January 27, 2003

Undergraduate Research Committee
University of Evansville

Dear Committee Members:

Attached is a research proposal for which we are requesting funding from your committee. This funding is requested for Spring semester, 2003. The research project has been submitted to the Subcommittee for Protection of Research Subjects and is pending approval.

This is a student generated project. To be considered as "student generated," the student researcher must be responsible for the majority of the concept development, project design, and proposal writing. Student /faculty collaboration, however, is recognized as essential in providing the student with a positive learning experience. Student projects must have a faculty sponsor whose name shall appear on the written proposal. The faculty member will be responsible for the research project.

The students involved in this research meet one of the following four eligibility requirements (specific requirements met are indicated in the signature line): (1) good standing in the Honors Program; (2) GPA of 3.5 or greater; (3) academic scholarship winner (trustee, president, or faculty), or (4) written recommendation form the department chair or dean based on a consensus of the academic department or school (attach a copy of the recommendation).

Thank you for your consideration of our research.

Sincerely,

Susan Links (4)
1662 E. Walnut
Evansville, IN 47714-1123
475-9029
sl00@evansville.edu

Megan Gandy (4)
1718 Lincoln
Evansville, IN 47714-1503
475-5813
mg00@evansville.edu

Mary Moon (4)
2024 Lincoln Ave
Evansville, IN 47714-1574
475-6827
mm00@evansville.edu

Mandy Bowen (2, 4)
225 S. Weinbach
Evansville, IN 47714-1252
475-6225
mb00@evansville.edu

Fred Underhill, PhD
Professor of Fine Arts
479-1253
fu00@evansville.edu

The University of Evansville
College of Arts and Sciences
Department of Music
Research Proposal

Title: The effect of the dorsiflexion-eversion stress test on tibial nerve conduction parameters

Students: Susan Links, Megan Gandy, Mary Moon, Mandy Bowen

Faculty Sponsor: Fred Underhill, PhD, Professor of Fine Arts

Plain Language Summary:

{This is a new requirement as of 1/1/11. Provide a summary of the proposed work that is free of any discipline-specific terms and written in a style that is appropriate for a general audience. The summary should emphasize why the proposed work should be done and how the anticipated results will increase the understanding of the proposed topic. The summary should also discuss how the anticipated results may have a broader impact on a societal need or issue. **Note: The plain language summary and abstract is limited to one page including the title, students, and faculty sponsor information.***}*

Abstract:

Tarsal tunnel syndrome (TTS) is a relatively common entrapment neuropathy of the tibial nerve at the ankle. TTS is a somewhat controversial diagnosis, and is difficult to establish. For most peripheral entrapment neuropathies, abnormal nerve conduction detected during clinical electrophysiologic testing (CEPT) is the most definitive evidence. However, for unknown reasons, there is an unacceptably high rate of false negative nerve conduction tests in patients with clinical signs and symptoms of TTS. Therefore, surgeons must often rely on less accurate patient histories and physical examinations to determine whether to recommend surgical release of the tarsal tunnel. Researchers have recently described a clinical test that is reported to provoke symptoms in patients with TTS, but not in individuals with no signs nor symptoms of TTS. The dorsiflexion-eversion stress test (DEST) is analogous to the Phalen test, used to provoke symptoms of carpal tunnel syndrome in the upper limb. Combining the DEST with CEPT may result in a clearer diagnosis of TTS, thus providing surgeons with better information to determine whether surgical intervention is warranted. Earlier diagnosis and treatment of TTS will reduce health-care costs, pain, and disability.

A convenience sample of 30 healthy subjects of either gender at least 18 years of age will be enrolled in this study. There is a single independent variable, TRIAL, with 2 levels, pre-DEST and post-DEST. The dependent variables will be the latency and amplitude of the responses to stimulation of the tibial nerve. Both compound nerve action potentials (CNAP) and compound muscle action potentials (CMAP) will be recorded from the medial and lateral plantar nerves in both lower limbs. The results will be compared using paired *t*-tests. It is anticipated that in this sample, there will be no change in the CMAP and CNAP parameters following a 30 second DEST, and will serve as the basis for further research in a sample of patients with symptoms of TTS. The total funding requested for this research is $1500.00. Data collection will begin as soon as the required equipment is available and all approvals have been obtained, and should be completed by May 31, 2003.

