas, or further limit it to all B-K amputees in Dallas. For your study, you will probably have to limit your study to those patients who use the O&P practice where you are a resident. You will also have to further limit the population to a time period, for example, all transtibial amputees seen by your office within the last year or those seen over the next six month period.

The sample

Fortunately, it is not necessary to gather data on every member of your target population for your study. Sampling methods allow you to select a subset of that population that will be representative of the entire population. National pollsters can accurately predict the outcome of a presidential election (50 million voters) with a sample size as small as 1000 specially selected voters. Universities generally offer a full semester graduate-level course in sampling methods but this paper will cover some simple methods that should be sufficient for your study.

Inferential statistics

The majority of statistical techniques fall into the category of inferential statistics. These methods allow you to measure persons in a sample and then infer that the results found are also true for the larger target population from which the sample (subset) was selected. Most studies would be impractical if the entire population had to be measured, so sampling and statistical inference methods provide an economy of research that allows even O&P Residents to do meaningful studies.

Sampling - Example 1

Lets say that you want to study salaries of ABC Certified Prosthetists (CP) versus Prosthetist/Orthotists (CPO). You want to find the average salary for each group. You also want to find out if there are significant differences between the salaries of the two groups. For this study you would have access to a list of the entire target population, the ABC Registry. For most studies you will probably not have a complete list of all members of your target population. It would be expensive and time consuming to get data for all practitioners in the registry, say 3000. Sampling methods and statistical inference theories would allow you select a subset of those 3000 practitioners. A good number for this study would be to get data on 100 practitioners from each group, CP's and CPO's. The study could be done with as few as 30 practitioners per group.

Since not everyone that you mail a questionnaire will respond you will need to send out more questionnaires to each group. You might expect to get a returned response from one out of three questionnaires mailed. You would obviously have to assure confidentiality in a way where their name was not associated with their salary. You would have to explain to respondents how this confidentiality is assured. If the first round of mailings did not result in 30 to 100 respondents per group, you may have to do some sort of follow-up on your first mailing or do a second mailing to other respondents. Non-respondents may bias the study in some way that affects the outcome of your study. For example, practitioners with the highest salaries may be less likely to respond, biasing the average salary downward.

Sampling methods - For this study you are fortunate in that you have a complete target population list, the ABC registry, with addresses and phone numbers. Let's say you have 2000 CP's and 1000 CPO's on the list. You would want to assign a sequential number to each of the CP's , 1 to 2000, and also assign separate sequential numbers to each of the CPO's, 1 to 1000. Assuming that maybe one out of three mailings would result in a response you would need to randomly select 100-300 names from each of the two groups in order to get your desired 30-100 respondents.

Random sampling - If you have access to any statistical software you can get your computer to select and print out a list of randomly generated numbers. You would instruct it to select 100 to 300 numbers between one and two thousand for the CP's and also select 100 to 300 numbers between one and one thousand for the CPO's. You would then take each of the 100 to 300 random numbers for CP's and mail a questionnaire to the corresponding person on your CP list. Then you would do the same for the 100 to 300 random numbers selected for the CPO list.

If you don't have access to a computer random number generator there is another method you might use. If your lists of all the CP's and CPO's are alphabetical then there is no reason to believe that their alphabetical order is in any way related to the size of their salaries. For the CP's, since your list contains two thousand practitioners you can select every sixth person until you have approximately 300. If you only wanted a sample size of 30 completed questionnaires, you would select every eighteenth person on the list to give you about 100 people whom you would mail a questionnaire. For the CPO's you can select every third person until you have approximately 300 people. If you only wanted a sample size of 30 completed questionnaires then you would select every ninth person on the list to give you about 100 people whom you would mail a questionnaire. You would also need to randomly select the starting point on the list. The key to a random sample is that each person on the list has an equal chance (probability) of being selected.

Another alternative would be to cut up each individual name or number on the list, mix them thoroughly in a bowl, and select the number needed for your sample. This is called the hat draw method. For this example, you would need to have separate drawings for the CP's and the CPO's.

Sampling - Example 2
If you do a study involving data on patients, it is likely that you will be limited to patients seen at

the O&P office or institution where you are doing your residency. Let's say that you want to examine the process of evaluating, fitting, and adjusting pediatric AFO's. You want to know if the total amount of practitioner time spent on this process is related to the patient/parent satisfaction level with the process. In other words, does the patient/parent satisfaction increase as the total amount of practitioner time spent increases.

The target population would be defined as all pediatric AFO patients seen at your practice within a specified time period, say the next six months. At a busy pediatric practice the office might see 300 pediatric AFO patients in a six month period. Sampling theory would allow you to reduce the number of patients measured in order to reduce the cost and time involved in the study. As a general rule in this type of study you would want a minimum sample size of 30 and a preferred sample size of approximately 100. You could, if necessary, use a sample size of less than 30. Small sample size comparisons will be discussed later in this paper under the sections discussing two group comparisons using the T-test and also the section on non-parametric tests for small samples.

If you measured all the pediatric AFO patients seen within the six month time period then you would have the entire target population and a sample would not be necessary. You would not need to infer the results from the sample to the population since you have data on the entire target population.

You might make the argument that the pediatric patients seen over the next six months of your study are approximately the same in important characteristics as those who have used this O&P practice over the last six years and, therefore, the results should hold for the broader population of all pediatric AFO patients seen in this practice over the last six years. You might also assume or argue that the pediatric AFO patients seen at your practice are representative of those found nationwide. These are assumptions rather than any type of statistical inference and would need to be justified with supporting arguments or evidence. This might be simply based on the observations of the practitioners over that time period that the pediatric AFO patients have not changed with respect to relevant characteristics and that bracing methods have remained relatively constant. Readers of your research would be free to accept or reject your assumption.

