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AN EVALUATION OF THE FOOT TAPPING TEST (FTT) IN
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Abstract

The reliability of the foot tapping test (FTT) has not been well identified in a normal healthy population. In order to make it clinically relevant, more research must be done on the FTT in healthy individuals in order to determine if it is a reliable measure of foot tapping ability. **Purpose:** The purpose of the study was to investigate the FTT in a healthy population using a variety of different measurement methods. By comparing the different measurement methods, we hope to make recommendations for future FTT research. **Methods:** 20 healthy individuals (10 male and 10 female), ages of 18-31, completed a series of foot tapping trials spread out over 4 separate visits. While seated, subjects tapped their foot repeatedly for 10 seconds while researchers counted the number of foot taps. The starting foot was randomized during each visit and each foot would be tested twice with the shoes ON and twice with the shoes OFF (resulting in 8 trials per visit * 4 visits = 32 trials per subject). The number of foot taps was determined with visual inspection, video playback (slowed and normal speed), and with the use of a force plate. The mean values of the FTT trials were compared across days, dominant vs. non-dominant foot, the shoes ON/OFF conditions, and with the different counting methods. **Results:** Significant differences were found in foot tapping rates in the shoes ON vs shoes OFF and dominant vs. non-dominant foot analyses ($p < 0.05$). Furthermore it was found that a significant difference in the mean number of foot taps existed between visit 1 and the other 3 visits ($p > 0.05$). It was found that the FTT exhibited high test-retest reliability (Pearson $r > 0.80$) and high Cronbach's alpha (alpha > 0.80) across the live, slowed video counts, and force plate measurements for both the

shoes ON and shoes OFF trials. Results allowed authors to make further suggestions for future FTT research

CHAPTER I INTRODUCTION

Though seemingly simple enough, tapping the foot repeatedly in quick succession actually requires a precise and rapid modulation of both motor unit recruitment and discharge rates [1]. Often taken for granted, the ability to properly plantar and dorsi flex the foot at the ankle joint is an important component to human locomotion. Of particular concern is the act of dorsiflexion, or the raising of the toes during gait. It is the job of the anterior tibialis muscle to dorsiflex the foot during gait in order to prevent oneself from tripping over their toes. [2-4]. Poor control or weakness of the anterior tibialis during gait can result in a phenomenon known as foot drop in which the foot is unable to be lifted high enough off the ground to clear the swing phase of gait resulting in a dragging of the toes [2-4]. Consequently foot drop negatively impacts walking efficiency and may increase the likelihood of falling, which increases fall related injuries [3, 4].

There can be many different causes of foot drop but the most common instances appear to be associated with a lower motor neuron dysfunction such as in cases of damage to the L4-L5 vertebrae or peripheral neuropathy. [5] Of particular concern to our lab though is the presence of foot drop associated with upper motor neuron dysfunction, which is a common symptom in individuals with Multiple Sclerosis [4, 6]. In cases of suspected upper motor neuron dysfunction, foot drop could be associated with nerve compression between the cortex and lumbar nerves, axonal or demyelination damage, or central lesions. [5]

Analogous to the presence of foot drop is a slowing of rapid and repetitive movements in patients with motor neuron disorders. In cases where a motor neuron

dysfunction may be suspected it is not uncommon for physicians or researchers to conduct neurological assessments. One such test is known as the Foot Tapping Test or FTT. The foot tapping test is an assessment that requires the subject to rapidly and repetitively contract the lower limb for 10 seconds [1, 7-11]. The test is performed in a seated position with legs bent at 90° and heel firmly planted on the ground, the FTT requires the subject to tap the ball of their foot against the ground as many times as possible for 10 seconds [1, 7-11]. The number of times the subject is able to tap their foot is then counted and compared to that of a healthy control [1, 7, 9, 11]. Much like in raising the toes during walking, the anterior tibialis muscle is primarily responsible for dorsiflexing the foot during the FTT [1, 7]. It is hypothesized that a person's ability to rapidly and repetitively tap the foot is indicative of the proper functioning of the upper motor neurons responsible for dorsiflexion of the foot. [1, 7, 9, 12] Therefore if someone experiences a FTT score significantly lower than that of a healthy control subject then it could be indicative of a dysfunction of the upper motor neurons.

It has been shown in past research that there is a significant reduction in foot tapping speed in certain clinical populations such as the elderly [7] and those affected by Cervical Myelopathy [9], Amyotrophic Lateral Sclerosis [1, 8], Parkinson's disease[13] or multiple sclerosis[10, 11]. In these clinical populations it was found that the maximum number of foot taps performed during the FTT were significantly reduced compared to a healthy control population [1, 7, 9, 11, 13]. In such populations it is hypothesized that the reduction seen in foot tapping speed could be associated with a loss or damage to motor neurons responsible for the contraction of the lower limbs [1, 7-9, 12, 14]. To that end, the FTT is an ideal method for assessing one's ability to

produce a rapid repetitive movement. Not only is the FTT, simple, and cheap but the FTT is appropriate for a wide range of different clinical populations including those who are non-ambulatory or have difficulties maintaining their balance[9].

Despite the allure of the FTT as a means of discerning motor neuron dysfunction there are still many problems that prevents it from being used to it's full potential. One such problem is the lack of a normative FTT score for healthy individuals [9]. Without normative foot tapping data from healthy individuals, it makes it difficult for physicians and researchers to discern what is or isn't normal for a person of a given age or clinical status. To date, studies of the FTT have only been concerned with showing some mean difference in foot tap scores between a diseased population and control group[1, 7, 9, 11, 13]. No study to date has been specifically designed to identify normative values or even standard guidelines for testing procedures for the FTT in an exclusively healthy population. What data does exist on normative FTT scores tends to vary depending on the methodology used (range of means: 31-47 taps in healthy individuals) [1, 7, 9]. Without better agreement on normative values and testing procedures the FTT will remain limited in it's ability to use the FTT as a means for screening for motor neuron dysfunction.

Even more concerning, are the inconsistency in methodologies seen between FTT studies [1, 7-13, 15]. During a MEDLINE search a variety of inconsistencies regarding testing procedures were seen ranging from test duration, counting method, and even subject positioning [1, 7-13, 15]. These inconsistencies make it difficult to determine the standard error of the measure associated with the FTT and calls into question it's very reliability and validity. If all of the studies utilizing the FTT had used

a standardized protocol then we could at least estimate a normal range of foot taps using their data from healthy control subjects.

Testing an individual's ability to perform rapid repetitive movements is a crucial aspect of any neurological exam because often times a decline in voluntary contraction rate can be one of the earliest signs of a central disorder of motor control[14]. Up to this point, very little research has been done on the foot tapping test in a normal healthy population. Researchers and physicians have shown sufficient evidence to suggest that there is indeed a difference in the maximum number of foot taps performed during the FTT in certain clinical populations as compared to a healthy control [1, 7, 9, 11]. However, because of a lack of consistency in foot tapping test procedures between studies, it makes it hard to generalize their findings in a way that would make it useful for physicians trying to assess a patient's level of motor function.

PURPOSE

Therefore, the primary purpose of this study was to investigate the reliability of the foot tapping test in a normal healthy population. By studying the FTT in a healthy population, it is our hopes to elucidate not only the reliability of this test but to establish normative values of foot tapping in individuals free from any known motor neuron dysfunction.

Research Questions

1. What is the reliability of foot tapping test and the various methods of counting it?
2. What is the number of trials/visits to determine stability?

Sub-Questions

1. Is there a significant difference in the maximum number of foot taps when performing the FTT with or without shoes on?
2. Is there a significant difference between the number of foot taps counted when counting with live, video playback, or force plate methods?

Research Hypotheses

1. H_0 ; We hypothesize that the proposed FTT protocol will exhibit a high level of reliability.
2. H_a ; We hypothesize that there will be a significant learning effect between trials or visits..

Sub-Hypotheses

1. H_0 ; We hypothesize that there will be no significant difference in the number of foot taps performed with either shoes on or off.
2. H_a ; We hypothesize that there will be significant differences in the number of foot taps counted when counting with the three different methods.

Significance of the Study:

The foot tapping test happens to be one of the easiest and fastest methods to assess the presence of upper motor neuron dysfunction [14]. The test is quick, simple, non-invasive, and appropriate for even non-ambulatory individuals[9]. In previous research it has demonstrated that the number of foot taps in certain clinical populations is significantly less than that of healthy controls. Despite everything that's been learned from the FTT thus far, many problems still exist due to the inconsistency of the FTT in past studies. By studying the foot-tapping test in healthy populations, we hope to expand the current knowledge base as well as elucidate the reliability of the FTT using a variety of different counting methods. This study serves not only as an investigation into the reliability of the FTT in healthy population, but also serves as a guide for future researchers. By being as thorough and descriptive as possible in describing our FTT methodology, it is our hopes that this study will aid in developing a sound standardized procedure for conducting FTT research in the future.

Delimitations

The delimitations of this study include:

1. Healthy individuals between the ages of 18-31.
2. Individuals with no known disease or injury affecting the lower limbs.
3. Women who are pregnant are not permitted to participate in this study.

Limitations

1. Participants were recruited on a volunteer basis; therefore, they may not represent all healthy individuals ages 18-31 years old.
2. Physical activity outside of the study was not controlled for. .

Assumptions:

1. Participants provided accurate information with regards to known injuries or diseases affecting lower limbs.
2. Participants gave max effort with each test.
3. Participants adhered to pretesting guidelines

Operational Definitions:

1. **Foot tapping Test (FTT):** A test in which the subject must rapidly tap the foot against the ground from a seated position as many times as possible within 10 seconds. The number of foot taps has been correlated with upper motor neuron function [1, 7, 9, 12, 13].
2. **Upper Motor Neurons (UMN):** Motor neurons that originate in either the motor cortex or in the brain stem. The loss of UMNs has been shown to negatively affect central motor drive [1, 8, 9, 12].
3. **Central Motor Drive (CMD):** Amount of efferent motor nerve output to skeletal muscle [16, 17].
4. **Amyotrophic lateral sclerosis (ALS):** A chronic degenerative disease that destroys nerve cells in the brain and spinal cord leading to the loss of upper and lower motor neurons. Can lead to loss of voluntary muscle control, slowing of contraction speed, muscle weakness and wasting, and hyporeflexia [1, 8, 18].
5. **Parkinson's Disease (PD):** A chronic and progressive movement disorder resulting from the destruction of the dopamine producing brain cells of the substantia nigra. Characteristics of Parkinson's disease include the slowing of

voluntary movements, tremors at rest, rigidity, and postural instability [13, 19, 20].

6. **Multiple Sclerosis (MS):** A chronic and progressive autoimmune disease that affects the central nervous system leading to damage of the myelin sheath of the motor axons. Symptoms can vary but fatigue, delayed reaction and cognitive ability, motor weakness, impaired coordination, bladder dysfunction, and sensory disturbances are all common complaints [10, 16, 21, 22].
7. **Validity:** The degree to which a test actually measures what it is intended to measure [23].
8. **Reliability:** Describes the degree to which a test will provide consistent results when repeated [23].
9. **Test-retest Reliability:** A measure of the reliability when a test is completed multiple times over a period of time [23]
10. **Inter-rater Reliability:** A measure of reliability used to express the degree to which different raters agree on an assessment [23].

CHAPTER II

REVIEW OF LITERATURE

INTRODUCTION

The foot tapping test (FTT) is an exam that can be used to assess motor neuron and central drive dysfunction in a variety of different clinical populations [1, 7-10, 12, 13]. It has been hypothesized that damage to the upper motor neurons is associated with changes in central motor drive that lead to a slowing of contraction speed, slowed repetitive movements, weakness, and decreased muscle activation which can all translate into a higher fall risk [1, 19, 24]. To that end it is believed that the maximum number of foot taps a person is able to perform in 10 second period is reflective of proper functioning of the upper motor neurons (UMN) responsible for contraction of the lower limbs [1, 7, 9, 10, 12].

Previous research has shown a correlation between the maximum number of foot taps and various measures of UMN dysfunction [1, 9, 13, 25]. The FTT is an ideal method for testing UMN function because it is quick, non invasive, doesn't require any special equipment and is even appropriate for non-ambulatory individuals [9]. The FTT has been previously utilized in studies involving clinical populations such as those with amyotrophic lateral sclerosis [1, 8], Parkinson's disease [13], multiple sclerosis [10], and cervical myelopathy [9]. In these populations the mean number of toe taps was found to be significantly less than those of a healthy control sample.