Introduction and Literature Review

Pain in the ankle and foot is a common cause of disability, and results in considerable cost in terms of lost productivity and health care expenses. One potential cause of ankle and foot pain is entrapment or compression of the tibial nerve in the region of the ankle, a condition referred to as Tarsal Tunnel Syndrome (TTS). Appropriate treatment of pain in the ankle and foot is dependent upon an accurate diagnosis. Because TTS is not a well-defined clinical entity, the diagnosis is difficult. Although the patient's description of the symptoms, a physical examination, and clinical tests are helpful in the diagnosis of TTS, demonstration of abnormal conduction of action potentials in the tibial nerve is often considered definitive evidence of TTS. However, clinical electrophysiologic testing (CEPT) of the distal aspect of the tibial nerve is technically difficult, and results in an unacceptable number of false negative tests. Methods to increase the sensitivity (decrease false negative tests) of CEPT in the assessment of patients will result in earlier definitive treatment, and thus decrease pain, disability, and the economic impact of ankle and foot pain.

The tibial nerve, a continuation of the sciatic nerve, enters the foot posterior to the medial malleolus, through a defined space referred to as the tarsal tunnel.[1] The osseous structures of the tarsal tunnel are the medial calcaneous and the medial malleolus, with the flexor retinaculum (laciniate ligament) forming the roof.[2] Other structures in the tunnel include the tendons of the tibialis posterior, flexor hallicus longus, and flexor digitorum longus, as well as the tibial artery, tibial vein, and connective tissue.[2] The motor neurons of the tibial nerve innervate all intrinsic musculature of the foot (except the extensor muscles)[1], and the sensory fibers supply the skin on the plantar aspect of the foot and the heel.[2]

When a peripheral nerve is subjected to external pressure that exceeds the pressure in the *vasa nervosum* (the vessels that supply the supporting neurilemmocytes and the axons in the nerve), ischemia of the section of the nerve subjected to the pressure results.[3] The short-term consequence of this ischemia is a rapidly reversible conduction block of the nerve across the ischemic segment, which will produce a loss of sensation in the peripheral nerve field, and a loss of motor function in those muscles innervated by the nerve.[3, 4] If the pressure-induced ischemia persists, there will eventually be a disintegration of the myelin sheath around the myelinated axons, and potentially an axonotmesis.[4] This pathology is not reversed rapidly, and recovery will not occur until the compression is relieved.

Tarsal tunnel syndrome is a distinct clinical entity, and results from compression of the tibial nerve as it passes into the foot through a defined space posterio-inferior to the medial malleolus.[2] The symptoms of TTS include pain in the ankle and foot, especially near the tarsal tunnel, and sensory disturbances in the plantar and calcaneal aspects of the foot.[5, 6] Any one or all three branches (medial plantar, lateral plantar, or calcaneal) of the tibial nerve may be compromised.[2] Any condition that either reduces the available space in or increases the contents of the tarsal tunnel may produce a compression of the tibial nerve. Researchers have reported many possible causes, including anomalous muscles (e.g., an accessory flexor digitorum longus or tibiocalcaneus internus)[7], ganglion cysts[8, 9], tarsal coalition[2, 9], overuse[10], and pes planus.[2]

Although many patients with TTS present with signs common to peripheral nerve entrapments (e.g., a positive Tinel sign, pain with palpation of the involved nerve, and sensory deficits in the nerve distribution)[2], the diagnosis of TTS based on a history and physical examination alone continues to be difficult.[6] Routine electrophysiologic testing has been advocated as a means to clarify the diagnosis, but there is an unacceptable rate of false negative tests.[11] A clinical test recently described by Kinoshita et al[5] appears to provoke symptoms in the tibial nerve distribution in individuals presenting with ankle and foot pain. If the dorsiflexion-eversion stress test (DEST) described by Kinoshita et al[5] results in ischemia of the tibial nerve, then changes in the evoked nerve action potential should be observed as a result of the ischemia.

Purpose

The purpose of this study is to determine whether the DEST will alter the evoked response of the tibial nerve in individuals without signs or symptoms of tibial nerve entrapment at the ankle. The results from this study will then be used to determine whether the combination of electrophysiologic testing with the DEST will result in an improved diagnostic accuracy in patients with ankle and foot pain.

Rationale

If the DEST results in ischemia of the tibial nerve as it passes through the tarsal tunnel, then a conduction block of the sensory and motor axons in the tibial nerve should result. A conduction block of axons will result in a decreased amplitude of the evoked response or an increase in the latency of the response.

