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A Comparison of Spinal Reflex Function and Morphological Adaptations of the Achilles Tendon Between Individuals Chronically Post-Stroke and Healthy Controls

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ABSTRACT

Purpose/Hypothesis: The hallmark gait deviation in individuals with post-stroke hemiparesis is slow walking speed. Reduction in gait speed after stroke is influenced by decreased propulsive forces, which may likely be related to impaired spinal circuit function and spasticity of the paretic plantarflexors. Chronic muscle tone maladaptations in paretic ankle plantarflexors can result in altered Achilles tendon (AT) morphology, therefore leading to altered mechanical properties, force transmission capabilities and subsequent insufficient propulsive forces during walking. The purpose of this study is to characterize the chronic maladaptations in both the spinal Ia afferent loop excitability and AT morphology after stroke lesions in the brain in individuals with chronic post-stroke hemiparesis.

Materials and Methods: Nineteen non-neurologically impaired individuals and fifteen neurologically impaired individuals participated in this study. Ultrasound imaging was conducted, acquiring two views at three locations along bilateral ATs to measure tendon thickness, cross-sectional area (CSA), and collagen fiber organization. Spinal Ia afferent loop excitability was assessed by measuring the soleus (SOL) H-reflex amplitude. Surface electromyography of the tibial nerve was recorded using surface electrodes on the SOL muscle to obtain a recruitment curve. Peak-to-peak amplitudes of the H-reflexes were averaged, and expressed as H_{max}/M_{max}. Outcome measurements to assess spasticity and level of function in individuals with post-stroke hemiparesis were also performed. Additionally, all individuals participated in a 10-Meter Walk Test (10MWT) to assess gait speed. One-way ANOVAs with repeated measures and post hoc analyses were conducted to compare the tendon morphology and H-reflex amplitudes of the paretic and non-paretic limbs in individual with post-stroke

hemiparesis, as well as the non-impaired limb (right limb) in non-neurologically impaired individuals.

Results: We observed significantly greater thickness of the AT at the calcaneal insertion and midportion, as well as increased collagen fiber disorganization at the calcaneal site of the paretic limbs when compared to non-neurologically impaired limbs. It was also observed that individuals with chronic post-stroke hemiparesis had slower self-selected walking speeds compared to the non-neurologically impaired individuals as measured via the 10MWT ($p<0.05$). No significant difference in CSA was found amongst the groups. No statistically significant differences in H_{max}/M_{max} ratios were found in the paretic legs compared to the non-paretic and non-impaired legs in the paretic limbs of individuals post-stroke.

Conclusion: This study found that tendon thickening and increased collagen fiber disorganization in the insertion site of the AT were present in the paretic limb, which may explain the reduction in propulsive forces needed for adequate gait speed in individuals with post-stroke hemiparesis. Our findings also depict no significant difference in H_{max}/M_{max} ratio in the paretic limb of individuals with post-stroke hemiparesis compared to non-neurologically impaired individuals. The changes in H-reflex excitability of the paretic plantarflexors and altered morphology observed in the paretic Achilles tendon potentially underlie post-stroke walking deficits. Thus, future rehabilitation programs should consider adopting an integrated approach addressing both neurological and mechanical deficits to restore walking function in individuals chronically post-stroke.

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1. INTRODUCTION

Stroke is a leading cause of adult disabilities and incidences of stroke have increased as the growing population of older adults are living longer(1, 2). One of the principal functional deficits observed in individuals with post-stroke hemiparesis is decreased gait speed, which has become a large focus of the literature, as appropriate gait speed is a predictor of quality of life for individuals post-stroke(3). A multimodal rehabilitation program consisting of aerobic, task-oriented, and balance exercises, as well as stretching has been shown to improve community mobility and quality of life(3). The aforementioned evidence supports the efficacy of applying rehabilitation programs to increase ambulation speed and enhance physical and psychosocial domains in individuals with chronic post-stroke hemiparesis(3).

Propulsive force, the force that drives the body forward while walking, is one primary determinant of walking speed, with decreased propulsive force directly correlated to slow walking speed(4, 5). Lower propulsive forces have been observed in the paretic limbs of individuals post-stroke even after achieving ambulatory speeds greater than 0.8 m/s, which has been defined as functional walking speed(6). Excessive braking force, the force that slows the body during gait, also contributes to slow and effortful walking(6). The inability to direct foot forces in the appropriate direction contributes to the combined challenges of insufficient propulsive force and excessive braking force in individuals post-stroke. These challenges often result in slower walking, increased effort, reduced efficiency, altered kinematics, and a higher risk of falls(6-9). Computing propulsive minus braking forces can establish a quantifiable method of measuring the net mechanical contribution of the paretic leg vs the non-paretic leg during walking(6). Such measures have indicated that those with more severe hemiparesis

produce less total work propelling themselves forward(6). Specifically, less net force production has been identified during the pre-swing phase of the paretic leg's gait cycle(6).[4] These findings support that walking after a stroke is associated with reduced gait speed, impaired coordination in the legs, reduced gait symmetry, increased variability and decreased quality of walking patterns(6, 10, 11).