<u>Sampling - the post-hoc study - Example 3</u>

When planning your research it may not be possible to measure future patients. You may not have 3 to 6 months, or longer, to gather future data for your study. It may be necessary to go back into the patient files at your practice and extract data from past patient visits. This is often referred to as a post-hoc or "after-the-fact" study. In other words you are using pre-existing historical data on your patients rather than collecting new data for your study. A study where you collect new data is generally preferable to a post-hoc data study for a variety of reasons, including confounding variables, discussed later. However, a post-hoc study may be of great value and may be the only one you are able to do given the limitations of your situation.

Let's say you are interested in patient satisfaction of adult stroke patients with their AFO's. This assumes that your office has been collecting data via patient satisfaction surveys or other follow-up measures. You would first want to define your target population so that you can sample from it. Hopefully your office or institution would have computer data that would allow you to identify all stroke patients seen over the last few years. This could be as many as 1000 stroke patients which would be too many to include all of them in your study. Fortunately, sampling theory would again allow you to select a smaller sample that would be representative of the target population. You would want to put together a population list of all adult stroke patients found during the historical period of interest. From this list you would use one of the random sampling methods discussed previously to select a sample of adequate size. Again, in this situation, you would want a minimum of 30 and preferably about 100 patients in your sample. You will probably find missing or incomplete satisfaction data on some of the patients selected in the sample. You would either need to randomly select additional patients or initially select more than needed. In general, the larger the sample size the more reliable the results will be and the greater the chance of getting statistically significant results.

Other sampling considerations

In general, the more heterogeneous the target population you are interested in, the larger the sample size necessary to adequately capture that diversity. For example, if your study examined a diverse group of patients with many different pathologies, ages, and treatments then the sample size necessary to capture that diversity would be larger than for a more homogeneous group like post-polio patients only. The post-polio patients would be mostly middle-age and elderly with similar pathology-related experiences, treatments, etc.

Confounding variables

A confounding variable is one that is not under study but interferes with results of the study by influencing the variable(s) you are studying. For example, let's say you are comparing the recovery times of patients using two different types of back braces following surgery to determine which is the best back brace. However, all of the type A back braces were prescribed by one orthopedic surgeon while all of the type B back braces were prescribed by another orthopedic surgeon. It is possible that the two orthopedists differ in surgical skills and experience and that this is influencing recovery time in addition to the brace type. "Prescribing orthopedist" would be considered a "confounding variable" which interferes with the variable under study, "brace type". In this case the effect of the confounding variable can be eliminated by random assignment of patients to brace groups. With random assignment to groups you would expect the prescribing physicians to be approximately equally represented in each brace group.

A confounding variable can also be introduced by doing a non-representative sample. For example, your sample may contain a disproportionate number of low socio-economic status (SES) patients due to a "time of the year" factor related to a government funding program. Your sample may be heavily biased in this direction, resulting in low SES being a confounding variable that interferes with your study variable, such as patient compliance. In other words, patient compliance may be lower due to low SES. The effect of confounding variables can be greatly reduced or eliminated by a method called stratified random sampling which can control for a variable like SES.

In the O&P **Research Reference Guide** you will find two helpful articles on sampling under the category of "The research sample".

SOME SIMPLE RESEARCH DESIGN IDEAS

So far we have covered how to identify a research topic or question(s). We have also examined the literature review, and have explored how to define a target population and select a sample from it. Now we get to the heart of the matter, which is the research design and methods used. This section will explore several simple methods that would be appropriate for a residency study. Hopefully, we will have covered each method in enough detail where you can identify one that would be appropriate for your study. You will likely have to explore the method(s) chosen in more detail than given here, but hopefully these methods will point you in the right direction.

TWO-GROUP COMPARISON

This type of study compares two sample means on one variable. In sampling example 1, previously examined, Certified Prosthetists (CP) and Certified Prosthetist-Orthotists (CPO), the variable salary was compared. We gathered a sample of 30 to 100 respondents from each group. From this data we can calculate the mean (average) salary for each group. However, comparing the means from two samples is not so simple and requires some level of understanding of the concept of statistical inference.

If we had measured salaries for the entire list of CP's and CPO's in the ABC registry, approximately 3000, then we would have the entire target population for each group. We could then examine the mean salaries for the two groups and see if they differed and by how much. Population means can be directly examined and compared, sample means cannot. Sample means differ from their respective target population means by sampling error. Comparing sample means requires a test of statistical significance of the difference between means to determine the probability that the population means also differ significantly.

If we had selected random samples of size 30 to 100 from each target population, CP's and CPO's, then the calculated means for each group may differ from the actual target population for each group by sampling error. We cannot visually examine the two sample mean salaries and say that they differ in their respective target populations.

Comparing two sample means requires a test of statistical significance, in this case a T-test. A statistically significant T-test allows us to say that the difference between means calculated on our samples shows that the difference between population means is also significant. In other words, we infer that if there is a statistically significant difference between our sample means that our population means also differ, within certain probabilities.

Remember, in most cases it is not possible or feasible, with respect to time and money, to measure the whole target population. Using tests of statistical significance allow us to measure a much smaller sample of the target population and still make inferences from our sample results about the respective variables in our target population, within certain probabilities. This concept is covered in detail in a second course in statistics called inferential statistics.

Calculating a T-test:
Hopefully, you will have access to a computer that has some basic statistical software that will allow you to enter the data and calculate the results of a T-test, as well as some other basic statistics. If not, then any basic statistics textbook will have a section on T-tests which should include definition and computational formulas for the T-test. Such a text should also tell you how to interpret the results in detail. Basically, a statistically significant T-test tells you that the difference between sample means is greater than you would expect by chance alone and therefore the sample means came from two populations that also likely differ with respect to these variable means.