Individuals without a compression of the tibial nerve should have no change in the evoked response as a result of the DEST. If there is no change in a sample of individuals with no symptoms of compression, then any changes observed in a sample of individuals with symptoms of compression will be interpreted as objective evidence of pathology. If the evoked response does change in individuals without symptoms following the DEST, then any changes in the evoked response following the DEST in a sample of individuals with symptoms will require caution in interpretation.

Hypotheses

The null hypothesis for this research is that there will be no change in the tibial nerve evoked response following the DEST beyond chance sampling error. The alternative hypothesis is that there will be a change in either the latency or amplitude of the evoked response following the DEST.

Delimitations

The results of this study will apply only to those individuals with no symptoms of tibial nerve compression. However, these results will form the basis for further research with individuals with ankle and foot dysfunction.

Limitations

The results of this study will not apply to individuals with symptoms of focal tibial nerve entrapment, nor to individuals with generalized peripheral neuropathy.

Definitions

Clinical electrophysiologic testing for this study refers only to nerve conduction testing, using surface recording and stimulating electrodes. This process involves placing recording electrodes over a peripheral nerve or a skeletal muscle, delivering an electrical current to the nerve, and recording the volume-conducted action potential (the evoked response). Parameters measured include the latency of the response (time from onset of stimulus to response) and the amplitude of the response.

Ischemic conduction block: failure of a peripheral neuron to conduct an action potential across a segment of the axon that is ischemic. The block is typically the consequence of an inability of the axon to repolarize following a depolarization due to a lack of energy available for the Na^{+}-K^{+} ATPase.

Methods

Subjects

The sample will consist of 30 individuals with no symptoms nor history of pain or sensory disturbance in the ankle and foot. Subjects will be at least 18 years of age, and will be free of systemic conditions know to alter peripheral nerve function (e.g., diabetes mellitus, ethanol abuse) by self-report. Subjects will be recruited from the local community by word of mouth. Both limbs will be tested in each subject, giving a total sample size of 60.

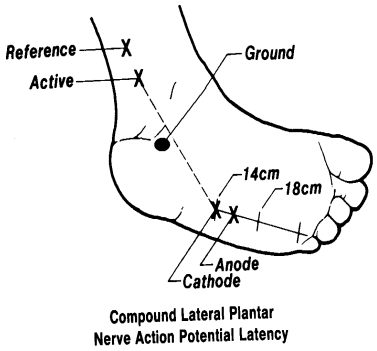
Materials

Electromyography equipment (stimulator, pre-amplifier, amplifier, display screen, recording device), electrode leads, surface disposable electrodes, conductant gel, skin preparation solution, alcohol swabs, tape measure, recording paper, plotter pens, thermometer.

Procedures

After agreeing to participate in the study, informed consent will be obtained. The subject will remove footwear and socks, and will lie prone on a treatment table. Nu-Prep will be used to reduced skin impedance over the tibial nerve just proximal to the flexor retinaculum, as well at the stimulation areas on the plantar aspect of the foot between the 1^{st} and 2^{nd}, and 4^{th} and 5^{th} metatarsals and over the abductor hallicus and the abductor digiti minimi pedis muscles. The location of the tibial nerve proximal to the flexor retinaculum will be identified by palpation, and a mark will be made on the skin using a felt-tip pen. This site will be used as the recording site for assessment of the compound nerve action potential (CNAP). A flexible tape measure will be used to measure from this recording site to a point 100 mm distal on the plantar aspect of the foot

between the 1st and 2nd metatarsals, and the location will be marked. The tape measure will then be used to mark two CNAP stimulation sites, over the medial plantar nerve 40 mm distal to the 100 mm site, and over the lateral plantar nerve 40 mm lateral to the 100 mm site. See figures 1 and 2.