Despite showing a decreased rate of foot tapping in clinical populations as compared to healthy populations, , we still don't know much about the FTT in a healthy population. [1, 7, 9, 10] Currently, no study to date has examined the FTT in an

exclusively healthy population. Because no study to date has examined the FTT in a healthy population it makes it hard to say what exactly is and isn't a normal range of foot taps for a healthy individual without a UMN. Therefore without normative values across ages it is difficult to make clinical judgments of UNM function without this critical information.

In addition to a lack of normative foot tapping values, is the lack of a standardization of testing procedures. Depending on the research group, the FTT can differ in the test duration, anywhere from 10-15 seconds or untimed altogether, to the positioning of the subject from lying down in supine position to sitting with legs at 90°, the method of counting foot taps from visual inspection to using a specially made counting device, and other aspects related to methodology (i.e. number of testers, leg order, unilateral/bilateral testing, rest intervals, etc.) [1, 7-13, 15]. The fact that the FTT methodology tends to differ so much between studies is a cause for concern because it brings into question the reliability and validity of the FTT as means of assessing central drive and motor neuron dysfunction. A more standardized protocol would surely serve to make the FTT a more valid and reliable test of motor function. Not to mention testing procedures should adhere to consistent standards to provide the most robust and generalizable data possible.

This review of literature will be used to examine the utilization and methodology of the foot tapping test in previous research. By examining the previously used methodologies it is our hopes to identify the shortcomings of the FTT in previous research in order to design a more sound protocol. The remainder of the chapter will be broken into the following sections: FTT in Clinical Populations, FTT in Healthy

Populations, Subject Placement, Foot tap Counting Methods, FTT Reliability, and Foot Tapping Rate and Age.

FTT In Clinical Populations

In patients with Amyotrophic Lateral Sclerosis (ALS) there has been evidence to suggest that rapid repetitive foot movements are slowed compared to controls [1]. In a study by Kent-Braun et al 1998, foot tapping speed was measured in 27 patients with ALS and in 15 healthy age/gender matched controls. It was found that the mean number of foot taps in ALS patients was 23.9 ± 2.4 steps/10s and was significantly less than that of the healthy control subjects whom averaged 43.2 ± 1.5 steps/10s. In a six-month follow-up, 13 of the original 27 ALS patients were brought back in order to remeasure foot tapping speed. It was found that the max number of foot taps in these 13 ALS patients was reduced from 25 ± 4 taps to 18 ± 5 taps over a 6-month period. The authors of the study attributed the decline in foot tapping speed to a further progression of disease and a significant change in UMN function during this period [1].

Similarly, in a study by Mitsumoto et al 2007, researchers also found a significant decline in foot tapping speed over time in ALS patients. In this study, 30 patients with ALS were tested for foot tapping speed (mean visits: 3) over an average of 9.2 months (range: 6-15 months). It was found that the patients with ALS saw a mean decline in foot tapping speed of about $1.90 \pm .65$ steps per month. Additionally it was found that foot tapping ability is correlated to central motor conduction time to hand/leg muscles ($r=0.33$, $p=0.01$) and NAA/tCr ratio (r and p not given) [8].

In a study by Gunzler et al 2009, the number of foot taps was measured in 50 patients with Parkinson's disease. It was found that for repetitive foot tapping, the mean

number of taps was 32.2 taps/15 seconds [13]. There was no healthy control population to compare the results to but the number of foot taps would suggest an impairment of UMN function when you consider results found by other FTT studies. A few things to consider when comparing foot taps in this study to other similar studies is the time of the test and how foot taps were recorded. For this study the foot tapping test was extended to 15 seconds instead of the usual 10 seconds. Also, researchers decided to use a custom made foot tapping device that required the subject to exert at least 2.72 kg of force in order to depress the pedal that counted the steps. The fact that these researchers used a longer testing time and a custom made device probably makes the results less comparable to other studies utilizing the FTT. These differences will be later discussed in the Foot Tapping Counting Methods section.

In a study by Numasawa et al, the FTT was evaluated in 252 patients with cervical myelopathy and 792 healthy individuals. It was found that the subjects with cervical myelopathy had a significantly reduced number of foot taps (23.8 ± 7.2 steps/10s) compared to the healthy subjects (31.7 ± 6.4 steps/10s) [9]. In the myelopathic group it was found that the FTT score significantly correlated with the lower extremity motor function of modified Japanese Orthopedic Association score ($r=0.662$, $P<0.0001$). Additionally this study tracked 126 of the myelopathic participants who underwent surgery to relieve their symptoms of cervical myelopathy. It was found that the average value of the FTT improved from 22.4 ± 7 steps/10s to 28.4 ± 8.1 at 1 year postoperatively and continued to strongly correlate with JOA scores ($r=0.431$, $P<0.0001$).

Again, despite showing a decrease in foot taps in these clinical populations as compared to a healthy control, the FTT is still limited by the fact that we still don't really know what is considered a "normal" range of foot taps. Because we don't really know what a normal range of foot taps is for a healthy individual it makes the FTT less reliable as a means for detecting the presences of a UMN dysfunction. Right now there's no minimum threshold number of foot taps for determining what is and isn't considered a possible sign of UMN dysfunction.

FTT in Healthy Populations

So far very little research has been done on the FTT in healthy populations. Many studies that have looked at the FTT in diseased populations have also looked at the number of foot taps in a healthy control population [1, 7, 9, 10]. However to date, no study has had its primary objective as to examine the reliability of the FTT in an exclusively healthy population. The mean number of foot taps in healthy populations tends to vary from study to study and this likely is due to variations in testing methods and study design. In order to determine what is considered a "normal" range of foot taps for the FTT more studies must be conducted using a healthy population across an age range. It is necessary to see if the differences in the mean number of foot taps found in healthy controls between studies are due to varying procedures or some other confounding variables.

Subject Placement

An important part of any examination is the proper placement of the subject. Depending on what kind of examination is being conducted the improper placement of a subject could yield drastically different results. Unfortunately, up to this point there hasn't really been any comparative studies on the FTT that has sought to determine the most efficient and reliable method of collecting foot tap data [1, 7-10, 12, 13, 15]. Because the action of dorsiflexion is most often used while walking you would think that the most logical method for a FTT would be to have the subject stand up while tapping. However when you start testing clinical populations such as the elderly, those with MS, ALS, CM, or Parkinson's disease, balance, pain, spasticity, and fatigue start to become an issue to test while standing, therefore the most logical modification to standing is to have the participant in a seated position [1].

Probably the most common way you see the FTT being performed is the method described in a study of ALS patients by Kent-Braun et al 1998 [1]. In this study, both ALS and healthy control subjects performed the FTT in order to see if there was a significant reduction in foot tapping speed of the ALS group. The FTT was performed from a seated position with the knees and hips at 90 degrees of flexion. With the heel firmly planted the subjects were then instructed to tap the floor with the ball of their foot as quickly as possible for 10 seconds. It is unclear exactly why the researchers chose to use a testing interval of 10 seconds for the FTT. This method would later be used in other studies that utilized the FTT likely because it was fast and didn't require any special equipment [1, 7-10]. A further description of the study's sample groups and findings will be discussed later in this review.

In another study by Miller and Johnston 2005, subjects were required to perform a foot tapping test while lying down in the supine position while tapping their foot against a physician's hand[12]. This study will be further discussed in the FTT counting methods section.

Foot Tap Counting Methods

During the FTT, the number of foot taps is most often visually inspected at the time of testing [1, 7, 9]. This is probably advantageous for many studies because it is fast and doesn't require any expensive equipment. However the downside to this method is that it relies on the researcher's often-subjective observations, which can increase the likelihood of human error. To remedy this some studies have used a custom built device to measure the number of foot taps rather than relying on visual inspection [13, 15]. For studies with especially large sample sizes using a piece of equipment to count the number of foot taps is advantageous from not only a time perspective but also because it doesn't require multiple researchers in order to count foot taps.

In a study by Gunzler et al.2009, the rate of foot tapping was measured in patients with Parkinson's disease with a custom built device that required the subjects to depress a lever with their foot [13]. This device consisted of two pedals separated by 30 cm. Each pedal required the subject to exert at least 2.72 kg of force in order to push it 36mm to its bottom limit. The sensor output would range from 0 to 982 Ω and would require the pedal to be depressed by at least 20% before the computer program would count the movement as a foot tap [13]. Researchers failed to mention this in their paper but it is assumed that the pedal was spring loaded so that the pedal would return to the start position after each foot tap. The fact that the pedal produced resistance and was

possibly spring loaded is problematic to the study because we cant really be sure how much the number of foot taps could be related to some kind of fatigue effect as a result of having to depress the pedal repeatedly. It follows that if the pedal was spring-loaded it may have also made the dorsiflexion movement a passive movement rather than the subject needing to actively dorsiflex the foot. It is unclear if such a device would be appropriate for a foot tapping test as we cant really be sure how the resistance from the plantar flexion movement and the assumed spring loaded aid during the dorsiflexion movement may be affecting the results. Unfortunately the researchers in this study did not compare their device to the more commonly used FTT method described by Kent-Braun et al 1998 [1].

In another study by Knights and Moule 1967, foot tapping was measured in children with the use of a finger counter mounted on the end of a 6x10-in board. The tapping lever was installed perpendicularly $1\frac{3}{4}$ inches above the board and at 30 degrees from the horizontal. The lever itself was spring loaded and had to be depressed $\frac{1}{4}$ inch with at least 400 gm of force in order to be counted [15]. Like in the study by Gunzler et al [13] we cant really be sure if the resistance produced by the pedal affected the total number of foot taps . Again, the researchers did not compare their method of foot tap counting to a more common protocol such as that by Kent Braun et al [1].

Some studies utilizing the FTT either didn't count the number of foot taps or failed to mention in their methods section exactly how foot tap data was collected [7, 8, 10]. In a study by Miller and Johnston[12], foot tapping ability was measured by assessing the speed of the foot taps rather than the actual number able to be performed. In this study foot tapping speed was assessed in ten subjects by ten different physicians.

Eight of these ten subjects suffered from some kind of known upper motor neuron dysfunction. By blinding the physicians from the subject's medical history this study sought to determine whether foot tapping rate or the Babinski test better predicted the presence of UMN dysfunction.

The Babinski sign is a well-known sign of upper motor neuron dysfunction and is widely considered an essential element of any complete neurological exam [12]. A physician assesses the presence of the Babinski sign by stroking the sole of a patient's foot and examining the subsequent reflex. In a healthy individual the normal response during the Babinski sign test is the flexing of the big toe. However in a person presenting signs of a neurological disorder the big toe has been seen to extend and may be accompanied by the fanning of the toes [26]. As such each physician would take a turn in examining the ten subjects. The patients were asked to lie down on their back in the supine position and were each tested for the Babinski reflex and asked to perform a foot tapping test by rapidly tapping their foot against the physician's hand. However rather than actually counting the number of foot taps, the physicians were asked to assess the rate of foot tapping as either slow or normal[12]. The obvious problem with this method is that the rate of foot tapping couldn't be objectively measured and instead relied upon the physicians' subjective opinion on what's considered slow or normal. It was found that the agreement with known motor neuron weakness was found to be 56% for the Babinski sign and 85% for foot tapping [12]. This seems to indicate that foot tapping rate could possibly be a more sensitive measure of UMN dysfunction.

FTT Reliability

Because there's so many different ways the FTT has been conducted between studies it is unclear as to what kind of reliability to expect in a normal healthy population. A study by Gunzler et al 2009 examined the FTT in individuals with Parkinson's disease and found that at least three practice tests should be performed when using the foot tapping test [13]. There appears to be about a 14% increase in the number of foot taps between the first of three trials and the scored trial (4th trial) of the FTT. The researchers attributed this increase from the 1st to 4th trial to the learning effect.

In a study by Numasawa et al 2012, researchers sought to quantify the number of foot taps in patients with cervical myelopathy (CM) and healthy individuals [9]. It was found that the FTT scores tend to have high test-retest reliability for both legs in the healthy control (Left: $r=0.899$, Right: $r=0.931$) and cervical myelopathy (Left: $r=0.899$, Right: $r=0.934$) subjects. Furthermore it was found that the mean number of foot taps did not significantly differ from left to right side for both groups (means not reported) [9].