An article in the O&P **Research Reference Guide** on "Making inferences in research" examines the T-test in more detail. It also expands on the concept of inferential statistics which is so important to these statistical tests.

Independent versus correlated sample means
There are different T-test computations for correlated and independent sample means. If the two samples are drawn independently of each other then the test for independent samples is used. The previous example using CP's and CPO's salaries shows two independent samples.

Correlated samples are best illustrated by pre-test and post-test measurements on the same person. For example, first we would measure gait speed on a stroke patient as a pre-test. Then we would make them an AFO. After some period of training with the AFO, we would again measure gait speed as a post-test. In this situation we would have pre and post measurements that were correlated because both were done on the same person. If we repeated the process for 30 stroke patients then we would have a sample mean for pre-AFO and a sample mean for post-AFO. The two means being compared are related and would require the use of a T-test for correlated means. See example 5 below for more detail on correlated means.

Example 4 - Comparison of means from two independent samples
We are interested in comparing patient satisfaction with two different lumbosacral braces following lumbar fusion surgery. The first brace is the Cybertech-style, off-the-shelf, lumbosacral brace. It is being compared with an LSO overlap brace factory made from measurements. The variable of interest is patient satisfaction as estimated by the patient on a scale of 1 to 5, with a score of 1 being low satisfaction and a score of 5 being high satisfaction. The patient is asked to consider both pain relief and comfort issues combined in their 1 to 5 rating of the brace. The ratings would take place 4 weeks after the patient begins wearing the LSO.

We will use the next 30 patients scheduled for lumbar fusion surgery. We will assign the first one to the cybertech group and the next one to the LSO overlap group. We will continue alternating groups with each successive patient. By alternating assignment of patients to the two groups there is no reason to believe that we are systematically biasing either of the groups. In effect, we are randomly assigning patients to the two groups. Because of this we would not expect the two groups to differ on any confounding variables. Any significant difference between the ratings of the two groups would be expected to be due to the difference in type of LSO assigned.

Once all 30 patients have gone through the 4 week bracing period, and rated their respective braces, we would want to calculate a T-test for independent means from the data. A statistically significant T-value would indicate that the ratings for the two group samples differed more than you would expect by chance alone. You would then want to make a judgement as to whether the difference between the two mean ratings had any practical or clinical significance. Statistical significance just eliminates chance (sampling error) as a reason for the difference between means. Practical significance is a clinical judgement as to whether a statistically significant difference has any practical meaning with respect to the size of the difference.

Example 5 - Comparison of means from two correlated samples.

The most common example of correlated samples involves measurement of the same person before and after some experimental treatment. In this example, we want to know if a common gait measurement, gait speed, changes significantly with the use of an AFO for stroke patients. The next 30 stroke patients selected for gait training at the clinic are chosen as the sample. An initial gait speed measurement is taken for each patient and recorded. An AFO is then made for each patient ASAP. Each patient is given a 7 day period to adjust to the AFO and then is re-measured for gait speed. The formula for comparing means from correlated samples is used to calculate a T-value. We might expect that the results would show that difference in gait speed with an AFO was statistically significant. Then we would make a judgement on the practical or clinical significance of the difference with the AFO and whether the improvement would justify the cost of the AFO. There would obviously be other variables to consider other than gait speed, such as improved stability, increased ambulation time, etc.

In this example, we did not randomly select these 30 stroke patients but rather we took the first 30 who were appropriate for gait training. However, there would probably be no reason to believe that these 30 patients differed from all of the appropriate stroke patients who had come through the clinic in the last, say, three years. We might be justified in inferring our results to all stroke patients selected for gait training in the last few years. We would need to ask if these 30 stroke patients differed from those we want to infer the results to, on one or more important characteristics.

MULTIPLE-GROUP COMPARISONS

In the previous section we covered the two-group comparison of means using the T-test. If you are comparing means for more than two groups then you would use a method known as "analysis of variance" or ANOVA. If you need to compare three or more group means on one variable of interest then we suggest you consult a basic statistics book on the topic of ANOVA. The following example using ANOVA should give you some idea of the steps involved but not the details. An article listed in the O&P research reference guide examines an example of a three group comparison in more detail. It is the article on "Making inferences in research".

<u>Example 6 - Analysis of variance - three group comparison of means.</u>
We want to compare patient satisfaction ratings on three brands of prosthetic feet. Our subjects are transtibial amputees, one leg only. As transtibial patients came in for a new prosthesis, they would be assigned to one of the three groups. You would like to have equal numbers of patients in each of the three sample groups. The best way might be to assign the first patient to group 1, second patient to group 2, and the third patient to group 3. You would then repeat the assignment process for each successive group of 3 patients that came in for a new prosthesis. Due to some of the assumptions underlying the use of ANOVA you would like at least 30 patients per group, and, preferably, you would want as many as 100 per group. Practical considerations may force you to use fewer patients than you would like. The higher the number of patients in each group the greater your chances of getting a statistically significant difference between means.

Once patient satisfaction ratings were collected for each of the 3 groups, you would calculate an F-test using analysis of variance. A significant F-value indicates that there are one or more significant differences between the 3 groups. If a significant F-value was obtained you would use post-test comparisons to identify which of the 3 mean comparisons yielded a significant difference. The post-test comparisons would include groups 1 and 2, groups 1 and 3, and groups 2 and 3. After you identified the significant differences between means you would still need to make a judgement on the practical or clinical significance of the differences between means. In other words, are the significant differences between means large enough to have some practical implications to the patient or field of prosthetics.