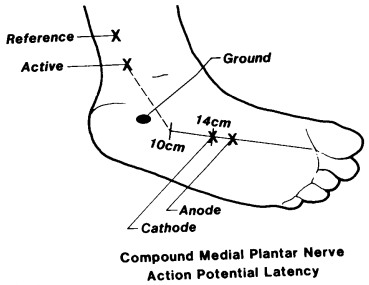
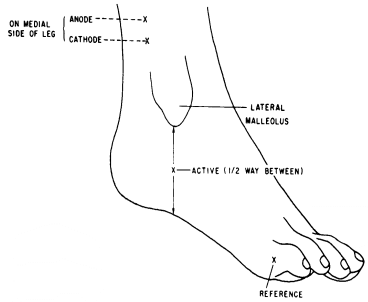


Figure 1 **Figure 2**

For assessment of motor function, the abductor hallicus will be marked at a point 10 mm inferior and 10 mm posterior to the navicular tuberosity, and the abductor digiti minimi pedis will be marked at a point midway between the inferior tip of the lateral malleolus and the base of the 5th metatarsal. The active recording electrodes will be placed on these sites, and a stimulation site over the tibial nerve will be marked 100 mm proximal to the abductor hallicus site. See figures 3 and 4.



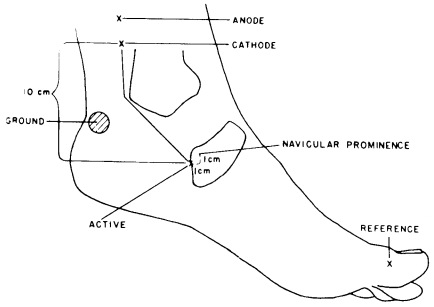


Figure 6.10. Medial plantar nerve motor latency to the abductor hallucis muscle.

Figure 3 **Figure 4**

Skin temperature will be monitored with a Triplett Model 2101 multimeter and thermocouple placed over the medial calcaneous, near the malleolus. If the skin temperature is less than 31 C (88 F), a hot pack or warm water immersion will be used to increase the temperature to at least 31 C. As the skin temperature falls below 31 C, there is a progressive decrease in conduction velocity (or increase in latency) and an increase in evoked response amplitude.[12]

Self-adhesive, disposable recording electrodes will be placed over the abductor hallicus, the abductor digiti minimi pedis, and over the tibial nerve. For the motor studies, the reference recording electrode will be placed over the 1st and 5th MP joints respectively, and for the CNAP studies, the reference recording electrode will be placed 40 mm proximal to the active recording electrode. A ground electrode will be placed between the CNAP stimulating and recording sites.

The recording parameters on the electromyograph for the motor studies will be: high cut filter 10,000 Hz, low cut filter 10 Hz, sweep speed 5 ms per division, and gain 5,000 μV per division. For the CNAP studies, the parameters will be: high cut filter 2,000 Hz, low cut filter 20 Hz, sweep speed 2 ms per division, and gain 10 μV per division. Conductant gel will be applied to the stimulator, and the previously marked stimulation sites will be stimulated. The amplitude of the stimulus will be gradually increased to obtain a maximal response. After recording the latency and amplitude of the evoked response, the next site will be stimulated in a similar manner. The order of stimulation sites (motor to abductor hallicus and abductor digiti minimi pedis, and CNAP from the medial plantar nerve and the lateral plantar nerve) will be determined prior to data collection using a random number generator.

After collection of the four evoked responses, the DEFT will be administered as described by Kinoshita et al.[5] Briefly, the ankle will be placed in a position of maximal dorsiflexion and eversion, and the digits will be fully extended. All movements will be passive, and the position will be held for a total of 30 seconds. Immediately after the test, all four evoked responses will again be recorded in a random order. The latency of the motor responses will be measured to the onset of the negative deflection, and of the CNAP responses to the peak of the negative deflection. The amplitude of the motor responses will be from the baseline to the peak of the negative deflection, and for the CNAP responses from the peak of the negative deflection to the nadir of the positive deflection. The data will be reduced and analyzed using paired *t*-tests.

References

1 Taber KH, Duncan G, Chiou-Tan F, Patni P, Hayman LA. Sectional neuroanatomy of the lower limb II: Leg and foot. *J Comput Assist Tomogr*. 2001;25:823-826.

2 Dawson DM, Hallett M, Wilbourn AJ. Entrapment neuropathies of the foot and ankle. In: *Entrapment neuropathies*. 3rd ed. Philadelphia, Pa: Lippincott-Raven; 1999:297-334.

3 Dawson DM, Hallett M, Wilbourn AJ. Pathophysiology of nerve entrapment. In: *Entrapment neuropathies*. 3rd ed. Philadelphia, Pa: Lippincott-Raven; 1999:4-19.

4 Dumitru D, Zwarts MJ, Amato AA. Peripheral nervous system's reaction to injury. In: *Electrodiagnostic medicine*. 2nd ed. Philadelphia, Pa: Hanley & Belfus, Inc; 2002:115-157.

