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Influence of examiner experience on interrater reliability using the KT2000 knee ligament arthrometer

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Influence of Examiner Experience on Interrater Reliability Using the KT2000 Knee Ligament Arthrometer

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CHAPTER ONE

Introduction

Manual clinical stress tests are a relatively simple way to determine ligamentous injury through joint displacement. Furthermore it offers only a rough estimate of the degree of injury due to the subjective nature of the test (Malcom et. al. 1985). These reasons make apparent the need to develop standardized methods of quantifying knee stability. This has lead to the development of devices which are designed to objectively quantify the amount of tibial translation.

The KT-2000 knee ligament arthrometer is perhaps the most widely used device in ensuring knee joint translation (Highenboten, et.al.1992). This device objectively measures anterior and posterior (AP) translation of the tibia on the femur. More recently, testing of knee ligament integrity with devices such as the KT-2000 knee ligament arthrometer has gained increasing popularity. The most common uses of theses devices have been (1) to confirm the presence of cruciate ligament disruption, (2) to document the degree and type of injury, and (3) to evaluate the success of treatment, both surgical and therapeutic (Ballantyne et. al. 1995).

In using the KT-2000 knee ligament arthrometer, various external factors play a significant role in obtaining accurate as well as reliable data. Some of these factors include knee joint flexion, knee joint

rotation, displacement force, muscle guarding and limb position (Daniel et. al. 1984 & Highenboten et. al. 1989). Another significant factor to consider is the tester reliability in using the KT-2000 knee ligament arthrometer. The reliability in using this device between testers is very important. The data from this test is often passed on to physicians who then decide how rehabilitation will proceed. Therefore, if there are different testers performing this test each time determining the reliability is imperative. According to Greenfield et. al. (1998), reliability is defined as "the ability to reproduce or repeat the same measurements."

Statement of the Problem

The purpose of this study was to determine the influence of examiner experience in using the KT-2000 knee ligament arthrometer.

Operational Definitions

Arthrometer MEDmetric - A device used to measure knee ligament stability by measuring displacement of the tibio-femoral joint.

Experienced tester - An individual who has had approximately two to six years experience in using the KT-2000 knee ligament arthrometer.

Foot support - A support placed under both feet to establish symmetrical axial knee position before each test.

Graduate assistant - An opportunity for a student to have an assigned position to work in their field of interest in exchange for paid tuition.

Novice tester - An individual who had no prior experience in using the KT-2000 knee ligament arthrometer.

Thigh support - A platform placed under both thighs to maintain symmetrical knee flexion.

Total anterior-posterior displacement - Total displacement resulting in a 20lb posterior push and a 20lb anterior pull.

BASIC ASSUMPTIONS

1. All subjects had the same desire to participate in the study.
2. The KT-2000 Knee Ligament Arthrometer was properly calibrated and displayed accurate results.
3. The tester set up the patient and used the KT-2000 knee ligament arthrometer correctly.
4. The measurements taken by the experimenter with the reticular scale were performed accurately.

LIMITATIONS

1. Only 13 volunteers participated in this study.
2. The subjects may have not been on the same comfort level for the participation.
3. The subjects may have exhibited different hamstring tightness that could have altered the final results.
4. The novice testers having no previous experience with patient setups, detecting muscle guarding, and lack of confidence in using this device.

NULL HYPOTHESIS

1. There will be no difference in results between expert versus novice test results (N_{en}).

2. There will be no difference in results between expert versus expert or novice versus novice test results. (N_{ee}).

3. There will be no difference in results between the right and left knee test results (N_{rl}).

4. There will be no difference in results between the test at 15 and 20 pounds of force regardless of the tester ($N_{\#f}$).

CHAPTER TWO

REVIEW OF THE LITERATURE

The KT-2000 knee ligament arthrometer serves many purposes within the clinical setting. Clinicians use this instrument to provide a more quantitative assessment of knee injury through knee joint laxity.

This objective data is used to assess knee joint laxity but also to determine progression with rehabilitation. For example, if during the course of rehabilitation following anterior cruciate ligament reconstruction periodic testing reveals a progressive increase in laxity, a more conservative treatment protocol may be initiated. Conversely, if these tests revealed the anterior-posterior displacement of the involved knee continues to remain stable and tight, a more aggressive regimen of mobilization and exercise could be initiated (Ballantyne et. al., 1995).