<u>CORRELATION AND REGRESSION ANALYSIS</u>

<u>Correlation between two variables</u>
Correlation is a measure of the degree to which two variables change together. A positive correlation means that an increase in one variable is accompanied by a similar increase in the second variable. Also, a decrease in the first variable is accompanied by a similar decrease in the second variable. A negative correlation means that as the first variable increases the second variable decreases in value. Also, a decrease in the first variable accompanied by an increase in the second variable would also indicate a negative correlation.

The degree of correlation is measured by a "correlation coefficient". The correlation coefficient ranges from +1.0 to -1.0 with +1.0 indicating a perfect positive correlation and -1.0 indicating a perfect negative correlation. A correlation of 0.0 shows that there is no relationship between the movements of the two variables, or said another way, the two variables are unrelated in the correlational sense. Any basic statistics book will have both a definition and a computational formula for the "correlation coefficient".

Knowing the correlation coefficient between two variables tells you something about the relationship between the two variables. This can be a valuable part of a research project. However, correlation does not mean there is a cause and effect relationship between the two variables. In other words, even with a high positive correlation it does not mean that an increase in variable A causes an increase in variable B, or vice-versa. It just means that they tend to change together. It may well be that a third causal variable in influencing them both similarly. In general, knowing the correlation coefficient between two variables may give you some insight or understanding into the two variables. More importantly, if two variables are highly correlated you can use a measurement of the one variable to predict what the value will be for the second variable, or vice versa.. This prediction method is called simple regression analysis and will be covered below.

Example 7 - Correlation coefficient

This example will consider a simple correlation between two variables. Lets say, you are interested in knowing how a patient's attitude towards a transtibial prosthesis, prior to getting one, affects their success in using one. For variable A you might ask the patient to rate, on a scale of 1 to 5, their attitude towards getting a prosthesis. A rating of 1 would indicate an extremely negative attitude while a rating of 5 would indicate an extremely positive attitude towards the process. A rating of 3 would indicate a neutral attitude, possibly a mix of positive and negative feelings. For Variable B, after six weeks of use of the prosthesis, you might ask the patient to rate their degree of success with the prosthesis on a scale of 1 to 5. A rating of 1 would represent a highly unsuccessful or negative experience while a rating of 5 would represent a highly successful outcome with the prosthesis. A rating of 3 would represent a neutral experience with balanced positive and negative outcomes.

In order for the correlation between Variable A and Variable B to be reliable, you would want to measure a minimum of 30 patients in your sample, and preferably you would like as many as 100. Do the best you can on sample size. As for sample selection, the ideal would be a randomly selected sample from a larger population. In practice, you will probably have to settle for the next 30 to 50 transtibial patients that come in to your practice.

Once you have measured all your patients, before and after receiving and using the prosthesis, you would want to calculate a correlation coefficient. Chances are, you would get a positive correlation coefficient which would tell you that their success and follow-up attitude is positively related to their attitude at the beginning of the process. The higher the correlation coefficient the stronger the relationship. A high positive correlation might suggest that a practitioner needs to really work with the patient in the beginning in order to encourage a more positive attitude going into the process. It may suggest additional education for the patient on the process or further exploration of the details behind the patient's incoming negative attitude.

Example 8 - Correlation of several variables
To expand on example 7 above, rather than a single measure of attitude before and after the prosthesis experience you might want to do a more thorough examination. You could expand the number of questions before and after the prosthesis experience from one question to ten. Ten questions before and ten questions after would give you a much more detailed examination of patient attitudes. I would recommend that each of your questions be in the form of a rating scale, from 1 to 5, rather than yes/no type questions. This is a more powerful type of data (ordinal versus categorical) yielding more information in your results. Coming up with the 10 prior and 10 follow-up questions will take quite a bit of work and will largely determine the quality of your research, so do your best on these questions. Later in the paper you will find a section to help you design such questions.

Once you have collected data on all your patients (30 to 50) then you would calculate a correlation coefficient between each variable and every other variable. This would include correlating each of the pre-prosthesis variables with each other as well as with each of the follow-up variables. This really means correlating each variable with every other variable. Examining and interpreting the results will be time-consuming. Every high correlation coefficient, say, .40 or greater, would be examined to try to understand more about which variables were related. It would also be useful to understand which variables seem to be unrelated (low correlation). After examining and contemplating all of the variable relationships, you would want to draw some conclusions from the data and translate the conclusions into practical implications or suggestions for prosthetics. The end goal in this example would be to better understand the patient's attitudes with the intent of improving the whole process and increasing the level of success for patients.

Prediction - Simple linear regression
The correlation coefficient gives you some insight into the relationship between two variables. Simple linear regression is based on the correlation coefficient and is a method for predicting or estimating the value of Variable A based on the value of Variable B. Variable A, the predicted variable, is called the dependent variable. Variable B, the predictor variable, is called the independent variable. The independent variable is used to predict the value of the dependent variable. The larger the value of the correlation coefficient between the two variables the better the prediction of one variable from the other. Simple regression takes into account the correlation coefficient between two variables but also compensates for the difference between units of the two variables. For example, if you were trying to predict the height of women from their weight, then weight would be in pounds while the height would be in inches. The simple regression prediction formula would adjust the units so that given a weight measurement in pounds the calculated prediction value for height would come out in inches.

For the details of simple regression analysis you can read any good basic statistics book. Also, this topic is covered in an article in the O&P **Research Reference Guide**, "Simple Regression: A statistical technique in the investigation of a relationship between two variables".