5 Kinoshita M, Okuda R, Morikawa J, Jotoku, T, Abe, M. The dorsiflexion-eversion test for diagnosis of tarsal tunnel syndrome. *J Bone Joint Surg Am*. 2001;83-A:1835-1839.

6 Öztuna V, Özge A, Eskandari MM, Çolak M, Gölpinar A, Kuyurtar F. Nerve entrapment in painful heel syndrome. *Foot Ankle Int*. 2002;23:208-211.

7 Sammarco GJ, Conti SF. Tarsal tunnel syndrome caused by an anomalous muscle. *J Bone Joint Surg Am*. 1994;76-A:1308-1314.

8 Nagoka M, Satou K. Tarsal tunnel syndrome caused by ganglia. *J Bone Joint Surg Br*. 1999;81-B:607-610.

9 Takakura Y, Kumai T, Takaoka T, Tamai S. Tarsal tunnel syndrom caused by coalition associated with a ganglion. *J Bone Joint Surg Br*. 1998;80-B:130-133.

10 Fredericson M, Standage S, Chou L, Matheson G. Lateral plantar nerve entrapment in a competitive gymnast. *Clin J Sport Med*. 2001;11:111-114.

11 Robinson LR. Entrapment neuropathies and other focal neuropathies. In: Johnson EW, Pease WS, eds. *Practical Electromyography*. 3rd ed. Baltimore, Md: Williams and Wilkins;1997:237-272.

12 Weber RJ. Nerve conduction studies. In: Johnson EW, Pease WS, eds. *Practical Electromyography*. 3rd ed. Baltimore, Md: Williams and Wilkins;1997:131-194.

Proposed Budget
(Itemize in details as much as possible)

Accounting Code			
1000	I.	A. Faculty Honorarium	$750.00
		B. Faculty Summer Stipend ($7,500 max)	
		C. Student Summer Stipend ($3,500 max)	
		D. Student Summer Housing	No
2000	II.	Secretarial and other paid assistance	
3000	III.	Travel (for research purposes) not to include travel to conferences	
4000	IV.	Contract Services	
5000	V.	Supplies and Materials	
		Small tab electrodes (4 packages)	$350.00
		Ground electrodes (1 package)	$250.00
		Conductive gel (1 tube)	$4.00
		Nu-Prep (1 tube)	$1.00
		Recording paper (5 rolls)	$100.00
		Plotter pens (2 packs of 3)	$30.00
		Shipping	$15.00
6000	VI.	Capital Assets (equipment to be purchased off campus)	
7000	VII.	Other items not listed above (itemize)	
Total Budget Requested			$1500.00

Faculty Biographical Sketch

Name: Fred Underhill
Position: Professor of Fine Arts
Education:

Institution	Degree	Year	Field of Study
Cleveland State University	BA	1977	Music Performance
Baylor University	MFA	1979	Music
Columbia University	PhD	1984	Philosophy

Positions Held

1997 - Present: Professor of Fine Arts, University of Evansville. Teach music performance, choreography.

1984 - 1997: Assistant and Associate Professor of Performing Arts, University of Delaware. Taught music theory. Developed independent research projects in musculoskeletal injuries of performing artists.

Role of the students and faculty

This is a student generated project. The students developed the research question and conducted the literature review with input from Dr. Underhill. Dr. Underhill developed the methods, and the students will be responsible for data collection and analysis, with Dr. Underhill's supervision. All investigators will interpret the data, and will co-write the final report.

Timetable for research and plan for dissemination of findings

Data collection will commence as soon as the students have acquired the skills necessary to reliably record evoked responses. Skill acquisition will begin upon receipt of the needed equipment. Data collection should be completed by the end of the Spring 2003 semester. Data analysis and writing the manuscript will occur during summer of 2003. The manuscript will be submitted to a refereed journal.

Documentation of Informed Consent
The effect of the dorsiflexion-eversion stress test on tibial nerve conduction parameters

Purpose and duration of study

You are invited to participate in a research study on 30 volunteers. The purpose of this study is to learn whether holding your ankle in a certain position for 30 seconds will change the way a nerve in you leg transmits information. Information learned from this study may be used by health care workers in helping diagnose the cause of ankle and foot pain.