The KT-2000 knee ligament arthrometer is commonly used as a tool in deciding further rehabilitation goals and progression options following post surgical patients. There are many knee arthrometers available for use by clinicians. Some include the KT-1000/2000, the Stryker Knee Laxity tester, and the Genucom Knee Analysis system. While all analyze knee laxity, they are different in their designs and setup protocols. Anderson & Lipscomb (1992) compared the KT-1000, Stryker Knee laxity tester and the Genucom Knee

analysis system to the Lachman's knee stability test. The data from the KT-1000 knee ligament arthrometer and the Stryker arthrometer were similar when compared to each other in similarity to the Lachman test. However, the KT-1000 knee ligament arthrometer most closely approximated the clinical finding of the Lachman test. Both the KT-1000 arthrometer and the Stryker arthrometer were found to be most similar when comparing them to the Lachman test. The Genucom arthrometer was found to be the least similar in comparison.

Review of the literature has generally concluded that objective instrumented evaluation of knee laxity is important in reporting results. However, the question remains regarding the interater and intrarater reliability in reporting results. Myrer et. al. (1996) tested the reliability of the KT-2000 arthrometer and concluded there was a significant difference (p value < 0.0001) between tester for anterior laxity in individual knees but not for side to side knee differences.

Highenboten et. al. (1989) performed a study using the KT-1000 in conscious and unconscious patients at 15, 20 and 30 lbs. of force. In the conscious state, he reported 64% of subjects at 20lbs of force and 83% of subjects at 30lbs of force had greater then 2 millimeters difference between normal and anterior cruciate ligament deficient knees. In unconscious patients, 72% of subjects at 20lbs of force and 83% of patients at 30lbs of force also had a difference

greater than 2 millimeters. Highenboten et. al. (1989) concluded that his results support the validity of the KT-1000 knee ligament arthrometer measurement in the diagnosis of anterior cruciate ligament disruption.

Among the previous research are raised the same questions regarding reliability and reproducibility of the KT-1000 knee ligament arthrometer. Many relate to the patient set up including knee flexion, arthrometer placement, and muscle guarding. Previous research have all made reference to one or more of these questions and its relationship to the objective data reliability (Anderson et. al.1992, Berry et. al. 1999, Daniel et. al.1988 & Hanten and Pace et. al.1987).

Daniel et al. (1988) reported that as a result of their research a clinical test should include: 1) define limb resting position, 2) define direction and point of application of applied force, 3) measure motion in degrees of rotation or millimeters of displacement and 4) define site of displacement measurement. Huber et al. (1997) supported this report by making specific references to the importance of foot alignment, muscle relaxation, proper instrument alignment with bony landmarks and angle of knee flexion.

Wroble et al. (1990) studied the repeatability of KT-1000 knee ligament arthrometer and its variability in trial to trial difference, installation to installation and day to

day differences. In trial to trial differences no significant differences were found when using the 90% confidence limits. The same was found for the between installments (within day) among any of the testers. Day to day reproducibility for translation on individual knees showed significant differences with anterior translation. Wroble et. al. (1990) suggested that the paired right to left knee difference should be used for reporting results rather than individual knee differences.

In testing only one limb, the measurement ignores inherent changes present in the contralateral knee, such as tightness of the anterior cruciate ligament or possibly the hamstring muscles. The evaluation should also be supplemented by a repeat evaluation on a different day to verify the accuracy of translation values obtained which may decrease any potential learning effects (Wroble et. al, 1990).

Hanten & Pace (1987) examined intrarater and interater reliability for experienced examiners using the KT-1000 knee ligament arthrometer in 43 asymptomatic male athletes. The two 20 pound anterior force measurements were taken on the right knee only. The authors reported an ICC value of .92 for intrarater reliability. The first anterior measurement from the initial examiner was also compared with a second experienced examiner's single anterior measurement which revealed an ICC value of .92. This value indicates this

correlation was significant at the 90% confidence limits for these comparisons.