The deficiency in propulsive force is partially due to impaired spinal circuit function(12). Individuals post-stroke commonly experience spasticity, hypertonia in the plantar flexors, and hyperactive reflexes due to disruption/alterations in supraspinal inputs(12). Foot force control, spasticity, increased excitability, and hyperreflexia contribute to impaired reflex modulation and postural control (7, 12, 13) and affect overall coordination and rhythm of gait patterns(14). Specific changes in gait include decreased cadence, increased stride and step length, unequal step lengths between paretic and non-paretic legs, and an increased swing and shortened stance phase on the paretic leg(13). Additionally, impaired reciprocal inhibition of the ankle dorsiflexor muscles during gait contributes to foot drop(14). Due to the aforementioned changes in individuals post-stroke, the plantarflexors of the paretic limb experience consistent abnormal forces which may cause chronic loading to the Achilles tendon (AT)(15-17).

It has been suggested that consistent abnormal forces may produce changes in the mechanical properties of tendons comparable to those found in degenerative tendons(15, 18). Previous research suggests that tendons that presented with these adaptations due to high magnitude loading are more likely to develop overuse injuries and ruptures when placed under continuous stress(18). Moreover, repetitive abnormal overloading of the AT can lead to tendinopathies which may also contribute to morphological changes(18). These changes typically include an

increase in cross-sectional area (CSA) increased ground substance in the extracellular space, collagen fiber disruption, loss of type I collagen fibers, and increased type II collagen(18, 19). The AT may develop a lower stiffness and decreased Young's modulus(18). These changes, along with the degeneration of the tendon and alterations in tissue composition, may then lead to higher strains on the tendon(18). Most of these changes, particularly the increased water and glycosaminoglycan content present in ground substance, may lead to excessive compliance in the tendon. Excessive compliance then results in increased energetic costs during gait, as muscles must work harder to produce adequate propulsive force(18). Consequently, it has been observed that these changes in tendon compliance also contribute to the increased production of type III collagen fibers, which may result in the tendon having less tensile strength, and more elastic mechanical and material properties(18). Taken together, impaired spinal reflex function and increased tendon compliance from abnormal mechanical loading are thought to contribute to weakness in propulsive force, further increasing the demand on ankle plantarflexor muscles of the paretic leg in the terminal stance phase of gait(17, 18). It is crucial to examine the aforementioned potential changes in AT morphology and differences in spinal Ia afferent circuitry between individuals post-stroke and non-neurologically impaired individuals(17). Spinal Ia circuitry can be quantified by assessing the H-reflex. The H-reflex, or Hoffman reflex, is the reflex elicited by the stimulation of Ia afferent fibers to create a motor response of the soleus (SOL) muscle, which is represented by the M-wave(20).

Closing this gap of knowledge in the literature may inform the principles of treatments that target the ambulatory impairments of this large individual population. Thus, the overall purpose of this study was to examine the chronic changes in AT morphology and the SOL

muscle H_{max}/M_{max} ratio in individuals with chronic post-stroke hemiparesis, which may negatively influence gait speed due to the impacts on propulsion. Based upon previous findings, we hypothesized that individuals with chronically post-stroke hemiparesis would demonstrate the following: an increased H_{max}/M_{max} ratio, increased tendon CSA and thickness, and a lower Peak Spatial Frequency Radius (PSFR) value, which indicates tissue disorganization in the AT, in the paretic versus non-paretic leg. We also hypothesized that these differences would be apparent when comparing paretic limbs to non-neurologically impaired limbs. Finally, we hypothesized that there would be functional deficits between the groups, with the individuals post-stroke having slower walking paces than the control groups as measured via the 10MWT. Such findings could contribute to the critical foundational understanding of post-stroke biomechanics necessary to assess specific treatment modalities that aim to improve these morphological changes(21).