Tarsal tunnel syndrome is a condition that is the result of pressure on a nerve that supplies the bottom of the foot and the heel. As the nerve enters the foot, it passes through a tunnel, and may have too much pressure applied. Pressure on this nerve can cause a pins and needles sensation, as when your hand or foot "falls asleep". If the pressure stays for a longer time, such as due to some injury of the ankle, the nerve can be damaged. There are electrical tests that are used to help diagnose this condition, but they are not perfect. Other tests that place extra stress on the nerve are also used, but they are also not perfect. We believe that by combining the stress test and the electrical tests, we may be able to improve the ability to diagnose this condition. Before we can use this combination of tests in people with pain, we need to learn whether people without pain are affected by the tests.

Procedures

After you say you are interested in being part of this study, we will answer any questions you have, and ask you to sign this consent form. We will ask you questions about injuries and medical conditions you have experienced. If you have had certain injuries, such as ankle sprains, or diseases, such as diabetes, we may not allow you to be part of the study. This is for your protection, and to make sure we have correct information. We will then have you put on a pair of shorts.

Next, we will check your reflexes with a rubber hammer, and see if you can feel a light touch on the bottom of your foot. You will also be asked to contract a few muscles in your leg very strong, and move your ankle. To help us record the responses of your nerves and muscles, we will use a special cream, and rub it on parts of your foot, and use an alcohol pad to remove any oil or lotion. Next, we will mark places on your foot and ankle with a felt-tip pen, and measure with a tape measure to make sure to place the electrodes correctly. A small cable will be touched to your ankle to measure the temperature of your leg. If your leg is too cool to let us record correct information, we will put a hot pack on your ankle and foot, or have you put your ankle and foot in warm water for a few minutes.

We will then put small metal tabs, or electrodes, on your ankle and foot, connect some wires to the electrodes, and put a small probe on your ankle and foot. This probe will be used to shock the nerve several times. The shock will be gradually increased until the nerve responds as much as it can. This shock is very brief, only about one ten-thousandth (1/10,000) of a second, and is in no way dangerous, but will produce some discomfort. The amount of discomfort is about the same as when you get shocked touching a doorknob after walking across a carpet. You should

receive about 40 of these shocks total. After the responses have been recorded, the tabs will be removed, and you will be finished with the project. Your total time commitment should be about one hour.

Risks or discomfort

You will have almost no risk of injury. The shocks will be unpleasant, but there has never been anyone injured by these shocks. We will keep any risks at a minimum by inspecting our equipment often and will keep it in good working order.

Benefits

You will benefit from being a subject in this project by learning if your nerves are functioning normally. If we find any indication of a problem with your nerves, we will recommend you seek care from your family physician. The benefit to society from you being a subject will be that more people will get correct medical care for ankle and foot pain.

Alternatives to volunteering for this research

The alternative to volunteering for this research is to not volunteer. If you have no interest in this research, you should not volunteer.

Confidentiality of records of study participation

We will assign an identification number to your data form so that anyone reading the form will not know that it is your form. A list of names and numbers will be kept in a locked desk, and will be destroyed as soon as the research is completed. This informed consent document with your name on it will not include any information other than your name, and will not be available to anyone other than the researchers.

Entitlement to care

Your volunteering for this research will not alter any entitlement to medical care in any way.

Voluntary nature of participation

Whether you volunteer for this research is entirely your decision. You must not feel pressured to volunteer, and you must realize that there will be absolutely no negative results if you choose to not participate. If you do volunteer, and at any time decide to no longer be a subject, all you need to do is tell any of the researchers that you wish to stop. We will immediately stop collecting data from you, and will discard all information except this consent form. If at any time we feel it is in your best interest to stop your participation in the research, we may do so with or without your consent.

The principal investigator on this study is Susan Links, who may be contacted at (812) 475-9029 if you have any additional medical or scientific questions regarding this study. If you have any questions about the ethical, legal, or social aspects; the review of this study by the University of Evansville's Subcommittee for Protection of Research Subjects; or other questions you would like to discuss, you may contact the chair of this committee, Frank B. Underwood, PT, PhD, ECS, Professor of Physical Therapy, at (812) 488-1053, who will answer your questions or refer you to an appropriate person.

****

I have read the above explanation and agree to participate in the investigational study described.

I am aware that information gained from my participation in this study may be published in medical literature, discussed for educational purposes, and used generally in the furtherance of medical science. I also understand that by participating in this investigational study, I will not be personally identified.

Volunteer's signature and date	Witness's signature and date

Volunteer's address and telephone number