Though the actual number of foot taps was not counted, the previously mentioned study by Miller et al 2005 is one of the only studies that examined the interobserver reliability of foot tapping speed. Over the course of 199 independent tests it was found that the evaluation of the rate (rated as either slow or normal) of foot tapping was substantially high ($\kappa=0.73$) for the ten different researchers. The interrater reliability for the Babinski sign (another measure of UMN function) was found to be significantly less ($\kappa=0.30$).

Unfortunately most studies either don't report interrater reliability or don't assess it all. It is unclear if other FTT studies utilize one or multiple observers when counting foot taps and how they would reconcile the numbers if there were multiple counters.

Foot Tapping Rate and Age

It has been shown from past FTT data that age negatively correlates with foot tapping speed.[7, 9]. In a study by Kent-Braun and Ng 1999, foot tapping speed was measured in 24 young (32 ± 1 year) and 24 older (72 ± 1 year) individuals. It was found that the maximum number of foot taps in otherwise healthy elderly individuals (34 ± 1 tap) was significantly less than that of young individuals (47 ± 1 tap) [7]. The researchers concluded that the slowing of foot tapping speed seen in the older group is likely due to an age related decline in the ability to rapidly modulate discharge rates and motor unit recruitment [7].

A similar decline in the ability to rapidly tap the foot was also seen in the FTT study by Numasawa et al [9]. In this study, foot tapping speed was assessed in 792 healthy individuals (mean age: 57.5 years) and 252 individuals with cervical myelopathy (mean age: 64.8 years). It was found that foot tap speed tends to have a moderate negative correlation with age in both the healthy control ($R = -0.369$, $P < 0.0001$) and in patients with cervical myelopathy (R & P values not given).

SUMMARY

As previously discussed a person who suffering from some kind of UMN dysfunction would likely exhibit an impaired ability to perform rapid and repetitive movements [1, 7-10, 13, 14]. By testing a person's maximum number of foot taps a physician could then compare it to a known values in healthy populations to detect and track the progression of dysfunction. There has been very little research done to examine the reliability of a standardized foot tapping test in healthy populations. In order to better detect UMN progression through use of the FTT, a standardized and reliable protocol must be established and more research must be done in order to identify normative values for healthy populations.

CHAPTER III

METHODS

INTRODUCTION

Up to this point very little research has been done on the foot tapping test in an exclusively healthy populations. When you look at data on the FTT in healthy controls, the average number of foot taps tends to vary from study to study depending upon the methods used. [1, 7, 9, 13] Because there is such poor agreement between studies on the average foot tapping score for healthy individuals it dilutes the efficacy of the FTT as a means for testing for UMN function. Furthermore very little data even supports the hypothesis that the FTT is reliable in healthy subjects. Therefore the purpose of this study is to determine the associated error and reliability of the FTT in a healthy population. From this we may hopefully then be able to elucidate a normal expected range of foot taps for a healthy individual unaffected by any motor neuron dysfunctions.

This chapter contains the methodology for the current study. This includes a description of the samples, research design, data collection procedures, instrumentation, and data analyses.

SAMPLE

For this study, 20 healthy subjects ages 18-31 were assessed. Subjects were recruited thru word of mouth, email and fliers from the Oklahoma City and Norman areas. In order to participate in the study, subjects were required to sign an informed consent form, which was approved by the University of Oklahoma Institutional Review Board (Health Sciences Center). In order to be considered for the study participants must be free from any known diseases or injuries that affect the lower limbs.

RESEARCH DESIGN

This study utilized a repeated measures design with one group of healthy individuals. Testing took place over four visits and was not allowed to exceed a period of four to five weeks from the start date. At least 24 hours was required between visits in order to prevent any possibility of fatigue. Visit 1 consisted of the filling out of paperwork, subject measurements, protocol familiarizing, and 8 recorded trials of the FTT. Visits 2-4 consisted of the same 8 recorded trials. See Table 1 below.

Visit 1:

On the first visit, subjects were given a briefing of the study and allowed to ask any questions they may have had. If they wished to continue they were given an informed consent, HIPPA form, and several other questionnaires. After completing the paperwork the subject's age, sex, height, weight, and shoe size were recorded. They were then familiarized with the foot tapping protocol and allowed to practice each of the different protocols. Once comfortable with the procedures, the subject's positioning was notated to ensure proper placement in future trials. Foot placement was notated by measuring the position of the big toe relative to a grid painted on the force plate (ex: C3, B2, etc). Subjects then performed the first set of 8 trials, 4 with shoes on and 4 with shoes off. For both the shoes on and shoes off conditions, 2 trials were performed for each leg. Randomization was used in order to determine the starting order of either the left or right leg for each visit. Trials were recorded using two tripod-mounted cameras. Foot tapping was simultaneously counted during trials by visually counting and with the use of the force plate.

Visits 2-4:

For Visits 2-4 the FTT protocol remained exactly the same as in the 1st visit. Similarly the starting leg (i.e. left or right) was randomized for each visit.

Table 1: Example Visit Protocol Outline:

| | Daily Procedures | Est. Time |
|-------------------------|--|-----------|
| Visit 1 | <ol style="list-style-type: none"> 1. Informed Consent 2. Familiarization 3. Subject measurement 4. 4 FTT trials shoes on 5. 4 FTT trials shoes off | 60 mins |
| Visits 2 & 3 | <ol style="list-style-type: none"> 1. 4 FTT trials shoes on 2. FTT trials shoes off | 30 mins |
| Visit 4 | <ol style="list-style-type: none"> 1. 4 FTT trials shoes on 2. FTT trials shoes off | 30 mins |

PROCEDURES**Foot tapping test (FTT)**

For the foot tapping test all subjects were seated in a chair with their knees bent at a 90-degree angle. Subjects were asked to sit up straight with their back supported by the chair. The feet should be parallel with each other and far enough forward so that balls of the feet come to rest on the force plate. If the subject is too short to sit with their

back against the chair and still touch the floor with their feet, then they were asked to sit as far forward as necessary to make contact with the force plate. Subjects were instructed that their feet should be positioned on the outer edge of the force plate in such a way so that the balls of the feet were resting on the plate while the heel of their foot was completely off of the force plate. Subjects were asked to dorsiflex and plantar flex the foot while keeping the heel in contact with the floor. If the subject was positioned correctly then there should be no force applied to the plate during dorsiflexion. The position of the subject's big toe was noted and used as a reference for repositioning the subject in later trials.

The procedure was then explained and the subject was allowed to practice the various protocols. Once comfortable with the procedures and given a chance to rest, the subjects started the recorded FTT trials. The starting leg (left or right) was determined at random for each visit. 4 trials (2 left and 2 right) were performed with shoes on, followed by 4 trials with shoes off. The subjects were given a countdown and started tapping on "Go". While keeping the heel of the foot in contact with the floor the subjects tapped the sole of their feet against the floor as many times as possible in 10 seconds. At the end of the 10 seconds, the subject was instructed to stop and the visual and force plate counts were saved.

Shoes ON vs. shoes OFF

As the protocol implies there were 4 trials of the FTT with shoes off at the end of each visit. This was done with the hope of determining if it made a significant difference in the number of taps counted. For these trials the subjects simply took off their shoes and set them aside. The type of shoes worn for testing was not standardized

beyond instructing the participant to wear what they would normally wear for recreational activity. We asked that the participant continue to use the same pair of shoes throughout the remaining visits.

Count Method

In order to measure the FTT, foot tapping rates were counted 6 different times for each trial, producing 6 measurements per trial. Each trial was counted visually (live count) and with the use of a force plate during the actual trial. They were then again reviewed by two different counters (counter 1 and counter 2) at a normal and slowed speed via video playback (producing 4 different video counts).

FTT with force plate

Force plate data was collected using the NeuLog Force Plate Logger (Model NUL-225, NeuLog, Rochester, NY) and NeuLog data acquisition software 7.46.31. During each FTT trial, the force plate was used to measure the number of foot taps being performed. This was done by having the subject's positioned on the force plate in such a way so that when they tapped their foot, the plate was able to pick up the force produced by tap. This information was then graphically displayed allowing each tap to be visually counted as a spike in the graph.

DATA MANAGEMENT

All data was collected using the NEULOG data acquisition software. It was then exported to a password protected excel spreadsheet and saved on the harddrive of a lab laptop. Video files were immediately transferred to the laptop harddrive and the files deleted from the camera. The laptop remained locked away in a file cabinet in the Body Composition and Physical Performance Lab when not in use.

STATISTICAL ANALYSES

Results were reported as means \pm standard deviation (SD). Statistical tests were ran with SPSS version 22 for windows. In order to determine if there was a significant difference in foot taps between trials 1 and 2 of each condition, a paired sample T-tests were ran. In order to determine if there was a significant difference between foot taps between dominant and non-dominant feet, paired samples t-tests were performed. In order to determine if day-to-day differences in foot tapping existed, a repeated measures ANOVA was ran for each condition. To determine if there was a difference in foot tapping between shoes on vs. shoes off conditions, a paired samples T-Test was performed. To determine if there was a significant difference in foot taps between the various counting methods a repeated measures ANOVA was used. To estimate the reliability of the FTT, the cronbach's alpha was calculated between 4 methods of interest. The Pearson R correlation was also calculated between trials 1 and 2 of each condition as a measure of test-retest reliability. Effect sizes were calculated and reported as Cohen's D (small, $d = .2$, medium, $d = .5$, large, $d = .8$). Significance for all statistical analyses was set at an alpha of 0.05.

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to evaluate the foot tapping test in a group of healthy individuals. The primary purpose this study was to determine the reliability of the foot tapping test. To that end, the FTT was examined and compared under various counting and testing conditions. Doing so will allow our researchers to make future recommendations as to the most reliable methods of conducting the FTT. The results obtained will be presented here in the following sections: Subject Characteristics, Trial 1 vs. Trial 2, Dominant vs. Non-Dominant, Day-to-Day differences, Shoes ON vs Shoes OFF, Slowed vs. Unslowed, Inter method Count Comparison, and Reliability Coefficients.

SUBJECT CHARACTERISTICS

20 healthy individuals (10 male and 10 female) between the ages of 18-31 were recruited for this study. All subjects were reportedly healthy and were free from any known injuries or diseases that may affect the lower limbs. The subject characteristics are displayed in Table 2.

Table 2: Subject Characteristics

| Variables | Males (n=10) | Females (n=10) |
|------------------|---------------------|-----------------------|
| Age (years) | 25.10 (3.18) | 22.70 (3.20) |
| Height (cm) | 178.95 (8.60) | 166.63 (7.62) |
| Weight (kg) | 81.80 (11.25) | 74.33 (18.90) |
| Shoe Size (cm) | 27.95 (1.15) | 24.85 (1.30) |

Group means (SD)

TRIAL 1 VS TRIAL 2

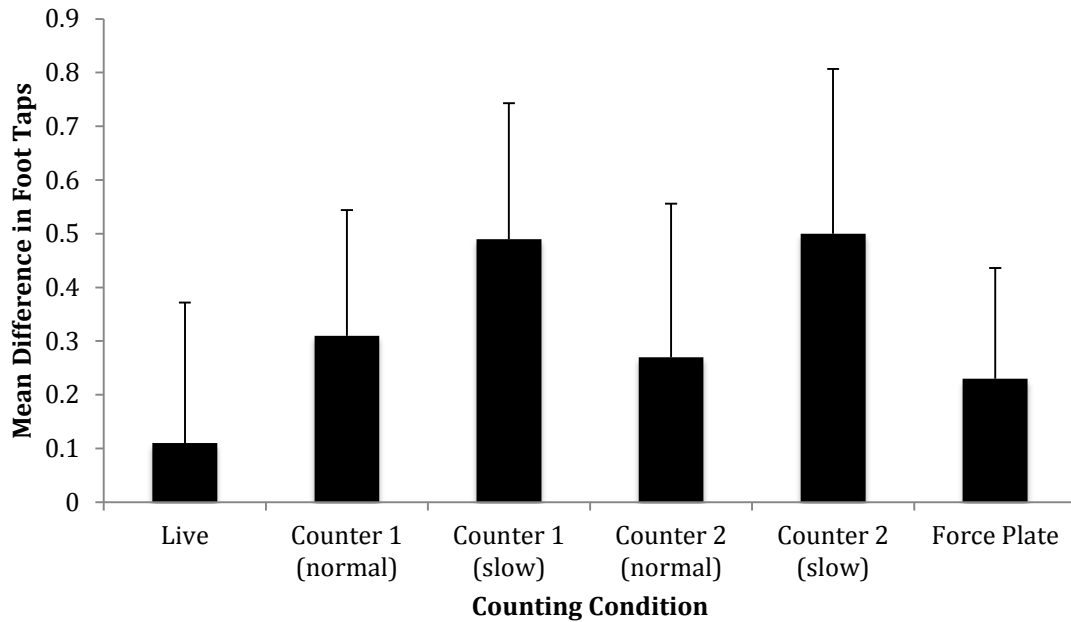
In order to determine the appropriateness of collapsing the data across trials 1 and 2 for each condition, a series of paired samples t-tests were performed. No significant difference between trials 1 & 2 for any of the counting conditions was observed (all $p < .05$). Table 3 displays the means, mean difference, p-value, and Cohen's d effect size for each of the counting conditions. Figure 1 displays the data graphically.