2. METHODS

Study Design: This observational study was approved by the Institutional Review Board (IRB) of the University of Nevada, Las Vegas. It included a cross-sectional analysis of data collected from individuals diagnosed with chronic post-stroke hemiparesis and non-neurologically impaired adults. AT thickness, CSA, PSFR, and H-reflex of the SOL muscle were the variables of interest in the paretic and non-paretic legs of individuals with chronic post-stroke hemiparesis compared with the right leg of non-neurologically impaired individuals. Measurements derived from ultrasound imaging were assessed between the right limb of non-neurologically impaired individuals, the paretic, and the non-paretic limbs of individuals with post-stroke hemiparesis.

Participants: Participants signed informed consent forms that detailed the purpose and process of this research study. With a Type 1 error of 0.05 and using a two-tailed analysis that compares mean differences between two independent groups, power analyses revealed that thirty-two individuals (sixteen neurologically impaired individuals vs sixteen non-neurologically impaired individuals) would be needed to ensure that each variable reaches a minimum power of 0.85. Based on previous research by Kulig et al(22)., the main effect of stroke on tendon morphology would yield an effect size of Cohen's d equal to 1.00. Inclusion criteria for individuals with chronic post-stroke hemiparesis were: 1) over eighteen years old; 2) > 6 months post single, unilateral, cortical, or subcortical stroke with residual hemiparesis; 3) able to perform the 10 Meter Walk Test (10MWT), which is a physical performance test used to measure walking speed by having the individual walk 10 meters at a preferred speed and fast speed and, 4) able to follow verbal cues and adhere to instructions. Post-stroke individuals were excluded if they had other neurological diagnoses, were pregnant or thought they were

pregnant, were currently taking spasticity medication, had received Botox injection(s) in the last 6 months in the lower extremity or had a history of cerebellar stroke(s), lower extremity surgery, or bilateral stroke(s). Non-neurologically impaired individuals were excluded if they were under the age of eighteen, unable to participate in the 10MWT, unable to follow verbal cues, unable to adhere to instructions, pregnant or thought they were pregnant, or had a history of lower extremity surgery, AT tendinopathy, or any neurological disorder.

Measurements: To characterize and compare the individuals' functional mobility and gait speed, the 10MWT(23) was performed by having the individuals walk a total distance of ten meters. The recorded time started when the individual's toes passed the two-meter mark to account for acceleration and stopped when the toes passed the eight-meter mark to account for decceleration. The six meters was then divided by the total walking time and recorded in m/s. Each individual performed two trials of the 10MWT, and their performance was timed using a stopwatch with the average of each of the trials documented to demonstrate ambulatory capacity at both a self-selected speed and a fast speed. In addition, the Fugl-Meyer Assessment of the Lower Extremity (FMA-LE)(24) is an impairment index that was performed for stroke-impaired individuals to quantify functional level of motor control, coordination, sensation, and balance as well as the Modified Ashworth Scale (MAS)(25) to quantify spasticity. FMA-LE was utilized to determine impairment severity for everyone in the neurologically impaired group. The MAS, a muscle tone assessment used to measure the presence of velocity-dependent resistance during passive range of motion on a zero to four scale, was used for each neurologically impaired individual to test for spasticity in the gastrocsoleus complex. The assessor would rapidly and manually dorsiflex the ankle to get a subjective rating, with zero

representing normal muscle tone, and higher scores representing increased spasticity/increased resistance to passive movement.

Procedures:

Tendon Morphology Assessment

Ultrasound imaging was utilized to determine AT morphology, including thickness, CSA, and collagen fiber organization. To obtain morphological measures of the AT, individuals lay prone with the knee in extension and ankle in a neutral position. The ultrasound linear transducer (GE 12L-RS, bandwidth 5-13MHz, width 38.4 mm, GE Healthcare, Milwaukee, WI, USA) was used with a knee musculoskeletal pre-set of 2 cm depth. Images were captured distally at the insertion of the AT on the calcaneus, at the midportion as measured 2 cm proximal to the AT insertion, and at the proximal portion measured 2 cm proximal to the midportion (Figure 1). Longitudinal views to measure AT thickness and transverse views to measure AT CSA were captured at each location(17, 26, 27).