In contrast, Forster et. al. (1989) refuted the claim of reliability on interater reliability on a clinically relevant population. Forster et. al. (1989) used the KT-1000 arthrometer on 4 subjects with no known ACL injuries and 6 other subjects with ACL injuries. Examiners were two experienced and two inexperienced surgeons who were instructed according to the manufacturer's guideline. The first examiner tested the right leg and then the left leg of each subject using 15lb and 20lb of force. Based on frequency tallies for various magnitudes of displacements measured, Forster et. al. (1989) questioned the reliability of the arthrometer because there was great variability among all measurements regardless of experience.

CHAPTER THREE

METHODOLOGY

Testing knee ligament stability is an objective way of determining the possibility of an injured anterior or posterior cruciate knee ligament. By using the KT-2000 knee ligament arthrometer, the tester is provided a more objective, hard copy of displacement of the involved knee. However, a review of the literature indicated that there are issues with reliability in using the KT-1000 knee ligament arthrometer instrumentation. In using the KT-1000 arthrometer, the device does not have the pen button to plot the displacement. This increases the chances of human error because the device requires eyeballing the approximate displacement on a small dial. In using the KT-2000 knee ligament arthrometer, the device provides the pen button and graph plotter. This suggests that the KT-2000 arthrometer may be more accurate as well as reliable based on the more objective form of the data recordings.

Subjects

Thirteen subjects (age=22-45) voluntarily participated in this study. All subjects had no prior history of anterior cruciate ligament disruption. Four testers from a local clinic performed the KT-2000 knee ligament arthrometer examination as determined by their clinic protocol. The two

experienced examiners were certified athletic trainers who reported using the KT arthrometer on approximately 100 patients over a span of two to six years.

The two novice non-certified athletic trainers were graduate assistants in a clinical setting. The two novice examiners had no prior contact with the KT-2000 knee ligament arthrometer.

Each tester followed the protocol as determined by the KT-2000 knee ligament arthrometer manual mentioned previously. Training of the novice examiners involved in a one hour training in-service including reading of the manufacturer's manual and observing the technique performed by one of the experienced examiners. Practice sessions were performed ten to fifteen times for one hour. Each novice tester completed approximately 10-15 practice tests.

Instrumentation

A standard KT-2000 MEDmetric Knee ligament arthrometer was used in this study. The patient set up was performed as described in the reference guide (Daniel, 1993).

Procedures

Before testing, subjects were given the informed consent form to read and sign. Patients were assigned a particular testing time and day for two tests. Each individual testing time was approximately twenty minutes with the entire experiment approximately one week. The

examiners were randomly chosen to perform the initial test. Before the tester performs the actual test, the investigator performed three practice sequences on each limb. This was to decrease patient guarding. It was important to note that while one examiner performed the test the other was not permitted to observe or interact with the patient or examiner. The subject was not informed of the results until the conclusion of the investigation.

The patient was positioned supine on the table with their arms at their side. The thigh support platform was place under both legs level to the popliteal space. It was important to note that the degree of flexion could effect the patellar placement in the trochlea. Therefore, it was important to ensure minimal patellar mobility as this could produce test errors.

The foot support was placed under both feet of the patient distal to the lateral malleolus. The importance of alignment and symmetry of the foot placement was mentioned in research performed by Ballantyne et. al. (1995). Review of the literature suggested that the KT knee ligament arthrometer minimally limits lateral rotation while allowing free medial rotation.

Once proper foot symmetry was achieved, the Velcro thigh strap was applied. The strap helped the patient to relax and ultimately decrease muscle guarding. The KT-2000 knee ligament arthrometer was positioned on the anterior

aspect of the lower leg so that the joint line arrow was in line with the joint line of the knee.

The arthrometer was adjusted by checking the joint line position and that the pressure on the patella was properly stabilizing the patella in the trochlea. The proximal calf was manually oscillated to induce a relaxation response in the hamstring muscles.

One hand was placed on the patellar sensor pad to stabilize the instrument. While maintaining pressure on the patellar reference pad, the displacement dial was adjusted to zero. Prior to recording the knee translation, a couple of practice sequences were performed to relax the patient and give them an idea of what the examination would feel like.