Example 9 - Simple regression analysis

Earlier, in example 7 for the correlation coefficient, we had a single measure of patient attitude, prior to the process of fitting and learning to use a prosthesis. We had a second single measure that reflected the patient's attitude after six weeks of using the prosthesis. Both measures were on a scale of 1 to 5, with 1 representing a highly negative attitude and 5 representing a highly positive attitude. It would be useful to develop a prediction model where you could use the measure of patient attitude going into the process to predict their attitude six weeks after fitting. If the prediction model were found to be a good one then it would help identify patients who would be expected to have a negative attitude toward their prosthesis experience six weeks after fitting. This could be used to identify patients who might need additional intervention, encouragement, education, etc. in order the change their outcome to a more positive one.

If you chose the next 30 transtibial candidates as your sample, you could measure each patient on their attitude at the beginning of the process and six weeks after fitting. The data for the 30 patients would be plugged into the formulas for simple regression analysis and the prediction equation generated. Please refer to any basic statistics book for the details of calculating the regression equation and interpretation of the results.

It is important to note that the prediction equation generated by the simple regression analysis would not be used to predict future attitudes for the 30 people in your original sample. The prediction equation was developed using the 30 people in your sample but it would be used to predict six week attitudes for other future patients outside your sample. In other words, the prediction model is developed on one set of data and then used to predict for other persons not in your original sample. The accuracy of your prediction model in this case is mostly dependent on the size of the correlation coefficient between the two variables in the model. To use the new prediction model you would simply use the single variable measure of a patient's attitude going into the process. You would plug the pre-attitude value into the equation and generate a predicted value or estimate of what you would expect their attitude to be six weeks after fitting. If the model predicted a negative attitude (say, below 3.0) you would want to take additional steps to turn this attitude more positive.

Multiple Regression Analysis

In simple regression analysis you have one dependent variable (predicted) and one independent variable (predictor). In multiple regression analysis you would still have one dependent variable but you would have two or more independent variables used to predict the value of the dependent variable. In general, by adding additional independent variables you can improve the accuracy of your prediction model and your understanding of the relationship between the variable you are trying to predict (dependent) and several other relevant variables. The quality and accuracy of the multiple regression model will be largely dependent on your perceptiveness in choosing variables that are strongly related to the dependent variable in a correlation sense. Choosing the appropriate independent variables generally requires some clinical understanding of the process you are investigating.

The goal of multiple regression is to get as accurate a prediction model as you can with as few independent variables as possible. In general, the more variables you add, the less stable the prediction model becomes. Two to five independent variables is probably an appropriate number for many prediction models. The details of multiple regression analysis are beyond the scope of this paper. If you are interested in using this method I recommend you read “Multiple Regression in Behavioral Research” by Fred Kerlinger. Also, a detailed example is given in the article listed in the O&P **Research Reference Guide**, “Making inferences in research”.

Example 10 - Multiple regression analysis
Most O&P offices would like feedback from their patients as to the quality of their experience with their office. Multiple regression analysis would help us to identify which variables are most important in determining the quality of their experience. For the dependent variable (predicted) we would ask them to summarize the quality of their experience with this process on a scale of 1 to 5. A rating of 1 would represent highly unsatisfactory while a rating of 5 would represent highly satisfactory. A rating of 3 would represent a neutral or mixed experience.

Next we would want to come up with a few variables that we thought were important in determining the patients attitude toward their experience in this process. These variables would be the independent or predictor variables. For example, we might want to use two or more of the following variables. All of these variables would use the same 5 point Likert rating scale described in the previous paragraph.

1) Rating of their experiences with your clerical staff.

2) Rating of their experiences with the practitioner(s).

3) Rating of their experiences with the Orthosis.

4) Rating of the quality of the facilities.

5) Rating of their experiences with their insurance company in this matter. This is included because some patients go through an ordeal trying to get insurance approval and are pretty angry by the time they get to your office.

We might want to wait at least a month after the fitting of the orthosis to allow for any adjustments of problems that might bias their ratings. This would also give them the necessary time to evaluate the orthosis.

Once the data had been collected on our desired sample, say, 100 patients, we would want to use some multiple regression analysis software to enter the data and calculate the results. While the details of the multiple regression analysis are beyond the scope of this paper two important concepts will be presented. The first concept is that of proportion of variance. The total variance of the dependent variable is 100%. The goal of the regression analysis is to find a few variables that account for, or explain, as much of that total variance (100%) as possible. The higher the percentage of variance accounted for by your independent variables, the better your prediction model.

Also, the proportion of variance accounted for by each individual variable is indicated by its Beta weight. This would tell us the relative importance of each variable in the presence of the other variables in the model. As you start with the first variable in the model its Beta weight represents the proportion of variance accounted for by that first variable. As you add the second variable to the model then the proportion of new variance explained by this second variable, excluding the variance already accounted for by the first variable. This gets a little complicated but, essentially, as each new variable is added to the regression model its Beta weight reflects only the new variance accounted for by this variable. It excludes variance already accounted for by any previous independent variables in the model.

The end result of the regression analysis is that it will identify which variables are most important in explaining the variance in the dependent variable, in this case patient ratings of the overall quality of their experience with your office. It will identify strong and weak points of your office. If the total variance (100% max) accounted for by your model is low, you would want to look for other important independent variables and repeat the study. A total percentage of explained variance of 70% would be pretty high for most studies. Even if there is a low total percentage of variance accounted for, your study still might identify one or two important variables to be used in further studies.

ATTITUDE, OPINION, AND INFORMATION SURVEYS

The more general your research question or topic, the more questions it will take to answer or explore your topic. For example, you may want to know how physicians who have used your practice feel about your services and performance. In its simplest form this could be summarized in one question to the physicians. You could ask them to rate your services on a Likert scale of 1 to 5, as in previous examples. However, you would learn a lot more if you came up with 10 to 20 questions that explored how physicians feel about various aspects of your services and performance.