Spinal Reflex Assessment

H-reflex was elicited from both the paretic and non-paretic SOL muscles and the bilateral SOL muscles in non-impaired individuals**.** Peak-to-peak amplitude measurements of the H-reflex was assessed to determine reflex excitability. Data was collected in the right side of the non-neurologically impaired controls. The individuals maintained a standing posture, with both arms at their sides, unless an assistive device was needed for support. To elicit SOL H-reflexes and M-waves, bipolar self-adhesive Ag-AgCl electrodes were placed over the popliteal fossa to electrically stimulate the tibial nerve (Figure 8), using a constant current stimulator and isolation unit (DS7A, Digitimer Ltd., Letchworth Garden City, UK)(28). After collecting data, the

H_{max}/M_{max} ratio was computed. An electrode was placed on the distal portion of the SOL muscle in order to record EMG data of the muscle (Figure 8). The electrode placement was decided initially based on the distal SOL muscle belly being lateral to the distal Gastrocnemius muscle. The electrode was adjusted accordingly following trial stimulation to ensure placement was yielding an appropriate recruitment curve of the H-Reflex. The peak-to-peak amplitudes, across 20-30 trials, of the maximal H-reflexes of the SOL muscle for each individual were recorded via electromyography (EMG) (Figure 5). These values and the values found as the maximal M-wave amplitudes (Figures 6), were averaged. The average H-reflex and M-wave amplitudes of each individual were then expressed as a ratio of the averaged H-reflex amplitude over the averaged M-wave value, known as the H_{max}/M_{max} ratio.

Reliability: Intrarater and interrater reliability derived from ultrasound imaging was assessed using intra-class correlation coefficients (ICC 3,3). For image acquisition, intrarater reliability obtained from ultrasound imaging was established by assessing the consistency of measures from images gathered from five individuals by the same rater over two sessions within seven days. For image analysis, intrarater reliability was established by comparing the measurements on the five individuals' images between two days. The investigator responsible for image acquisition showed fair to good intra-rater reliability for measuring tendon thickness (ICC=0.852), CSA (ICC=0.418), and PSFR (ICC=0.631). The investigators responsible for image analysis showed good to excellent inter-rater reliability for measuring tendon thickness (ICC=0.808), CSA (0.999), and PSFR (ICC=0.993).

***Data Analysis*:** Using the National Institute of Health's ImageJ software (available from https://imagej.net/Downloads), AT thickness was calculated as the perpendicular distance

between the borders of the tendon of the longitudinal images. AT CSA, defined as the region within the borders of the AT measured in mm^2, was measured on the transverse views via ImageJ (Figure 3). Tendons are considered organized when a parallel arrangement of collagen bundles is present and disorganized when a speckle pattern is present containing less of a banded structure. To quantify the level of tendon collagen fiber organization (PSFR), a custom MATLAB script created by the University of Nebraska, Lincoln, Department of Biological Systems Engineering department was utilized. AT thickness was measured by the length of a vertical line traced between the upper and lower borders of the AT (Figure 1). CSA measurements were measured by utilizing the polygon tool to select the boundaries of the AT in the transverse view and then the area was calculated via ImageJ software (Figure 3). The PSFR measurements were analyzed by tracing a rectangle in the middle of the AT (Figure 4) and then analyzed and calculated via the custom MATLAB algorithms. All images were analyzed at proximal, midportion, and calcaneal tendon sites.

For H_{max}/M_{max} ratio, peak-to-peak amplitudes of the H-Max and M-Max were analyzed and exported to excel. Line charts were created to visualize the recruitment curve for each individual (Figure 7). The amplitudes of each plot point were the result of an average between three trials taken at the same stimulation intensity. Intensity increased every 3 trials. This plot was also used to determine the minimum and maximum values of the H-reflex and M-wave.

AT Thickness Measurement

Figure 1. Setup for ultrasound image capture of longitudinal section of AT.

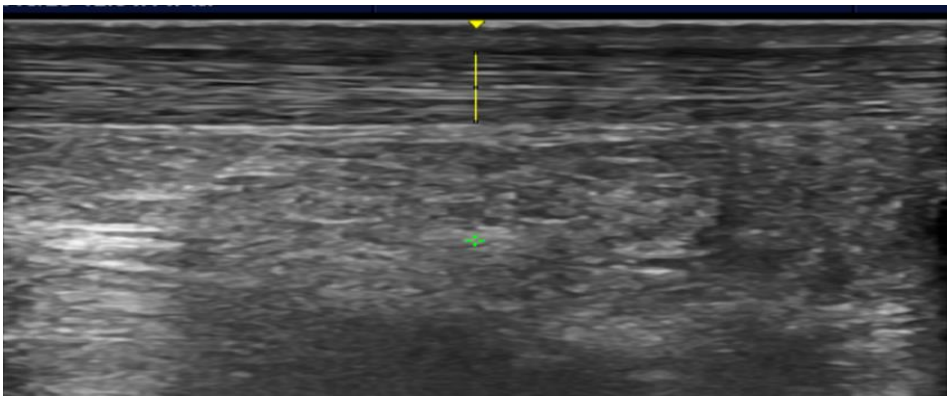

Figure 2. AT Thickness Measurement.
Vertical line traced between the upper and lower borders of the AT in imageJ. The most superior aspect of the yellow line represents the upper border of the AT and the most inferior

aspect of the yellow line represents the lower border of the AT. The vertical line computes the thickness of the individual's AT.