The push sequence occurred while depressing the pen button until the first tone was heard. Immediately following the tone, the pull sequence began until the first and second tones were heard. The tones indicated 15lb and 20lbs of force elicited during the pull cycle (Daniel, 1993). It is important not to exceed 30lb of force as this may lead to patient discomfort and muscle guarding (Daniel,1993).

After the testing had been recorded, the clear plastic reticular scale is used to measure displacement in millimeters at 15 and 20 pounds of force for anterior displacement. The average of the three tests for each knee was used for the final result.

Typically for the KT tests, the involved knee results are subtracted form the non-involved knee results (I-N). The average of the three measurements taken at 15lbs and 20lbs of force is recorded. A difference of greater than three millimeters is considered significant which is supported by previous researchers (Berry et.al.,1999, Daniel et. al., 1985, Daniel et. al., 1996, Forster et.al., 1989 & Myrer et.al., 1996). Each measurement of the knee was compared at 15lbs and 20lbs of force with other testers who performed the same test.

CHAPTER FOUR

RESULTS

The primary purpose of this study was to determine the influence of examiner experience in using the KT-2000 knee ligament arthrometer. A multiple linear regression was used to analyze the data for this study. This particular method was used because of the multiple variables considered in determining the relationship between them. When an asterisk appears in front of the data, it indicates there is a statistically significant relationship (Table 2).

Intrarater Test Data

Null hypothesis 1 stated there would be no difference between expert and novice test results (N_{en}). This study rejected null hypothesis 1 because there was a significant difference found at the 99% confidence interval [t=3.15] (Table 2).

Interrater Test Data

Null hypothesis 2 stated there would be no difference between interater test results for expert or novice test results (N_{bb}). This study failed to reject null hypothesis 2 because there was no significance found between these variable at the 99% confidence interval [t=0.19] (Table 2).

Right and Left Leg Test Data

Null hypothesis 3 stated there would be no difference between right and left knee test results regardless of the tester examined (N_{rl}). This study failed to reject null hypothesis 3 because there was no significance found between these variables at the 99% confidence interval [t=0.23] (Table 2).

Magnitude of Force Test Data

Null hypothesis 4 stated there would be no difference between 15 and 20 pounds of force performed during the test regardless of the tester ($N_{\#f}$). This study failed to reject null hypothesis 4 because there was a significance found at the 99.5% confidence interval [t-4.03] (Table 2).

CHAPTER FIVE

Discussion

The primary purpose of this study was to examine the influence of examiner experience in using the KT-2000 knee ligament arthrometer. This study examined the interrater and intrarater differences. Differences between the right and left knee and the magnitude of force was also examined.

Null hypothesis 1 stated there would be no difference between expert and novice testers. Because there was a difference found, null hypothesis 1 was rejected. These results were supported by Myrer et. al.(1996) who found there was a significant difference ($p=0.0001$) between testers when comparing anterior laxity differences for individual knees. Huber et. al. (1997) also supported these results in their study. They found that the intraclass correlation coefficient for the experienced examiner were higher than those for the novice tester when comparing posterior translation in the knee. Berry et. al. (1999) found there to be important differences between novice and expert raters. The novice raters' measurements were consistently lower than those of the experts.

Null hypothesis 2 stated there would be no difference between interrater test results with expert or novice testers. This meant that there would be no difference

between a novice vs. novice comparison or an expert vs. expert comparison. The correlation between these variables were found not to be significant. Therefore, this study failed to reject the null hypothesis because no significant difference was revealed.

These results in general are in agreement with those reported by Hanten and Pace(1987) who declared the KT-1000 arthrometer to be interrater reliable. However, it should be known that this study involved two experienced testers who performed two 15lb anterior force measurements. This was performed on the right knee only and was removed and reapplied between tests.

Null hypothesis 3 stated there would be no difference between right and left knee test results with expert or novice testers. The correlation indicated that there was no significant difference in this study. Therefore, null hypothesis 3 was not rejected. This finding supports the assumption that all subjects had no prior history of anterior cruciate ligament instability present. There may have been inherent differences present between tight and left knees that were not statistically significant, but may have been clinically significant.