The quality of your questionnaire will largely depend on your perceptiveness in identifying the important questions to be asked. This may largely be affected by your experience level with physicians, patients, and the underlying topic of your research. A practitioner who has worked with physicians and patients for many years would probably be able to better identify the important questions or topics, compared to someone with little experience. It would be well worth it to solicit the advice or other assistance from those more experienced when finalizing your questions. A physician, patient, or practitioner will probably do a better job in filling out the questionnaire if it is obvious to them that the questions are good ones and that they get at the core issues that are important to them. In other words, the questionnaire isn't a waste of their time due to its poor quality.

If you have a captive audience for your questionnaire, then the number of questions is not as big an issue. For example, you may be giving it to participants in a seminar who are required to fill it out in order to get credit. A longer questionnaire would be more acceptable in this situation. However, if you are mailing a questionnaire to physicians, and it is too long, they may not respond. If you give out an exit survey to patients at your office, and it is too long, they may not respond or may not take the time to do a good job. The best approach is to choose your questions very carefully and cover the topic with as few questions as possible. Make sure each question asks something different so you don't get a lot of redundancy. You may have to limit the scope of your exploration in order to limit it to a workable number of questions.

<u>Questions appropriate to the level of your sample</u>
When writing your questions you need to consider the level of your sample subjects with respect to such things as reading level, comprehension, technical language, vocabulary, etc. Some of your patients filling out a questionnaire may have no higher than a sixth grade reading level. Your readers may not know what you mean by technical words like orthosis or gait. Give a lot of thought to your questions so that they don't measure confusion on the part of the person filling out the survey.

<u>Unbiased versus biased questions</u>
In general, you want to come up with questions, and an overall questionnaire, that is unbiased. If every one of your questions is written in a neutral way to avoid interjecting any bias into the survey then your questionnaire would be unbiased. A questionnaire might also be considered unbiased if you had 20 questions in which 10 were worded in negative terms and 10 questions were worded in positive terms.

In general, we would like questions that result in responses that vary widely. The more that survey participants vary in their responses the more variance we have to analyze and differentiate. Sometimes a neutral question may not result in as much variation in response as a question worded in a biased way. For example:

1) "Indicate how you feel about your dealings with your insurance company" would be considered a neutral question. (Likert scale 1-5)

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2) If you posed the statement as "I am unhappy with my insurance company", and asked respondents to agree or disagree, this would obviously be a negatively biased statement. If you worded the question as " I am happy with my insurance company" this would be a positively biased question. However, these biased questions might result in wider variation in responses on a 5-point Likert scale from strongly disagree (1) to strongly agree (5). If you had 20 Likert-scale

questions about their insurance company, with 10 being positively biased and 10 being negatively biased, then, overall, the questionnaire could be considered unbiased. When doing attitude surveys the balance of positively and negatively biased questions can sometimes be a better approach.

Types of Data

In order to squeeze the most out of your questions, it is important to make sure they use the highest possible data type justified by the data. You can do more analysis on a higher data type, and you may limit your analysis unnecessarily by choosing a lower data type. The four data types are categorical, ordinal, interval, and ratio. Briefly, definitions of the four types are:

1) categorical- data that can be assigned to a group or category. Examples include gender, ethnicity, prosthetic foot type, type of back brace, ABC Certification category, occupation, etc. Each group would be assigned a number that would identify group membership such as 1=Male, 2=Female.

2) ordinal - data that allows you to order data, such as “most to least”. You can say that one subject is higher than another on this variable, but it says nothing about the absolute value of that subject on that variable. This is referred to as rank order. As an example you could order a group of students based on their grade point averages. Each would be assigned a number representing their rank in the order. Their ranking, say fifth in their class, would be ordinal data.

3) interval - data that is rank ordered but, in addition, you know how far apart the data points are from each other. There is an assumption that the intervals between adjacent data points are equal. but that there is no absolute zero reference point. You can only evaluate how the data points compare to each other but not to some zero reference point.

4) ratio - data that has all the qualities of interval data but also has a rational absolute zero point. Height measurements for a group of patients would be ratio data since we know what zero height is. Stride length would be ratio data also since we know what zero distance is.

The O&P **Research Reference Guide** has several useful articles on data types and data collection under the category of “Variables and data collection”.

The 5-point Likert scale

Probably the most useful form for a question on an attitude/opinion survey is the 5-point Likert scale. This has been briefly presented in some of the previous examples. If you wanted to ask a patient how satisfied they are with their orthosis you could simply ask them to respond yes or no, that they were or were not satisfied with their brace. Unfortunately, this doesn’t tell you much about their degree of satisfaction. A person who was marginally satisfied with their orthosis would give the same response as a person who was elated with their brace, the answer being yes they were satisfied. The yes/no question limits the data type to categorical.

You could learn considerably more from this patient by asking the question in a Likert scale form. For example, you could ask them to rate their satisfaction level with the orthosis on a scale of 1 to 5, with the following choices:

` 1 = highly unsatisfied
2 = unsatisfied
3 = neutral
4 = satisfied
5 = highly satisfied

This gives you a clearer representation of their level of satisfaction with the orthosis. It can generally be assumed that this is interval data unless you have some reason to believe that the intervals between scale points are not equal. You might have reason to believe that the distance between points 1 and 2 is not the same as between points 4 and 5. This would be a judgment call based on your knowledge of the study at hand. As interval data, not only do you get more detail on their responses, but you can more easily analyze the data statistically. It is a richer form of data than the categorical yes/no response.