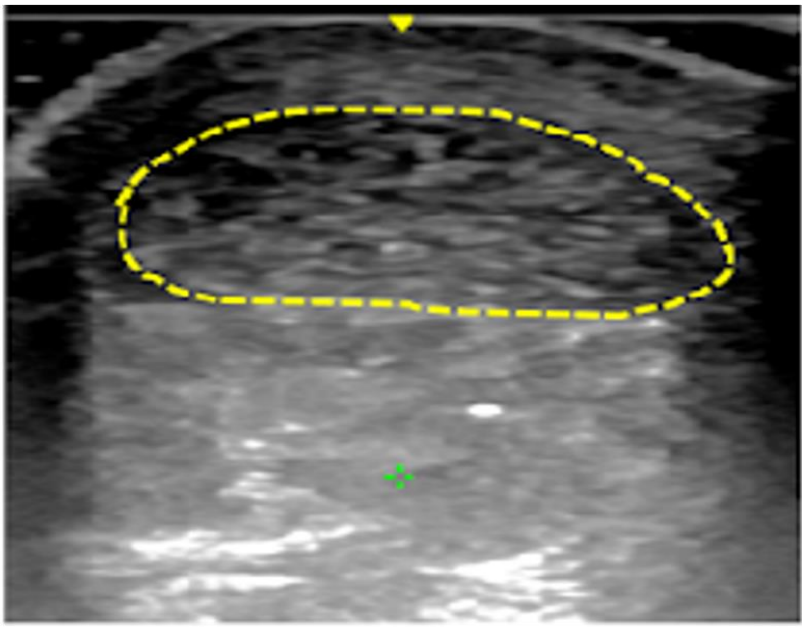

Figure 3. AT CSA Measurement.
Image of a polygon traced around the boundaries of the AT in the transverse view. The white line represents the boundaries of the entire CSA of the AT.

AT PSFR Measurement

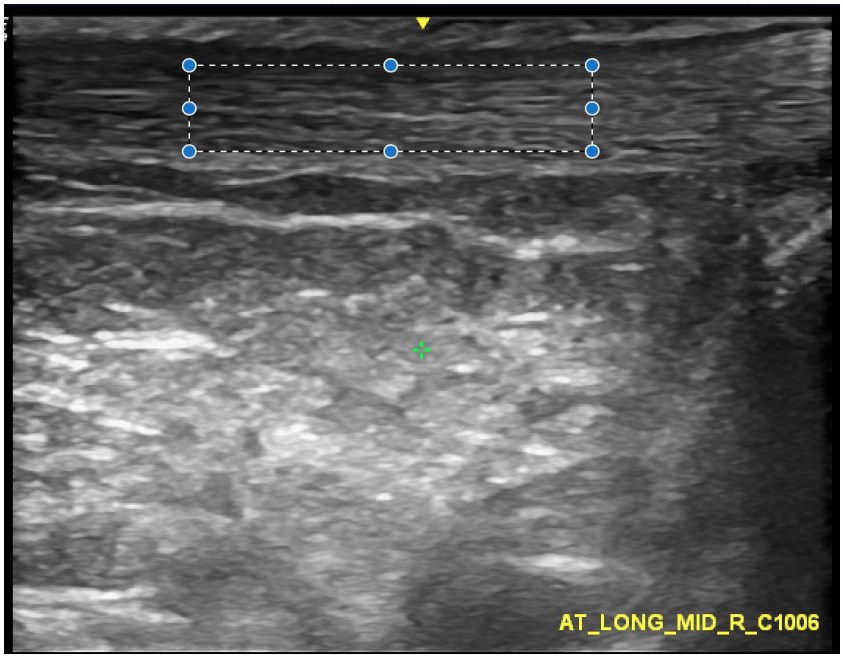

Figure 4. AT PSFR Measurement.
Image of a rectangle traced in the middle of the AT for consistency purposes and then analyzed and calculated via the custom MATLAB code. The blue dots and dotted white lines represent the boundaries of the collagen fiber organization that is computed. AT_LONG_MID_R_C1005 represents an image of the middle portion of the AT captured utilizing a longitudinal view with the US transducer on the right leg of individual C1005.