Table 3: Mean Differences in Foot Tapping Between Trials 1 and 2

| Counting Condition | Trial 1 | Trial 2 | Mean Dif. | p-value | Cohen's d |
|---------------------------|----------------|----------------|------------------|----------------|------------------|
| Live | 51.51 (10.27) | 51.39 (9.75) | 0.11 (4.66) | 0.664 | 0.01 |
| Counter 1 (normal) | 51.42 (10.05) | 51.11 (9.36) | 0.31 (4.16) | 0.190 | 0.03 |
| Counter 1 (slow) | 52.77 (10.05) | 52.28 (9.98) | 0.49 (4.50) | 0.053 | 0.05 |
| Counter 2 (normal) | 55.76 (13.54) | 55.49 (12.97) | 0.27 (5.09) | 0.354 | 0.02 |
| Counter 2 (slow) | 56.95 (13.42) | 56.45 (13.21) | 0.50 (5.47) | 0.105 | 0.04 |
| Force Plate | 45.33 (8.58) | 45.10 (8.43) | 0.23 (3.65) | 0.268 | 0.03 |

Group mean (SD)

Figure 1: Mean Difference in Foot Tapping Between Trials 1 and 2



Mean (SE)

DOMINANT VS NON-DOMINANT

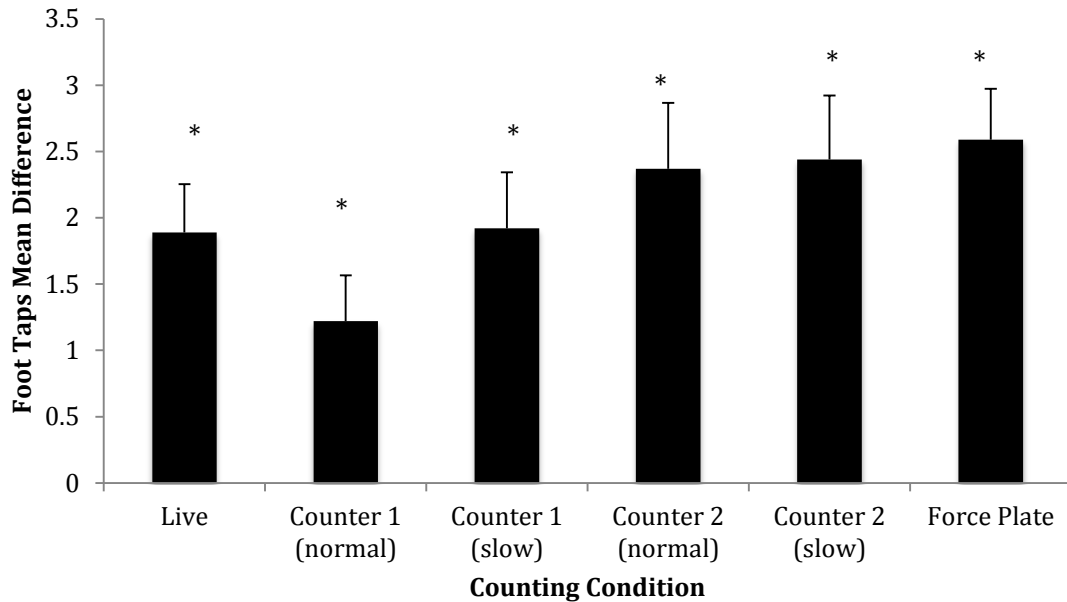
In order to determine whether the dominant, non-dominant, or the mean of both feet should be used in comparing foot taps, another series of paired samples t-tests was performed. It was found that the dominant foot exhibited a significantly higher rate of foot tapping than the non-dominant foot under all counting conditions ($p > .05$). Table 4 displays the means, mean differences, p values, and Cohen's d for the dominant and non-dominant feet for all counting conditions. Figure 2 displays the data graphically.

Table 4: Mean Differences in Foot Tapping Between Dominant and Non-Dominant Feet

| Counting Condition | Dominant | Non-Dominant | Mean Dif. | p-value | Cohen's d |
|---------------------------|-----------------|---------------------|------------------|----------------|------------------|
| Live | 52.39 (9.55) | 50.50 (9.76) | 1.89 (4.60) | 0.00 | 0.20 |
| Counter 1 (normal) | 51.86 (9.28) | 50.64 (9.58) | 1.22 (3.36) | 0.00 | 0.13 |
| Counter 1 (slow) | 53.53 (9.87) | 51.62 (9.91) | 1.92 (5.35) | 0.00 | 0.19 |
| Counter 2 (normal) | 56.87 (12.76) | 54.50 (12.91) | 2.37 (6.28) | 0.00 | 0.19 |
| Counter 2 (slow) | 58.05 (12.71) | 55.61 (13.28) | 2.44 (6.10) | 0.00 | 0.19 |
| Force Plate | 46.53 (8.11) | 43.94 (8.25) | 2.59 (4.83) | 0.00 | 0.32 |

Group mean (SD)

Figure 2: Difference in Foot Tapping Between Dominant and Non-Dominant Feet



Group Mean (SE). *Significant mean difference existed between dominant and non-dominant at $p \geq .05$.

DAY-TO-DAY DIFFERENCES

Now, using just foot tapping measures from just the dominant foot, the day to day foot tapping rates were compared for each of the counting conditions. In order to determine if foot tapping results were stable from day-to-day, a repeated measures ANOVA was ran on all of the counting conditions across the 4 visits. The ANOVA results indicated that only Day 1 tended to differ significantly from the other 3 days for all 6 counting conditions. In general, day 1 values were the lowest values. All other days (2 thru 4) were not significantly different from each other. Results are displayed in Table 5 and Figure 3. Table 5 indicates when there was a significant difference between day 1 and other days as the mean difference and p value used to determine significance. An “x” denotes that there was no significant difference between that day and day 1 for that particular counting condition. So for example, for the Live count, there was a significant difference from the 1st to 2nd day but not from the 1st to 3rd.

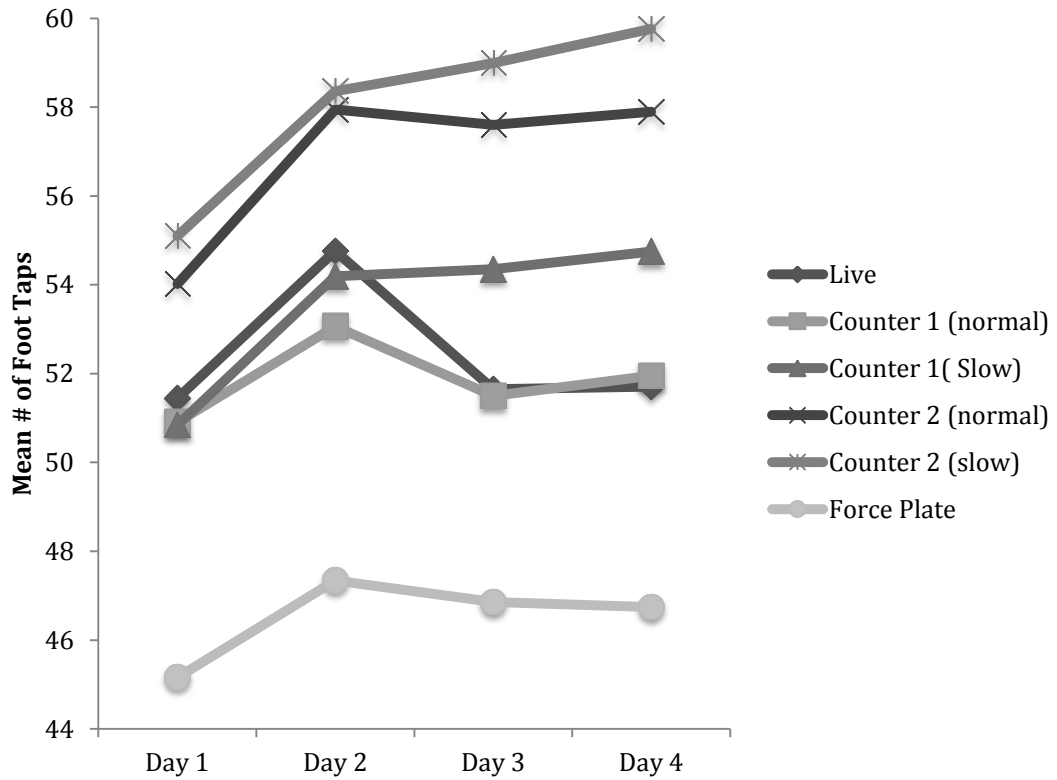
Table 5: Mean Foot Tapping Day 1 to Day 2,3,4 Differences

| Day 1 Counting Condition | Day | | |
|--------------------------|-------------|-------------|--------------|
| | 2 | 3 | 4 |
| Live | -3.31, 0.04 | x | x |
| Counter 1 (normal) | X | x | x |
| Counter 1(slow) | -3.35, 0.00 | -3.51, 0.00 | -3.912, 0.02 |
| Counter 2 (normal) | x | -3.58, 0.03 | X |
| Counter 2 (slow) | x | -3.89, 0.01 | -4.66, 0.01 |
| Force Plate | -2.18, 0.04 | x | X |

Group mean differences and p score

x= Non significance

Figure 3: Foot Tapping Means Day-to-day Comparisons



SHOES ON VS. SHOES OFF

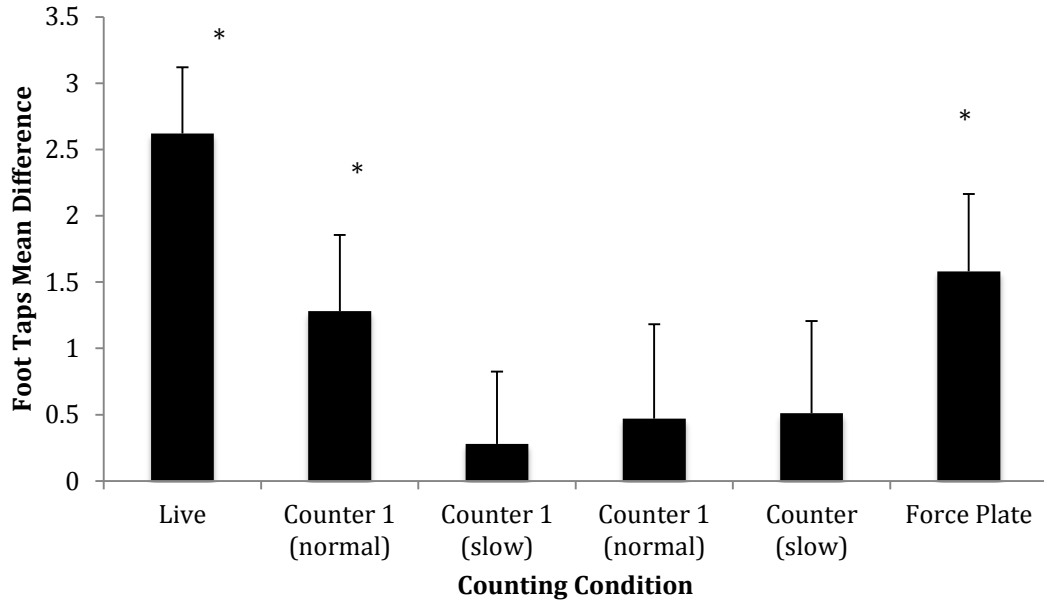
In order to determine how the shoes ON and shoes OFF values should be handled, a series of paired samples t-tests were ran for each of the counting conditions. Having shown a significant difference in the 1st day trials and dominant feet, analyses were ran with all first day and non-dominant trials removed. Results indicated that there was a significant reduction in foot tapping when performed with shoes OFF under the live, counter 1 (normal), and force plate counting methods. Table 6 contains the group means, mean differences, p values, and Cohen's d for the shoes ON vs. shoes OFF conditions. Figure 4 displays these mean differences graphically.