In the case of a non-surgical individual with an anterior cruciate ligament injury, the KT may reveal a difference of two and a half millimeters between knees. This may be enough to cause some concern for the clinician. However, if an individual has had surgery and

the KT test reveals a two and a half millimeter difference, this may not cause concern as the anterior cruciate ligament undergoes vascular and collagen changes during the healing stages.

Null hypothesis 4 stated there was no difference between 15 and 20 pounds of force applied throughout the push-pull sequence. This study failed to reject null hypothesis 4 because there was a significance found between these variables. The apparent difference in the amplitude of force, regardless of the tester, was an expected finding.

Improvements for further Research

When performing the tests, testers were permitted to perform the test in the position they were most comfortable. This meant that some testers stood at the foot of the patient while others stood at the side of the limb being tested. This may have affected the magnitude of the force being applied or the alignment of the arthrometer position on the leg.

The testers in this study were all right hand dominant. The testers who stood on the side of the limb being tested had to use their non-dominant hand when testing the left knee. Whereas, the testers who stood at the foot of the patient being tested, used their dominant hand to perform both tests. This may have altered

the final results in this study. It is suggested that tester position and hand dominance be constant when performing the tests.

The leg that was tested first may also have altered the results. The testers automatically tested the left knee first because of where the KT-2000 knee ligament arthrometer was placed in the room. In further studies, the knees tested should alternate so that each tester does not test the same knee first on each subject.

The data results for this study are limited because of the small subject population. A larger subject population would improve the generalizability to the population of expert and novice raters.

Summary and Conclusion

The major findings in this study were significant differences between expert and novice testers when test results were compared to each other. There were no differences found when the groups were compared to themselves, whether it be expert vs. expert or novice vs. novice.

The results from this study led to the conclusion that examiner experience did influence the results in using the KT-2000 Knee ligament arthrometer.

Appendix A

Table 1

Table 1: Descriptive Data

Number of Subjects	Age in Years	Activity Level	Gender
13	22 - 45	Sedentary	7 male 6 female

Appendix B

Table 2

Table 2: Table for Multiple Linear Regression ANOVA

Variables		Standard Error	T-Scores	Confidence Intervals
** N_{en}		0.1151	3.15	99%
N_{ee}		0.1151	0.19	>60%
N_{rl}		0.1151	0.23	>60%
** $N_{\#f}$		0.0460	4.03	99.95%

Confidence IntervalsT-critical for df=208

60%	0.253
75%	0.674
90%	1.282
95%	1.645
97.5%	1.961
99%	2.576
99.5%	2.576
99.95%	3.291

Appendix C

Table 3

Table 3: Mean and Standard Deviations for Expert and Novice Testers

	20# of force	SD	15# of force	SD
	(in millimeters)			
Expert	R = 4.31	1.66	R = 3.27	1.47
	L = 4.33	1.73	L = 3.37	1.42
Novice	R = 3.51	2.19	R = 2.62	1.58
	L = 2.48	1.56	L = 2.71	1.14

Appendix D

Informed consent forms

Informed consent form

To participate in the research project entitled: **Influence of Examiner Experience on Interater Reliability Using the KT2000 Knee Ligament Arthrometer**

Purpose of this study:
Subjects will report to the CAMC Sports Medicine Center on two different occasions. The first visit will consist of two KT2000 tests by two examiners. Approximately two days later, I will return to the clinic for a second test by two different examiners. Each test data is recorded and kept confidential to the extent the law allows.

Time Requirement:
Approximately 30 minutes will be required to perform the two tests each visit.

Risks:
Research has shown that there is minimal risk involved in this procedure. The risk may be soreness along the anterior tibia from the pressure of the KT2000. If I have any concerns about the risks involved, I will contact Michelle Phelan at (304) 346-9846.

Benefits:
I will receive no personal benefits through this investigation by my volunteering in this study. My participation in this study will benefit the investigation for the purpose of examining the reliability of testers using the KT2000.

Confidentiality:
The information I provide is confidential. My name will be released to the Institutional Review Board (IRB) at Marshall University and appropriate state and federal agencies if requested. However, in the final draft of this investigation, my name will not be used.

Voluntary participation:
My participation in this study is completely voluntary. There is no penalty for not participating.