H-reflex and M-max Measurement

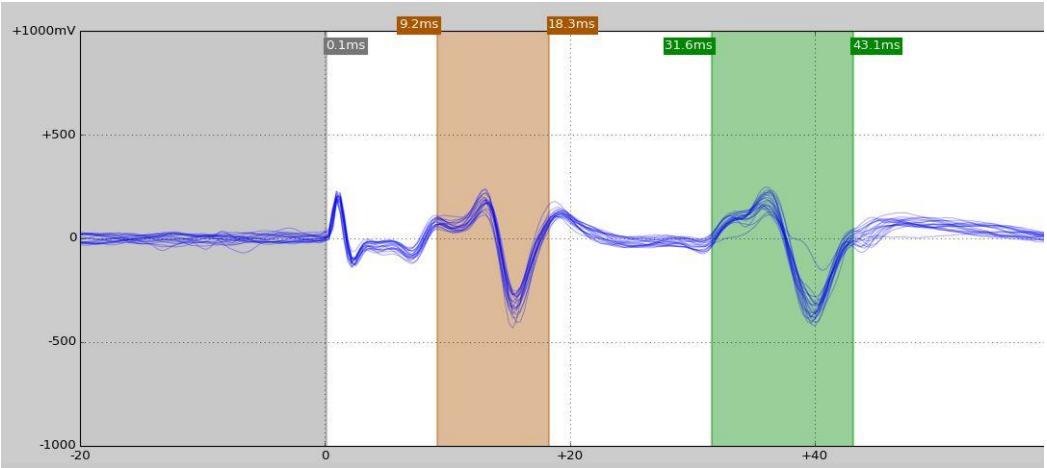

Figure 5. H-reflex and M-max measurement of non-neurologically impaired control.
Image recorded on EPOCS that displays a superimposed waveform of 20-30 trials of electrical stimulation at the same intensity to elicit the H-max of a non-impaired individual. The X-axis represents time (ms) and the Y-axis represents amplitude (mV). The electrical stimulation occurred at 0.1ms and is followed by the M-wave, typically seen at 6-9 ms (brown), then by the maximal H-reflex (Hmax), typically seen at 30 ms (green).[13]

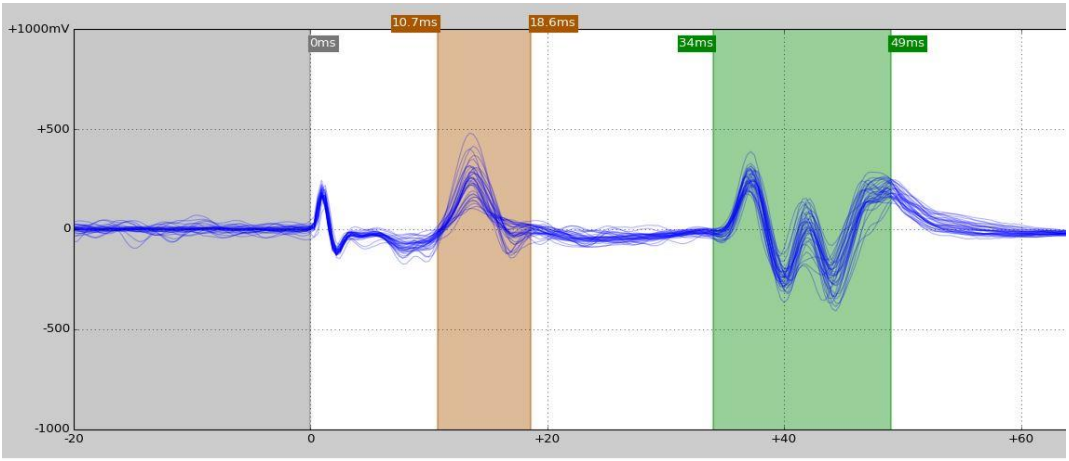

Figure 6. H reflex and M-max measurement of paretic limb.
Image recorded on EPOCS that displays a superimposed waveform of 20-30 trials of electrical stimulation at the same intensity to elicit the H-max of the paretic leg in an individual post-stroke elicited by electrical stimulation. The electrical stimulation occurred at 0.1ms and is followed by the M-wave, typically seen at 6-9 ms (brown), then by the maximal H-reflex (Hmax), typically seen at 30 ms (green).[13] It can be noted that a greater H-reflex amplitude was required to perform a motor response with similar amplitude to the image in Figure 5.