Table 6: Mean Differences Between Shoes ON and Shoes OFF Trials

| Counting Method | Shoes ON | Shoes OFF | Mean Diff. | p-value | Cohen's d |
|------------------------|-----------------|------------------|-------------------|----------------|------------------|
| Live | 54.02 (9.30) | 51.40 (8.90) | 2.62 (3.88) | 0.00 | 0.29 |
| Counter 1 (normal) | 52.80 (9.28) | 51.53 (8.53) | 1.28 (4.45) | 0.03 | 0.14 |
| Counter 1 (slow) | 54.57 (9.87) | 54.29 (9.31) | 0.28 (4.23) | 0.62 | 0.03 |
| Counter 2 (normal) | 58.05 (11.69) | 57.58 (12.92) | 0.47 (5.52) | 0.52 | 0.04 |
| Counter 2 (slow) | 58.78 (11.83) | 59.29 (12.31) | 0.51 (5.39) | 0.47 | -0.04 |
| Force Plate | 47.77 (7.97) | 46.19 (7.35) | 1.58 (4.53) | 0.01 | 0.21 |

Group means (SD)

Figure 4: Mean Difference Between Shoes ON and Shoes OFF Trials



Mean (SE). *Significant mean difference existed between shoes ON and shoes OFF trials at $p \geq .05$

SLOWED VS NORMAL VIDEO COUNTS

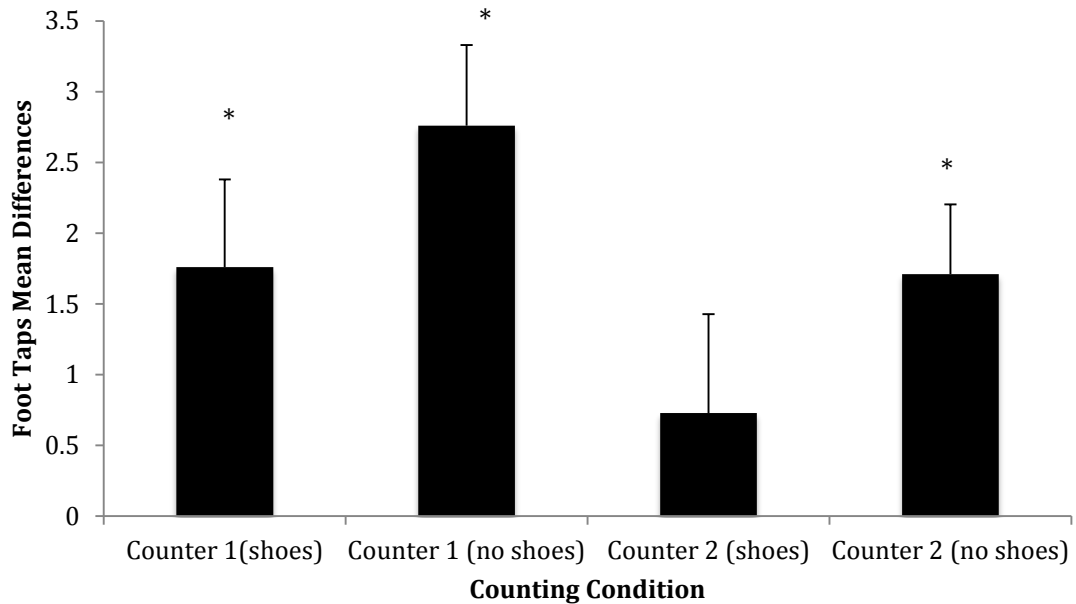
In order to determine if there was a significant difference between the slowed and unslowed video counts, for the both the shoes on and shoes off trials, a series of paired t-tests was ran. Again, statistical analyses were run omitting the visit 1 and non-dominant foot trials. It was found that significantly more foot taps were counted when using the slowed video playback method of counting as compared to normal speed counting in all cases except for counter 2's shoes ON counts. Results for each of the counters with the shoes on and shoes off are displayed in Table 7.

Table 7: Mean Differences in Foot taps Between Normal and Slowed Video Counts

| Counter (shoes/no shoes) | Normal | Slowed | Mean Diff. | p-value | Cohen's d |
|---------------------------------|---------------|---------------|-------------------|----------------|------------------|
| Counter 1(shoes) | 52.80 (9.28) | 54.57 (9.87) | -1.76 (4.79) | 0.01 | -0.19 |
| Counter 1 (no shoes) | 51.53 (8.53) | 54.29 (9.31) | -2.76 (5.40) | 0.00 | -0.31 |
| Counter 2 (shoes) | 58.05 (11.69) | 58.78 (11.82) | -0.73 (4.40) | 0.20 | -0.03 |
| Counter 2 (no shoes) | 57.58 (12.92) | 59.29 (12.31) | -1.71 (3.82) | 0.00 | -0.07 |

Group mean (SD)

Figure 5: Mean Differences in Foot Taps Between Normal and Slowed Video Counts



Means (SE). *Significant mean difference existed between normal and slowed video counts at $p \geq .05$

INTER METHOD COUNT COMPARISON

To compare the mean number of foot taps measured with each counting method, repeated measures ANOVA was calculated for both the shoes on and shoes off trials.

Day 1 and non-dominant foot trials were again omitted from analyses.

SHOES ON:

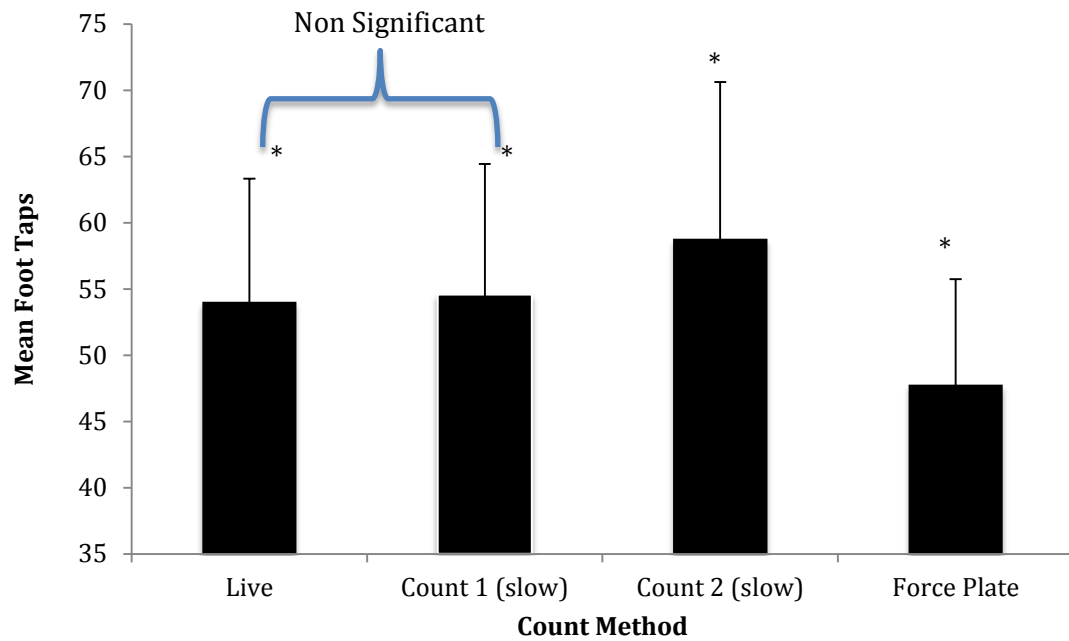
For the shoes ON trials, the repeated measures ANOVA revealed a significant difference between all counts ($p < .05$) except between the live count and counter 1's slowed video count ($p = 1.00$).

Table 8: Inter method Count Comparison (shoes ON)

| Counting Condition | Count |
|--------------------|---------------|
| Live | 54.02 (9.30) |
| Counter 1 (slow) | 54.57 (9.87) |
| Counter 2 (slow) | 58.78 (11.83) |
| Force Plate | 47.77 (7.97) |

Values expressed as group means (SD)

Figure 6: Inter method Count Comparison (shoes ON)



Group Mean (SE). * Significant mean difference between all counting conditions

SHOES OFF:

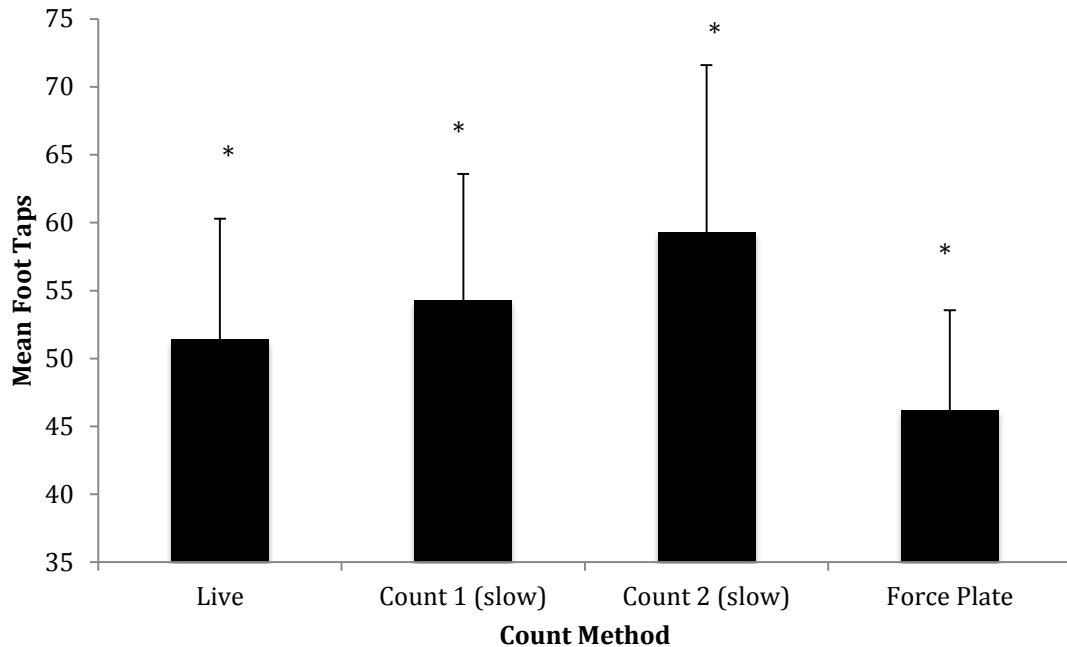
For the shoes OFF trials, the repeated measures ANOVA revealed a significant difference between all counting methods ($p < .05$).

Table 9: Inter method Comparison (shoes OFF)

| Counting Condition | Count |
|--------------------|---------------|
| Live | 51.40 (8.90) |
| Counter 1 (slow) | 54.29 (9.31) |
| Counter 2 (slow) | 59.29 (12.31) |
| Force Plate | 46.19 (7.35) |

Group means (SD)

Figure 7: Inter method Count Comparison (shoes OFF)



Group Mean (SE). * Significant mean difference between all counting conditions

RELIABILITY COEFFICIENTS

CRONBACH'S ALPHA

To determine the reliability of the 4 measures of interest, the Cronbach's alpha was calculated for both the shoes on and shoes off trials. As always, the 1st day and non-dominant trials have been removed from analyses. Between the 4 main methods of interest, the Cronbach's alpha was high for both the shoes ON and shoes OFF trials (cronbach's alpha of .907 and .867 respectively). The cronbach's alpha after each item was deleted from the comparison are displayed for the shoes ON and shoes OFF trials in tables 10 and 11. For both the shoes ON and shoes OFF conditions, the cronbach's alpha would increase with the removal of counter 2's values.