Experience shows that a 5-point Likert scale is a good choice. You can go to a 7-point or higher scale if you have a sophisticated sample of subjects who are able to make more discriminating judgments. For example, if you were surveying a group of physicians on a medical topic a 7-point scale might be appropriate. However, in most cases it has been found that in going from 5-point to 7-point or higher you lose some clarity due to the inability of the subjects to make those finer discriminations. You would always want to use an odd number of points so that there is a neutral value at the midpoint of the scale.

<u>Examples of Likert-scale questions</u>

Please circle the point on the scale that best represents your view on the matter. Please answer with one numerical choice.

1) My orthosis costs too much.

1---------------------2-----------------------3-----------------------4----------------------5
strongly disagree | disagree | neutral | agree | strongly agree

2) How would you rate the treatment given by your Orthotist?

1+++++++++++++2++++++++++++++3++++++++++++++4+++++++++++++5
poor | fair | neutral | good | excellent

3) My attitude toward getting a brace prior to seeing my Orthotist was:

1*************2	**************3	**************4	**************5	
highly negative	negative	neutral	positive	highly positive

4) How do you feel about the future of O&P ten years from now?

1---------------------2	---------------------3	---------------------4	--------------------5	
highly pessimistic	pessimistic	unsure	optimistic	highly optimistic

Types of analysis
Each of the questions included in your questionnaire should be there because the responses to that question are of value to your research. You want to know the answer to each question and hopefully each one will make a contribution to knowledge in the field of O&P. The next question is how do you statistically analyze Likert scale data. Some suggested possibilities are:

1) Calculate basic descriptive statistics for each question. These would include the mean and standard deviation. It might also be useful to do a frequency distribution for each question to see how many of your sample chose each possible response (1 to 5) for each question.

2) Calculate correlation coefficients for each question with every other question. You would only want to include questions that generated interval or ratio level data. Any question using the Likert scale ratings could probably be assumed to be interval data and could be used in the correlations. Analyzing the pairs of questions with high correlations might be insightful. Correlation coefficients of approximately .40 and above would generally be of interest. Correlation coefficients of .70 and above would be considered pretty high.

3) In addition to the Likert scale questions, you would probably want to include some personal data on your subjects such as age, ethnicity (if appropriate), gender, number of years employed in O&P, etc. Some of this data would be categorical and you might want to know if the different categories responded differently. For example, are there gender differences in various responses? For variables like age or number of years in O&P, you could either calculate correlation coefficients with each Likert variable, or you could break age up into categories and compare the means for different age groups on each Likert question. Note that comparing the means for different categories of a variable is not the same as a test of statistical significance so you could not infer the results beyond your sample. However, you might speculate that the results might hold for those outside your sample and suggest further exploration to pursue interesting findings.

4) With your correlations and descriptive statistics, you may have identified variables that would be useful as either dependent or independent variables in a simple or multiple regression model.

You could use your questionnaire data to do a simple or multiple regression analysis. Remember that you would use one sample to generate the regression model and then a separate sample to test the accuracy of the regression model. However, just generating the regression model on your questionnaire sample might certainly be of value and lead to further research.

5) In a non-quantitative sense, you would want to spend considerable time going over the results of your questionnaire, and any statistical analysis of it. You would want to try to summarize it, make sense of it, find interesting insights, and see what contributions your results might make to the field of O&P. This is the fun part - the payoff. You may discover some new finding(s) or data relationships heretofore unknown to the field of O&P.

There is a useful article listed in the O&P **Research Reference Guide** that explores survey research in some detail. It is titled "Survey research and measurement error" and is under the category of "Measurement: An overview of research methodologies". Several other articles listed under this category would also be helpful for the concepts relevant to survey research.

THE CASE STUDY

The case study provides an opportunity for unlimited creativity. The possibilities are limited only by the imagination of the practitioner. Consider the following points in deciding whether a case study is appropriate:

1) The case(s) should be important in some way.
2) The case(s) may illustrate an unusual medical or bracing problem.
3) The case(s) may demonstrate a unique solution not previously presented in the literature.
4) The case(s) may show a failed solution that would help others avoid doing the same.
5) The case(s) could demonstrate the use of a new device.
6) The case(s) could demonstrate the use of an old device in a new way.
7) It may be a case without a solution that solicits others to consider the problem and possible solutions.

What you include in the presentation of the case study is highly variable but should include some information on the following:

1) A description of the patient.
2) A description of the problem or challenge presented by the case.
3) A detailed description, and picture, of any orthosis, prosthesis, or device used.
4) A description of the procedures followed and any methods used.
5) A description of the outcome.
6) A statement of questions or issues raised by the case study.

A case study may be used to compare two or more orthotic or prosthetic devices. For example, you may choose to compare three different prosthetic feet with one patient per foot. There may be a good reason for making this comparison, but, it is important to understand its limitations with respect to drawing conclusions. This would be a three group comparison with sample size of one patient per group. This would not be a statistical study and would be of limited value. However, for the reasons presented above the study may still have considerable value.

EXPERIMENTAL DESIGN - A BRIEF OVERVIEW

In this paper we have briefly covered some simple statistical methods including two group comparisons, analysis of variance, simple and multiple regression analysis, correlations, and some basic descriptive statistics. If you are adventurous you may want to consider other possibilities, with respect to designing an experiment. Authors Campbell and Stanley have written a classic, brief, and readable book on various experimental designs. It is titled “Experimental and Quasi-experimental Designs for Research”. For a good introduction, see the article listed in the O&P **Research Reference Guide**, “Types of clinical studies”.

In addition to learning more about research, the above exploration of experimental designs may give you other ideas for a research project. I highly recommend that you at least read the recommended article and spend some time considering the possibilities.