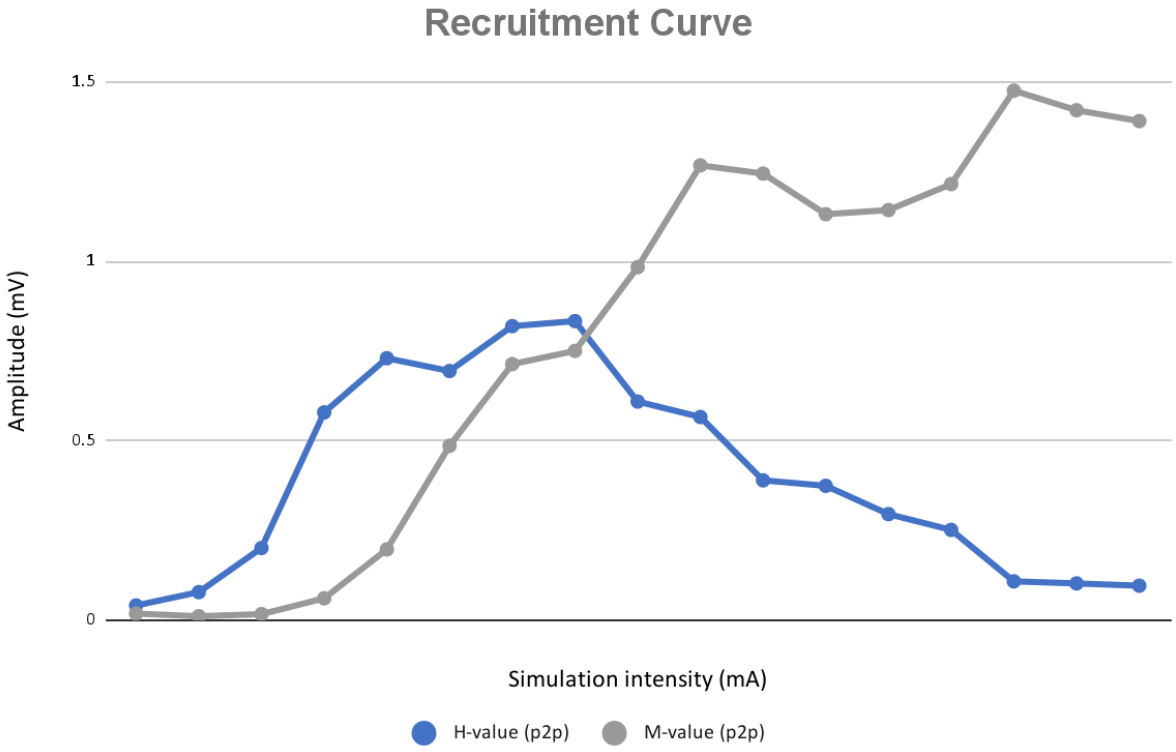

Figure 7. Soleus Recruitment Curve.
Line chart plotted in Microsoft Excel to visualize the SOL recruitment curve data using the peak-to peak (p2p) amplitude values retrieved from the analysis of Figure 6 in EPOCS, which was a single neurologically impaired individual. The amplitudes of each plot point were the result of an average between three trials taken at the same stimulation intensity. Intensity increased every 3 trials. This plot was also used to determine the minimum and maximum values of the H-reflex (blue) and M-wave (gray).