**Table 10: Shoes ON Inter method cronbach's alpha.
Cronbach's Alpha: .907**

| | Group Mean | Cronbach's alpha after removal |
|----------------|-------------------|---------------------------------------|
| Live | 54.02 (9.3) | .893 |
| Count 1 (slow) | 54.57 (9.87) | .851 |
| Count 2 (slow) | 58.78 (11.83) | .913 |
| Force Plate | 47.77 (7.97) | .865 |

Values reported as group means (SD)

**Table 11: Shoes OFF Inter method cronbach's alpha.
Cronbach's Alpha: .867**

| | Group Mean | Cronbach's alpha after removal |
|----------------|-------------------|---------------------------------------|
| Live | 51.4 (8.9) | .837 |
| Count 1 (slow) | 54.29 (9.31) | .784 |
| Count 2 (slow) | 59.29 (12.31) | .890 |
| Force Plate | 46.19 (7.35) | .815 |

Values reported as group means (SD)

TEST RETEST RELIABILITY

To test the immediate test-retest reliability of the FTT when using the 4 methods, the Pearson's R correlation was calculated between trials 1 and 2. These correlations may be found in table 12.

**Table 12: Trials 1 and 2 Pearson R
Correlations**

| Count Condition | Correlation |
|------------------------|--------------------|
| Shoes Live | .876 |
| Shoes Count 1 (slow) | .893 |
| Shoes Count 2 (slow) | .910 |
| Shoes Force Plate | .880 |
| NS Live Count 1 (slow) | .906 |
| NS Count 1 (slow) | .939 |
| NS Count 2 (slow) | .922 |
| NS Force Plate | .887 |

Correlations between trials 1 and 2
P value= 0.00 for all correlations

DISCUSSION

To our knowledge, this is the first study attempting to measure the foot tapping test simultaneously using 6 different methods over 4 different visits while also looking at the differences with shoes ON and OFF. Past studies have largely neglected to report reliability measures or even their methodology used to obtain said values. We were particularly interested in the aspects not mentioned in studies (i.e. shoes ON or OFF, dominant vs. non-dominant feet, number of trials, etc.) and how they may affect mean foot tapping values and the test's reliability. Without understanding the reliability of the FTT itself, it makes it impossible to trust our results and apply them meaningfully. So to that end, the current study was designed in a way so that we may get a better idea of the reliability of the FTT under various conditions and how it affects mean foot tapping rates. The results of the current study will be further discussed here in the coming sections.

TRIAL 1 VS. TRIAL 2

For each condition of the foot tapping test (i.e. left foot with shoes ON or right foot with shoes OFF), 2 trials were performed. This produced quite a lot of data when you consider that each testing condition had two trials and over 4 visits this resulted in 32 foot tapping scores for each subject. In order to reduce the amount of data we were working with, that meant that we either had to remove one of the trials, or average them together. To determine if there was a significant difference in foot tapping counts between trials 1 and 2, a series of paired sample t-tests were ran. It was found that there was no statistically significant difference between trials 1 and 2 as counted by the different methods. Table 3 reports these findings as the group means, mean difference,

and mean difference p-score. Figure 1 depicts the mean differences graphically as well. It is also worth noting that the effect size was very small (Cohen's $d < .05$) between trials 1 and 2 for all counting conditions. From this, it was determined that it would be appropriate to average the two trials together in order to collapse the data. For the remainder of the discussion, when referring to a FTT trial, we are actually referring to the mean score of trials 1 and 2.

DOMINANT VS. NON-DOMINANT

In order to determine whether the dominant, non-dominant, or the mean of the two should be used when comparing foot tapping scores, another series of paired sample t-tests was used. Dominant vs. non-dominant foot tapping scores for each counting method were compared and it was found that the dominant foot had a higher rate of tapping as rated by each of the counting conditions (see Table 4). Figure 2 depicts the dominant vs. non-dominant mean difference score for each foot tapping which were all considered significant. Despite showing a statistically significant difference, the Cohen's d calculations revealed a small effects size (Cohen's $d < 0.2$) between dominant and non-dominant trials for all counting conditions except the force plate which was slightly higher at $d=0.32$. As this was a healthy group of individuals and no asymmetries were to be expected, it was decided that the dominant foot would be used for all comparisons from here on out. In a study that seeks to quantify asymmetry scores or is studying clinical populations it may be more appropriate to keep and analyze both legs or simply use the mean difference scores for the two legs. Another foot tapping study by Numasawa et al found no significant difference between legs, which is contrary to the findings of the current study [9].

DAY-TO-DAY DIFFERENCES

In order to determine if there was any significant difference in foot tapping rates between days, a repeated measures ANOVA was ran for the different counting conditions. Results of the ANOVA (Table 5) indicated that the only day that varies significantly for any of the counting conditions was the 1st day. The mean foot tapping scores on the 1st day tended to be significantly less than that of the other days. The only counting condition that did not seem to significantly change from the 1st day was counter 1's normal speed playback counts. These relationships are displayed graphically in Figure 3. The tendency for that first day to be significantly lower than the other three days led researchers to decide that that first day should be thrown out from future analyses.

This change from the 1st day to the rest was attributed to the learning effect. Similarly, in a study by Gunzler et al, a learning effect was found to occur in the FTT. The study found that between the 1st and 4th trial of the FTT that a 14% increase occurred. It was therefore their recommendation that at least 3 practice trials be given [13]. It was for this reason, that when designing the current study, the subjects were given many opportunities to practice during the familiarization. Even though a familiarization period was utilized before testing on the first day, it did not appear sufficient to account for the learning effect seen. It is therefore our recommendation that a more extensive familiarization be done on a separate day before the actual day of testing. Perhaps by giving subjects a day or so between the familiarization and the first day of testing (rather than the same day) may lesson the learning effect across trials.

SHOES ON VS. SHOES OFF

One particular thing of interest to the researchers in this study was the effect of a person's shoes on their ability to perform the foot tapping test. It reasons that the weight or shape of a person's shoe may affect their foot tapping speed. Individual differences in shoe size and shape may make the comparison of foot tapping rates between subjects less reliable and thus performing the test with the shoes off may alleviate said issue. In order to determine if there was a significant difference in foot tapping ability when having shoes ON vs shoes OFF, a series of paired sample t-tests were performed. Results of the paired sample t-tests indicated that while the shoes ON trials tended to be higher than the shoes OFF trials, the shoes ON trials were only statistically significant for the Live, counter 1 (normal), and force plate counting conditions. Even then, despite the three counting conditions showing a sig. difference, the effect size remains small for shoes ON vs shoes OFF (Cohen's $d \leq 0.20$). These results can be found in Table 6 and graphically on Figure 4.

Few if any foot tapping studies have indicated how the test was performed in regards to the shoes. For the current study, the type of shoe worn was not controlled for other than ensuring that the shoe remained the same throughout the 4 visits. Because it couldn't be definitively said which measure was better (shoes ON or OFF), it was decided by researchers to keep both the shoes ON and shoes OFF trials separate in all future analyses in order to better understand how shoes may affect foot tapping measures. To truly understand the effects of shoes on foot tapping rates another study must be done that seeks to better classify shoe type by style, material, size, and heel thickness.

SLOWED VS. NORMAL SPEED PLAYBACK

The task of reviewing foot tapping can be quite tedious so researchers were interested in seeing if there was any real difference between counting foot tapping with either the normal speed or slowed speed video playback. In order to determine if there was a significant difference in the mean foot taps counted with the slowed and normal speed video playback methods, a series of paired sample t-tests was ran for both the shoes ON and shoes OFF conditions. It was found that the slowed video count was significantly higher for counter 1 for both the shoes ON and OFF conditions. In counter 2 however, there was only a significant increase in the mean foot taps for the shoes OFF condition. Table 7 and figure 5 displays these values.

It was decided by researchers to go ahead and remove the normal speed counts from the final analyses due to the fact that there was a statistically significant difference in 3 out of the 4 cases and also the fact that it logically seems to make sense that a slowed down video may be used to more accurately assess foot tapping.

INTERMETHOD COUNT COMPARISON

In order to determine if there was a significant difference in the number of foot taps counted with the varying counting methods, a repeated measures ANOVA was ran for both the shoes ON and shoes OFF testing conditions.

SHOES ON

For the shoes ON trials, it was found that the mean foot tapping score was significantly different for all 4 of the methods of interest (p values $>.05$) except for the comparison between the live count and counter 1's slow count. Table 8 and Figure 2 display the mean counts and SD for each method.

SHOES OFF

For the shoes OFF trials, it was found that the mean foot tapping score was significantly different for all 4 methods of interest (p values $>.05$). The means and SD for each method are displayed in Table 9 and Figure 3.

For both the shoes ON and shoes OFF trials it was found that the force plate count tended to be the lowest mean of all 4 counts but also tended to have the least standard deviations. Interestingly for the shoes ON trials there was found to be no significant difference between the live count and slowed count 1 but there was a significant difference for the shoes OFF trials. For both the shoes ON and shoes OFF trials, counter 2's counts tended to be significantly higher than counter 1's but also tended to have a higher standard deviation.

RELIABILITY COEFFICIENTS

In order to determine the reliability of the 4 measures of interest, the Cronbach's alpha for the 4 measures, as well as their individual Pearson correlations were calculated.

CRONBACH'S ALPHA

The cronbachs alpha for the 4 methods was calculated separately for the shoes ON and shoes OFF trials. It was found that both the shoes ON and shoes OFF trials exhibited a high Cronbach's alpha for the 4 methods (alpha: .907 and .867 respectively). For both the shoes ON and shoes OFF trials it was found that the cronbach's alpha would increase with the exclusion of Counter 2's trials. See tables 10 and 11 for mean and cronbach's alpha values.

PEARSON'S R CORRELATIONS

In order to determine the immediate test-retest reliability of the 4 different methods, the Pearson's R correlation was calculated between trials 1 and 2 of each of the 4 counts of interest for the shoes ON and shoes OFF trials. It was found that all 4 methods had a high level of correlation ($R > .80$) between trials 1 and 2 for the shoes ON and shoes OFF trials.

Because all of the values were so close it becomes difficult to definitively say which is better. The Cronbach's alpha analysis revealed that the statistic would actually increase with the exclusion of counter 2's values. One possible explanation of this is the fact that counter 2 may not have been as personally invested in counting as counter 1 who was one of the primary investigators in this study.

Having discussed all the aspects of the FTT examined in the current study, it becomes apparent that still more research must be done to examine the FTT. Even though a significant difference was shown with the dominant/non-dominant and shoes ON/shoes OFF comparisons, effect sizes were still shown to be small (Cohen's $d < 0.20$) in these cases. It raises still the question of whether these effects are strong enough to be worth controlling. Evidence of the current study would seem to suggest that some kind of learning effect seems to take place between trials and visits and that familiarization may be more important than once. Once corrected for however (1st day and non-dominant trials removed), the FTT was shown to have a high reliability (Pearson's $R > 0.80$ and Cronbach's $\alpha > 0.80$) for the live count, slowed video, and force plate trials. These aspects and their clinical implications will be further discussed in the conclusion section.

CHAPTER V

CONCLUSION

The purpose of this study was to investigate the reliability of the foot tapping test in a normal healthy population. By investigating reliability measures of the FTT in a healthy population it was our hopes to identify it's shortcomings as well as make recommendations as to the best method of counting in future FTT research.

RESEARCH QUESTIONS

1. What is the reliability of foot tapping test and the various methods of counting it? It was found that the foot-tapping test had a high test-retest reliability ($R > .80$) for all measurement methods. It was also found that the 4 main methods of interest had a high cronbach's alpha ($> .80$) for both the shoes on and shoes off trials though they may benefit by the removal of 2nd counter.
2. What is the number of trials/visits to determine stability? It was determined that when conducting the FTT, that it is necessary to conduct a more extensive familiarization period. Even with our familiarization on the first visit, there was still a significant difference in the mean foot tapping scores on the 1st day compared to others. A separate familiarization day rather than simply before the first recorded trial may help to alleviate this issue.