Right to Withdraw from this study.
I have the right to withdraw from this study at any time without penalty.

How to withdraw from the study:
If at any time I would like to withdraw from the study, I will tell the experimenter and leave the testing area.

Payment:
There will be no payment for participating in the study.

Who to contact if I have any questions regarding this study:
Michelle Phelan, ATC (304) 346-9846

Who to contact about my rights in this study as a research participant:
Henry Driscoll, MD
IRB Chairperson
1542 Spring Valley Drive
Huntington , WV (304) 696-7320

Agreement:
I have read the above information and understand the risk involved. In the event that I suffer from physical injury, no compensation, financial or otherwise, will be offered by the investigators or Marshall University.

Signature: _____ Date: _____

Witness: _____ Date: _____

Investigator: _____ Date: _____

Appendix E

Raw Data

Raw Data

	E_1		E_2		N_1		N_2	
	R	L	R	L	R	L	R	L
1	7.0	6.5	4.0	6.5	3.0	4.0	5.5	6.5
	5.0	5.0	3.0	4.5	1.5	3.0	3.0	4.5
2	6.0	8.0	6.5	5.0	4.0	4.0	6.0	6.0
	5.0	6.5	5.5	4.0	2.5	2.5	4.0	4.0
3	5.0	3.5	4.0	4.0	4.5	4.0	3.0	4.0
	4.0	2.5	3.0	3.0	3.0	3.0	2.0	3.0
4	6.0	5.0	6.0	4.5	3.5	4.0	5.0	4.5
	5.0	4.0	4.0	3.5	2.5	3.0	4.0	3.5
5	7.0	7.5	7.0	7.0	8.5	5.0	8.0	8.0
	6.0	7.0	6.0	5.5	6.0	3.0	5.0	6.5
6	3.5	4.0	2.5	1.5	2.5	2.0	1.0	4.5
	2.0	3.0	2.0	2.0	2.0	2.0	1.0	3.5
7	1.5	2.5	2.5	1.5	2.0	1.5	2.5	2.5
	1.0	2.0	2.0	1.0	1.5	1.0	1.5	1.5
8	5.0	4.0	3.5	3.0	2.5	2.5	2.5	4.5
	2.5	3.0	2.0	2.0	1.5	1.5	2.0	3.5
9	4.0	7.0	3.0	4.0	1.0	1.5	1.0	1.0
	3.0	5.0	2.0	2.5	1.0	1.5	1.0	1.0
10	5.0	4.5	5.0	3.0	5.5	2.0	6.0	5.0
	3.5	4.0	4.0	2.0	4.5	1.5	5.0	4.5
11	3.0	4.5	4.0	3.5	4.5	1.5	1.0	3.0
	2.5	3.5	3.0	3.0	5.5	2.0	1.5	2.0
12	2.5	3.5	3.5	2.0	2.5	1.5	4.0	4.0
	1.5	2.5	2.5	1.5	2.0	1.0	3.0	2.5
13	2.5	4.0	2.5	2.5	1.0	1.0	1.0	3.0
	2.0	3.0	2.0	2.0	1.0	1.0	1.0	4.5

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Abstract

The KT-2000 knee ligament arthrometer is frequently used by clinicians in determining the integrity of the anterior cruciate ligament. Researchers have questioned the reliability in using this device in reporting reliable results. The purpose of this study was to determine the influence of examiner experience in using the KT-2000 knee ligament arthrometer. Thirteen subjects (age=22-45) were recruited on a voluntary basis for this study. The KT-2000 knee ligament arthrometer was used to measure anterior-posrtior laxity for each patient. Results were measured at 15 and 20 pounds of force for right and left knees. A multiple linear regression ANOVA was used to analyze the data. There was a significant difference found when comparing expert and novice testers ($t=3.15$; $p=0.02$). However, when comparing novice and experts to themselves, there was no significant difference found ($t=0.19$; $p=0.05$). The differences between the right and left knees were found not to be significant ($t=0.23$; $p=0.05$). Finally, the differences between measurements taken at 15 and 20 pounds of force were found to be significant ($t=4.03$; $p=0.02$). These results concluded that examiner experience did have an influence in using the KT-2000 knee ligament arthrometer.