NON-PARAMETRIC STATISTICS

The inferential statistical methods discussed in this paper have some underlying assumptions about your sample data being normally distributed. While this concept is beyond the scope of this paper it is important to say that for many variables these assumptions will be met if you have a sample, or group size, of 30 or more subjects. In many medical situations the number of subjects available is limited and may be considerably less than 30 for sample size. The area of non-parametric statistics provides a variety of statistical tests for group comparisons, and other designs, when you have a small sample size (less than 30) and cannot meet the underlying assumptions of a normally distributed variable. For every statistical test of significance for large sample sizes (30 or greater) there is generally an equivalent statistical test for small samples. The details of non-parametric tests are beyond the scope of this paper but at least you know they exist. Do your best to get a large sample size and if you can’t, then good luck exploring the area of non-parametric statistics. There is one article listed in the O&P **Research Reference Guide** which introduces the concept of non-parametric statistics. It is listed under the category of “Statistical analysis”.

FORMAT FOR WRITING YOUR RESEARCH PAPER

There may be some flexibility or variation in the sections you include in your research paper but the following sections are useful and recommended:

1) Introduction
2) Literature review
3) Methods
4) Results
5) Discussion
6) Conclusions
7) Appendices
8) References

<u>The Introduction</u>
The following points should be considered when writing your introduction:

1) Include a clear statement of the problem or topic to be investigated.
2) What question(s) are you trying to answer? Do you have one or more research hypotheses?
3) Why is the research important and needed?
4) How will the study contribute to the field of O&P?

It may be necessary and appropriate to include a few references from your literature review in the Introduction section in order to make your points clear.

<u>Literature review</u>
While you may have included a few references in the Introduction section the bulk of your literature review should probably be in a separate section. In the Introduction you want to make your points as clearly as possible. If you include your full literature review in the Introduction it make take away from the clarity and brevity of your points. However, a more detailed Literature Review section will bring the reader up to speed and further strengthen the points made in the Introduction.

The Literature references should be organized in some reasonable manner. They might be organized based on the points in your Introduction, chronological order, or some other rational basis.

<u>Methods</u>
This section basically lays out the details of what you did in carrying out the research. Depending on the nature of your research you might need to include information on the following areas:

1) define the population and the sample
2) a description of the data and the variables
3) sampling and data collection procedures
4) your research design or method (two-group comparison, correlation, regression, etc.)
5) statistics and statistical tests used
6) equipment used

7) procedures followed
8) questionnaires or surveys used or developed

Results
This section should present the results of the procedures carried out in the methods section. It should be a balance of summarization of the data and analysis, while still presenting all necessary detail. Cumbersome data, like the breakdown of responses by subjects to each item on a questionnaire, should be presented in the appendices. However, you want to present some detail in the summarization of your data and results. It is a judgment call how much to include in the results and what goes in the appendices. The key word here is summarization, as much as possible. Consider including the following:

1) number of observations, respondents, etc.
2) unusable data, dropouts, incomplete questionnaires, non-respondents, etc.
3) descriptive statistics (mean, std. deviation, etc)
4) outcome of any statistical tests of significance
5) outcome of any statistical methods
6) appropriate tables and graphs
7) any problems encountered and how they were handled
8) computer resources used

There is one article listed in the O&P research reference guide titled "Discussing the results" that would be helpful for this section. It would also be helpful for the discussion and conclusion sections.

Discussion
In the results section, the data and analysis are presented in a summarized form.. In the discussion section, you want to present a more detailed discussion of the results, their meaning, and implications. While it is difficult to generalize about what should be included in the discussion section you might consider the following:

1) What did you find that is new and important?
2) Do your findings support or contradict other studies?
3) What are the implications of your findings?
4) What future research is suggested by your findings?
5) Were there any unexpected (serendipitous) findings?
6) How is the study affected by incomplete data, non-respondents, etc.
7) Discuss problems encountered and recommendations for dealing with them. What would you do differently?

Conclusions
This section should be relatively brief. It should clearly state the most important conclusions derived from the study. This is a chance to relate your findings back to the research questions

formulated at the beginning of the study. It re-examines the goals or purpose of the study and relates the findings to those. Were the goals or objectives of the study achieved? Were the research questions answered?

Appendices

These sections contain various tables, graphs, figures, pictures, and data that are too cumbersome, or in some other way inappropriate for the methods, results, or discussion sections. Including the data is a judgement call. If it is not too cumbersome and may be of value to other researchers, you might want to include the raw data in its most basic form.

The information in the appendices further adds to the detail and credibility of your research. They can be used to further support any implications or conclusions that you have derived from your research. Putting this information in the main sections of the paper might reduce the clarity of your arguments. Appendices information may not be of interest to everyone who reads your paper, but is available for those who want more detail.

References

Any journal article, book, or other published source referenced in your paper should be listed in the references section. The American Psychological Association offers a publication manual that details the appropriate way to list any kind of reference. This format is used by most professional journals including the *Journal of Prosthetics and Orthotics (JPO*). It you want to learn more about reference formats pick up a copy of the *APA Publications Manual*. It is available at most large bookstores. However, if you want to save some time then get one or more copies of the *JPO* and follow the formats shown in various articles.

GOOD LUCK

Between this paper and the articles listed in the O&P **Research Reference Guide** you should have plenty of information to absorb. Hopefully this information will help you focus and clarify what you need to do for your research project. Also, it should expand your knowledge of research methods considerably. There are some concepts in research and statistics that are difficult to grasp, so if there are parts you don't understand that seem relevant to your research project I hope that you will pursue it until it is clear. Be persistent and best of luck to you! At the very least, it is hoped that reading and studying the information in this paper and its referenced resources will significantly improve the quality of you research project.