SUB QUESTIONS

1. Is there a significant difference in the maximum number of foot taps when performing the FTT with or without shoes on? Yes, it was found that there was a significant difference between the FTT mean score with shoes ON vs shoes OFF. The FTT with shoes on was found to generally be higher but it could not be definitively said which was the most appropriate for measuring foot tapping ability. It reasons that the shoes

OFF trials may be more comparable between subjects because it removes any possibility of shoe effects.

2. Is there a significant difference between the number of foot taps counted when counting with live, slowed video playback (with two separate counters), or force plate methods?

Yes, it was found that all 4 counts differed significantly from each other. The live counts tended to be closer to counter 1's than they were to counter 2's. Both counters tended to count more foot taps with slowed video playback than the initial live count.

The force plate had a tendency to produce the lowest foot tapping score but also showed the least variability (mean SD).

CLINICAL SIGNIFICANCE

There are a few things that can be taken away from this study in terms of clinical significance. The first and foremost of which is in regards to the inter day differences. It was found that the first day was significantly less than other days for some of the counting methods. Even though a familiarization period was utilized on visit 1, the mean trials of visit 1 were still considered significantly lower than that of other visits which suggests that there was some kind of learning effect taking place. It is unclear whether this learning effect occurred between the trials of visit 1 (i.e. between trial 1,2,3,4,5,6,7, or 8) or whether it occurred at some point between days (i.e. between visits 1 & 2). The clinical implications of these findings seem to imply that the FTT might not be an appropriate test to perform and measure on a one-time basis. By this, we mean that it may not be appropriate to introduce someone to the FTT and get recorded measures within the same visit. It reasons that if a learning effect is indeed present between visits, then those values seen on visit 1 may not reflect a true measure of a person's foot tapping ability. So instead, it may be more useful for a clinician or

researcher to conduct the FTT over multiple visits to get an idea of a person's foot tapping ability. Another caveat of conducting the FTT across multiple visits is that it could potentially be used as a measure of a treatment effect or disease progression. That being said however, the measuring of the FTT over multiple visits may have its own inherent problems. It raises the question of whether the learning effect seen with the FTT remains consistent over time, or is it necessary to refamiliarize a person every single visit or every other few visits. Furthermore, if we see significant changes in foot tapping rates between visits, how can we be certain whether this is the effect of a treatment/disease or simply the influence of the learning effect.

It was also found that though small, there was a statistically significant difference found between the trials with shoes ON and trials with shoes OFF. The shoes ON trials tended to be higher than those of their shoes OFF counterparts, which may suggest that the type of shoes has an effect on a person's ability to rapidly tap their feet. So the question now is; should we conduct the FTT with the shoes ON or OFF? It reasons that a person's foot tapping with shoes ON would more closely correlate with ADL where shoes are typically worn (i.e. walking, climbing stairs, working, etc.). However on the other end, it reasons that having the shoes ON also invites a lot more room for variability and error. For example, if it were to turn out that the type of shoe (meaning: shape, size, heel thickness, weight, etc) affected foot tapping rate then it would necessitate controlling for the type of shoes worn by subjects. That means not only would ALL the subjects have to wear a similar type of shoe but they would also have to consistently wear the same pair of shoes throughout testing. One way of remedying this problem is to have all subjects perform the FTT with shoes OFF.

Though taking the shoes OFF may relieve the problem of shoe type it raises some of it's own issues. As previously mentioned, the FTT with shoes ON may more closely correlate to ADL requiring the shoes to be ON. Furthermore it may not always be practical to remove the shoes of those who are non-ambulatory, have balance deficits, or have difficulty removing and putting on their shoes.

In terms of reliability, we've shown that the FTT is a reliable measure of foot tapping ability (Pearson's R and Cronbach's alphas $>.80$) with both the shoes ON and OFF across the live, Counter 1 and 2's slowed video counts and force plate measures. Despite this, all 4 measurements were found to be significantly different from each other (with the exception of the Live vs. Counter 1 (shoes ON trials). The cronbach's alpha actually suggested that counter 2's removal might benefit the reliability of the 4 measures of interest. In this study, the inclusion of the 2nd rater only served to increase variability in the FTT measures. Though the FTT may appear to show strong reliability within the same rater, it's reliability between different raters remains questionable. To that end, it would be advisable that the raters remain consistent throughout the live and video recorded counts.

Despite showing less foot taps with live counting compared to the video playback method, it is advisable to still utilize a live count when conducting the FTT. Not only does technology have a way of failing at the most inopportune of times, but also in many clinical settings, it just wouldn't be practical to record and review hundreds of patient's foot tapping videos. The use of the force plate data also shows potential clinical relevance as it allows for researchers to quickly get a measure of foot tapping rates without the need for live counting or video playback methods. The use of

a force plate would be beneficial in a clinical setting as it offers an objective measure of foot tapping rate, which means that it would no longer necessitate the same tester for every single FTT trial. At a bare minimum, all clinical foot tapping data should utilize a live count and either a slowed video or force plate count. Ideally the inclusion of a force plate is desirable as it allows for an objective measure. It is however understandable that some clinics not wish to purchase extra equipment.

FUTURE RESEARCH

Despite this study being a good starting point, more research needs to be done on the foot tapping test in healthy individuals and eventually clinical populations. Specifically more research needs to be done on the effects of shoes on foot tapping measurements. Furthermore the use of a force plate or similar counting device should be further studied as it potentially offers a more convenient and precise measurement of foot tapping ability. It may also be useful to see if a person's daily activity levels as well as body composition measures have any effect on their foot tapping abilities.

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APPENDIX A

IRB Approval Letter
Informed Consent
HIPPA Form
Health History Questionnaire
Health Status Questionnaire
Physical Activity Questionnaire



Institutional Review Board for the Protection of Human Subjects

Initial Submission – Board Approval

Date: January 19, 2017
IRB#: 7475
Meeting Date: 12/19/2016
To: Rebecca D Larson, PhD
Approval Date: 01/18/2017
Expiration Date: 11/30/2017
Study Title: An Evaluation of the Foot Tapping Test (FTT) in a Healthy Population
Reference Number: 658808
Study Status: Active - Open
Collection/Use of PHI: Yes

At its regularly scheduled meeting the IRB reviewed the above-referenced research study. Study documents (e.g. protocol, consent, survey, etc.) associated with this submission are listed on page 2 of this letter. To review and/or access the submission forms (e.g. application) as well as the study documents approved for this submission, open this study from the *My Studies* option, click to open this study, look under Protocol Items to click on the current *Application*, *Informed Consent* and *Other Study Documents*.

If this study required routing through the Office of Research Administration (ORA), you may not begin your study yet, as per OUHSC Institutional policy, until the contract through ORA is finalized and signed.


As principal investigator of this research study, it is your responsibility to:

- Conduct the research study in a manner consistent with the requirements of the IRB and federal regulations at 45 CFR 46 and/or 21 CFR 50 and 56.
- Request approval from the IRB prior to implementing any/all modifications.
- Promptly report to the IRB any harm experienced by a participant that is both unanticipated and related per IRB Policy.
- Maintain accurate and complete study records for evaluation by the HRPP quality improvement program and if applicable, inspection by regulatory agencies and/or the study sponsor.
- Promptly submit continuing review documents to the IRB upon notification approximately 60 days prior to the expiration date indicated above.

In addition, it is your responsibility to obtain informed consent and research privacy authorization using the currently approved, stamped forms and retain all original, signed forms, if applicable.

If you have questions about this notification or using iRIS, contact the IRB @ 405-271-2045 or irb@ouhsc.edu.

Sincerely,



Martina Jelley, MD, MSPH
Chairperson, Institutional Review Board

1105 N. Stonewall Avenue, Oklahoma City, OK 73117 (FWA0007961)

Consent Form**University of Oklahoma Health Sciences Center (OUHSC)
University of Oklahoma Norman Campus
*An Evaluation of the Foot Tapping Test (FTT) in a Healthy Population******Principal Investigator: Rebecca D. Larson, PhD***

This is a research study. Research studies involve only individuals who choose to participate. Please take your time to make your decision. Discuss this with your family and friends.

Why Have I Been Asked To Participate In This Study?

You are being asked to take part in this trial/study because you are a healthy individual who is free from any known diseases or injuries that may affect the lower limbs.

Why Is This Study Being Done?

The primary purpose of this study is to determine the validity and reliability of the foot tapping test in a normal healthy population free of known diseases or injuries affecting the lower limbs. A secondary goal of this study is to elucidate a normal expected range of foot taps for an individual of this population.

How Many People Will Take Part In The Study?

About 100 people will take part in this study and all participants will participate at the Body Composition and Physical Performance Lab at the University of Oklahoma.

What Is Involved In The Study?

If you take part in this study, you will have the following tests and procedures:

Visit 1:

For the first visit we will discuss the purpose of the study and the details of each of the study visits. If you so choose to participate you will be asked to read and sign this form. You will also fill out a health status questionnaire and physical activity questionnaire.

After completing the questionnaires your height, weight, and shoe size will be measured. You will then be familiarized with the foot tapping test using the force plate with your shoes both on and off. You will be seated in a chair and required to rapidly and repeatedly tap your foot against the ground in 10-second intervals several times. You will be allowed to practice the test several times until you feel comfortable performing it with shoes on and off. You will then be asked to perform the first set of recorded trials. The number of times that you are able to repeatedly tap your foot in 10 seconds will be assessed using a force plate, with visual inspection of the researchers, and will be video recorded for later analysis. This will be done twice for each leg under the two conditions (shoes on and shoes off) for a total of 8 trials. You will be allowed two minutes of rest between each trial.



Visit 1 will take approximately 60 minutes.

Visits 2-4:

For visits 2-4, the exact same FTT protocols as visit 1 will be followed in order to measure foot tapping speed. Testing order, number of trials, and conditions will remain the same throughout all visits. At the end of the 4th visit you will undergo a full body dual X-ray absorptiometry (DXA) scan in order to measure the amount of lean body mass in your lower limbs. This procedure will require you to lie down and remain still for about 10 minutes.

Visits 2 and 3 should take approximately 30 minutes

Visit 4 will take approximately 60 minutes

How Long Will I Be In The Study?

We think that you will be in the study for a total of 2-3 weeks where you will visit the Body Composition and Physical Performance Lab on 4 occasions. Each visit will take approximately 30 minutes to 1 hour to complete

There may be anticipated circumstances under which your participation may be terminated by the investigator without regard to your consent.

- If it is determined that it is in your medical best interest.
- Your condition worsens.
- New information becomes available.
- You fail to follow study requirements.

You can stop participating in this study at any time. However, if you decide to stop participating in the study, we encourage you to talk to the researcher and your regular doctor first.

What Are The Risks of The Study?

Risks and side effects related to this study include:

DXA

During the DXA scan, you will be exposed to a very low dose of radiation.

This study involves exposure to radiation from an x-ray procedure that is being performed for research purposes only, and not required for medical care. The amount of radiation exposure is equivalent to less than the daily amount of natural background radiation exposure people in the United States receive. The risk of radiation is cumulative over your lifetime.

The radiation exposure in this study may be hazardous to an unborn child. As such you will be asked to perform a simple urine test to determine possible pregnancy. The test



will be free. A negative pregnancy test is needed prior to participating in the DXA scan. For unexpected pregnancies, subjects are encouraged to speak with their family physician.

The DXA and other research procedures are not for diagnostic purposes and if you have any questions about your test results, you should see a physician.

Are There Benefits to Taking Part in The Study?

There is no direct medical benefit in participating in this study.

What Other Options Are There?

You may chose to not participate in the study.

What about Confidentiality?

Efforts will be made to keep your personal information confidential. You will not be identifiable by name or description in any reports or publications about this study. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. You will be asked to sign a separate authorization form for use or sharing of your protected health information.

There are organizations outside the OUHSC that may inspect and/or copy your research records for quality assurance and data analysis. These organizations include the US Food & Drug Administration and other regulatory agencies, the OUHSC Human Research Participant Program office, the OUHSC Institutional Review Board, and the OUHSC Office of Compliance may also inspect and/or copy your research records for these purposes.

What Are the Costs?

There is no cost to you if you participate in this study.

Will I Be Paid For Participating in This Study?

There will be no monetary compensation for participating in this study.

What if I am Injured or Become Ill While Participating in this Study?

Taking part in this study is voluntary. You may choose not to participate. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. If you agree to participate and then decide against it, you can withdraw for any reason and leave the study at any time. You may discontinue your participation at any time without penalty or loss of benefits, to which you are otherwise entitled.

What Are My Rights As a Participant?

Taking part in this study is voluntary. You may choose not to participate. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled.



If you agree to participate and then decide against it, you can withdraw for any reason and leave the study at any time. You may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled.

We will provide you with any significant new findings developed during the course of the research that may affect your health, welfare, or willingness to continue your participation in this study.

You have the right to access the medical information that has been collected about you as a part of this research study. However, you may not have access to this medical information until the entire research study has completely finished. You consent to this temporary restriction.

Whom Do I Call If I have Questions or Problems?

If you have questions, concerns, or complaints about the study or have a research-related injury, contact Dr. Rebecca Larson at 352-359-8432 (cell) or 405-325-6325 (office).

If you cannot reach the Investigator or wish to speak to someone other than the investigator, contact the OUHSC Director, Office of Human Research Participant Protection, at 405-271-2045.

For questions about your rights as a research participant, contact the OUHSC Director, Office of Human Research Participant Protection at 405-271-2045.

Signature:

By signing this form, you are agreeing to participate in this research study under the conditions described. You have not given up any of your legal rights or released any individual or entity from liability for negligence. You have been given an opportunity to ask questions. You will be given a copy of this consent document.

I agree to participate in this study:

| | | |
|---|--------------|------|
| | | |
| PARTICIPANT SIGNATURE (age ≥18) (Or Legally Authorized Representative) | Printed Name | Date |

| | | |
|--|--------------|------|
| | | |
| SIGNATURE OF PERSON OBTAINING CONSENT | Printed Name | Date |

IRB Office Version Date: 09/21/2016



**AUTHORIZATION TO USE or SHARE
HEALTH INFORMATION THAT IDENTIFIES YOU FOR RESEARCH**
*An Informed Consent Document for Research Participation may also be required.
Form 2 must be used for research involving psychotherapy notes.*

Title of Research Project: **An Evaluation of the Foot Tapping Test (FTT) in a Healthy Population**

Leader of Research Team: **Rebecca D Larson, PhD**

Address: **Department of Health and Exercise Science, 1401 Asp Avenue, Room 117 HHC, Norman
OK 73019**

Phone Number: **405-325-6325**

If you decide to sign this document, University of Oklahoma Health Sciences Center (OUHSC) researchers may use or share information that identifies you (protected health information) for their research. Protected health information will be called PHI in this document.

PHI To Be Used or Shared. Federal law requires that researchers get your permission (authorization) to use or share your PHI. If you give permission, the researchers may use or share with the people identified in this Authorization any PHI related to this research from your medical records and from any test results. Information used or shared may include all information relating to any tests, procedures, surveys, or interviews as outlined in the consent form; medical records and charts; name, address, telephone number, date of birth, race, government-issued identification numbers, and can include physical findings from questionnaires, dual X-ray absorptiometry (DXA) scan, and foot tapping test (FTT) data.

Purposes for Using or Sharing PHI. If you give permission, the researchers may use your PHI to determine the reliability of the foot tapping test (FTT) and establish normative foot tapping rates for healthy individuals.

Other Use and Sharing of PHI. If you give permission, the researchers may also use your PHI to develop new procedures or commercial products. They may share your PHI with other researchers, the research sponsor and its agents, the OUHSC Institutional Review Board, auditors and inspectors who check the research, and government agencies such as the Food and Drug Administration (FDA) and the Department of Health and Human Services (HHS), and when required by law. The researchers may also share your PHI with no one outside the research team

Confidentiality. Although the researchers may report their findings in scientific journals or meetings, they will not identify you in their reports. The researchers will try to keep your information

¹ Protected Health Information includes all identifiable information relating to any aspect of an individual's health whether past, present or future, created or maintained by a Covered Entity.

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Version 01/06/2016



confidential, but confidentiality is not guaranteed. The law does not require everyone receiving the information covered by this document to keep it confidential, so they could release it to others, and federal law may no longer protect it.

YOU UNDERSTAND THAT YOUR PROTECTED HEALTH INFORMATION MAY INCLUDE INFORMATION REGARDING A COMMUNICABLE OR NONCOMMUNICABLE DISEASE.

Voluntary Choice. The choice to give OUHSC researchers permission to use or share your PHI for their research is voluntary. It is completely up to you. No one can force you to give permission. However, you must give permission for OUHSC researchers to use or share your PHI if you want to participate in the research and, if you cancel your authorization, you can no longer participate in this study.

Refusing to give permission will not affect your ability to get routine treatment or health care unrelated to this study from OUHSC.

Canceling Permission. If you give the OUHSC researchers permission to use or share your PHI, you have a right to cancel your permission whenever you want. However, canceling your permission will not apply to information that the researchers have already used, relied on, or shared or to information necessary to maintain the reliability or integrity of this research.

End of Permission. Unless you cancel it, permission for OUHSC researchers to use or share your PHI for their research will never end.

Contacting OUHSC: You may find out if your PHI has been shared, get a copy of your PHI, or cancel your permission at any time by writing to:

| | | |
|---|----|---|
| Privacy Official | or | Privacy Board |
| University of Oklahoma Health Sciences Center | | University of Oklahoma Health Sciences Center |
| PO Box 26901 | | PO Box 26901 |
| Oklahoma City, OK 73190 | | Oklahoma City, OK 73190 |

If you have questions, call: (405) 271-2511 or (405) 271-2045.

Access to Information. You have the right to access the medical information that has been collected about you as a part of this research study. However, you may not have access to this medical information until the entire research study is completely finished. You consent to this temporary restriction.

Giving Permission. By signing this form, you give OUHSC and OUHSC’s researchers led by the Research Team Leader permission to share your PHI for the research project listed at the top of this form.

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Version 01/06/2016



Patient/Participant Name (Print): _____

Signature of Patient-Participant
or Parent if Participant is a minor

Date

Or

Signature of Legal Representative**

Date

**If signed by a Legal Representative of the Patient-Participant, provide a description of the relationship to the Patient-Participant and the authority to act as Legal Representative:

OUHSC may ask you to produce evidence of your relationship.

A signed copy of this form must be given to the Patient-Participant or the Legal Representative at the time this signed form is provided to the researcher or his representative.

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Form 3.2 Health Status Questionnaire

This questionnaire identifies adults for whom physical activity might be inappropriate or adults who should seek physician consultation before beginning a regular physical activity program.

Section 1 Personal and Emergency Contact Information

Name: _____ Date of birth: _____

Address: _____ Phone: _____

Physician's name: _____ Height: _____

Weight: _____

Person to contact in case of emergency

Name: _____ Phone: _____

Section 2 General Medical History

Please check the following conditions you have experienced.

Heart History

- | | |
|--|---|
| <input type="checkbox"/> Heart attack | <input type="checkbox"/> Cardiac rhythm disturbance |
| <input type="checkbox"/> Heart surgery | <input type="checkbox"/> Heart valve disease |
| <input type="checkbox"/> Cardiac catheterization | <input type="checkbox"/> Heart failure |
| <input type="checkbox"/> Coronary angioplasty (PTCA) | <input type="checkbox"/> Heart transplantation |
| <input type="checkbox"/> Cardiac pacemaker | <input type="checkbox"/> Congenital heart disease |

Symptoms

- You experience chest discomfort with exertion.
- You experience unreasonable shortness of breath at any time.
- You experience dizziness, fainting, or blackouts.
- You take heart medications.

Additional Health Issues

- You have asthma or other lung disease (e.g., emphysema).
- You have burning or cramping sensations in your lower legs with minimal physical activity.



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- You have joint problems (e.g., arthritis) that limit your physical activity.
- You have concerns about the safety of exercise.
- You take prescription medications.
- You are pregnant.

Section 3 Risk Factor Assessment

Risk Factors for Coronary Heart Disease

- You are a man older than 45 yr.
- You are a woman older than 55 yr, have had a hysterectomy, or are postmenopausal.
- You have diabetes (type 1 or type 2).
- You smoke or you quit smoking within the previous 6 mo.
- Your blood pressure is >140/90 mmHg.
- Your blood cholesterol is >200 mg · dl⁻¹.
- You have a close male blood relative (father or brother) who had a heart attack or heart surgery before the age of 55 or a close female blood relative (mother or sister) who had a heart attack or heart surgery before the age of 65.
- You are physically inactive (you get <30 min of physical activity at least 3 days per wk).
- Your waist circumference is >40 in. (101.6 cm in men) or >35 in. (88.9 cm in women).

Section 4 Medications

Are you currently taking any medication? Yes No

If yes, please list all of your prescribed medications and how often you take them, whether daily (D) or as needed (PRN). _____

Of the medications you have listed, are there any you do not take as prescribed?

Section 5 Physical Activity Patterns and Objectives

List the type, frequency, intensity (e.g., low, moderate, strenuous), and duration of your weekly exercise. _____



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List your specific goals for your exercise program. _____

Please inform the fitness professional immediately of any changes that occur in your health status.

Patient Information Release Form

If you have answered yes to questions indicating that you have significant cardiac, pulmonary, metabolic, or orthopedic problems that may be exacerbated with exercise, you agree it is permissible for us to contact your physician regarding your health status.

Signature: _____ Date: _____

Fitness staff signature: _____ Date: _____

To be completed by fitness professional (circle one):

AHA/ACSM risk stratification: Low Moderate High Physician consent: Yes No

From E.T. Howley and B.D. Franks with G. Moore, 2007, *Fitness Professional's Handbook Instructor Guide, Fifth Edition*. (Champaign, IL: Human Kinetics.)



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Date: _____

Medical History Questionnaire

Name: _____ Date of Birth: _____
Address: _____ Phone Number: _____
_____ alt #: _____
Email: _____
Age: _____
Dominant side: Left Right (circle)
Blood Pressure: ____/____
Height: _____ Weight: _____ Shoe Size: _____
Sex: Male Female (circle) Gender: Male Female (circle)
Ethnicity: Caucasian African American Hispanic Asian Other: _____
Emergency contact name and number: _____

Please answer the following questions:

1. Have you ever been diagnosed with diabetes?
Y N If "yes," when were you diagnosed? _____
2. Have you ever been told by a physician that you have Osteoporosis/Osteopenia?
Y N
3. Have you ever had a heart attack or stroke?
Y N If "yes," what and when? _____
4. Have you ever been diagnosed with any disease affecting the brain, spine, or nerves? (ex: Multiple sclerosis, brain tumors, epilepsy, Parkinson's disease, Neuropathy, ALS, etc.)
Y N If "yes," what and when? _____

5. Have you ever been diagnosed with arthritis?
Y N If "yes," when?
6. Have you had any injuries of the lower limbs specifically involving bone, tendon, or ligament damage?
Y N If "yes," what and when? _____

7. Have you had any injuries of the lower limbs specifically involving the muscles?
Y N If "yes" what and when? _____

8. Do you experience frequent pain in your lower limbs?
Y N If "yes," where and how often? _____



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9. Do you have a decreased range of motion or mobility in your hips, knees, or ankles?

Y N If "yes," how much and where? _____

10. Do you use an assistive device for walking?

Y N If "yes," what? _____

11. Do you experience any difficulties producing and maintaining rapid and repetitive movements?

Y N If "yes," then describe. _____

12. Are you currently on any kind of medications?

Y N If "yes," what medication, amount taken, time on medication, and reason.

13. Is there anything else you feel that the researchers should be aware of?

I certify that these answers are accurate and complete

Your Signature:

Date:

Witness: _____

Date: _____



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INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (August 2002)

SHORT LAST 7 DAYS SELF-ADMINISTERED FORMAT

FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health-related physical activity.

Background on IPAQ

The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ

Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation

Translation from English is supported to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ

International collaboration on IPAQ is on-going and an *International Physical Activity Prevalence Study* is in progress. For further information see the IPAQ website.

More Information

More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000). *Assessment of Physical Activity: An International Perspective*. Research Quarterly for Exercise and Sport, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarized on the website.

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.



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INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

_____ **days per week**

No vigorous physical activities → **Skip to question 3**

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ **days per week**

No moderate physical activities → **Skip to question 5**

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

No walking → **Skip to question 7**

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

APPENDIX B

Data Analyses Rationale Flowchart

Data Analyses Rationale