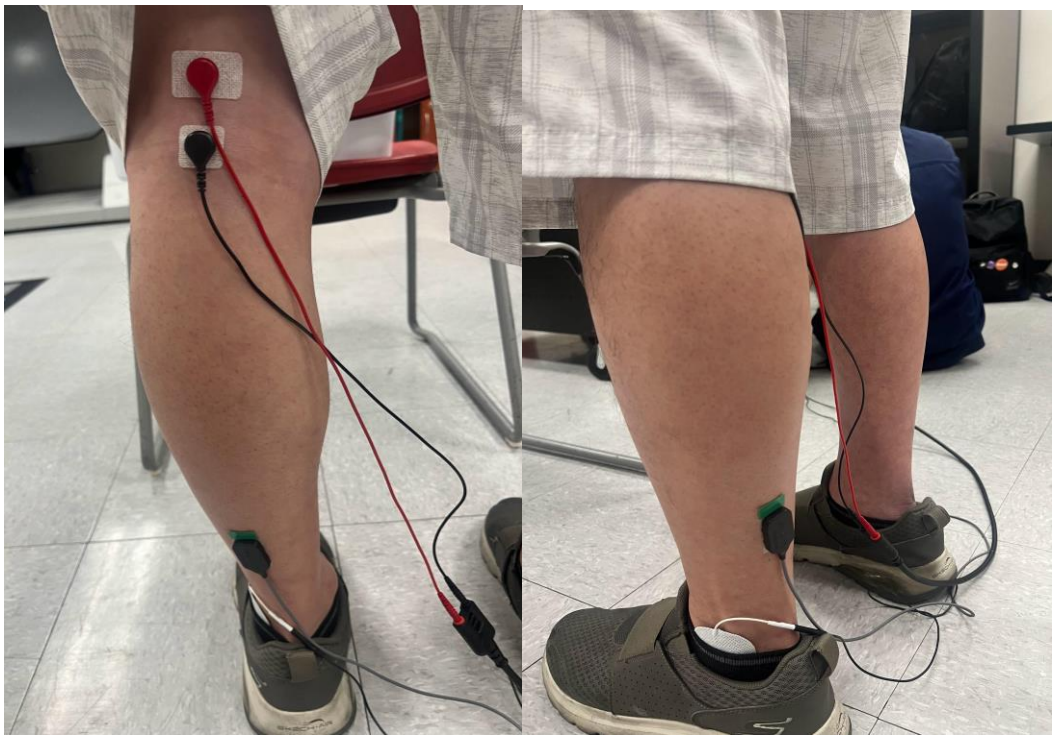

Figure 8. EMG Setup.
Stimulator electrode placement (black negative lead and red positive lead) on popliteal surface of the individual's lower extremity to target the tibial nerve, ground electrode placed on lateral malleolus, and EMG electrode (green) placed on distal end of SOL muscle.

Statistical analysis: Statistical analysis was performed in SPSS version 27. One-way ANOVAs comparing AT thickness, CSA, PSFR, and H_{max}/M_{max} ratios across the right limbs of non-neurologically impaired individuals and the non-paretic and paretic legs of individuals chronically-post stroke were performed. A Bonferroni post hoc test was then used to correct for multiple comparisons for each variable.

3. RESULTS

Participant Characteristics

Table 1 shows the characteristics of the thirty-four individuals included in this study. Among the thirty-four individuals, the mean age for neurologically impaired individuals was 59.20 ± 10.40 years and the mean age for non-neurologically impaired individuals was 55.30 ± 14.50 years. We observed seven females and eight males for neurologically impaired individuals and nine females and ten males for non-neurologically impaired individuals. The average height for neurologically impaired individuals was 168.70 ± 6.0 cm, while the average height for non-neurologically impaired individuals was 169.60 ± 8.90. The average weight for neurologically impaired individuals was 79.30 ± 13.20 kg, while the average weight for non-neurologically impaired individuals was 71.30 ± 15.0. The average time since the neurologically impaired individuals suffered their stroke was 6.70 ± 5.40 years. Six neurologically impaired individuals had a left paretic limb, while seven neurologically impaired individuals had a right paretic limb. The average self-selected walking speed for neurologically impaired individuals was 0.94 ± 0.53, while the average self-selected walking speed for non-neurologically impaired individuals was 1.44 ± 0.47 m/s. Though fifteen individuals were observed, only thirteen individuals were used during H_{max}/M_{max} data analysis due to unusable data caused by lack of M-Max plateau during data collection. The average FMA-LE score for neurologically impaired individuals was 21.87 ± 5.20, while the average MAS score for neurologically impaired individuals was 0.80 ± 0.40. Neurologically impaired individuals had a significantly slower gait speed compared to non-neurologically impaired individuals. Additionally, there was no significant difference in age, sex, height, weight, time since stroke, FM-LE score, or MAS score.

Table 1 Participant Demographics

	Neurologically impaired (n = 15)	Non-neurologically impaired (n = 19)	P
Age (Years) (mean ± SD)	59.20 ± 10.40	55.30 ± 14.50	0.305
Sex (Female/Male)	7/8	9/10	-
Height (cm) (mean ± SD)	168.70 ± 6.0	169.60 ± 8.90	0.835
Weight (kg) (mean ± SD)	79.30 ± 13.20	71.30 ± 15.0	0.420
Time Since Stroke (years) (mean ± SD)	6.70 ± 5.40	-	-
Paretic Limb (Left/Right)	6/7	-	-
Self-Selected Walking Speed (m/s) (mean ± SD)	0.94 ± 0.53	1.44 ± 0.47	0.013
FM-LE Score (mean ± SD)	21.87 ± 6.90	-	-
MAS Score (mean ± SD)	0.80 ± 0.40	-	-

[a]Fugl-Meyer (FM) Assessment - Lower Extremity (LE) motor function (total=34)
*indicates statistical significance ($p<0.05$) between groups.
[b]Modified Ashworth Scale (MAS) - Objective assessment of muscle tone

According to ANOVA, the results demonstrated a statistically significant difference in tendon thickness (Figure 9) observed both in the midportion ($p = 0.034$, $df = 2$, $F = 3.64$) and calcaneal portion ($p = 0.006$, $df = 2$, $F = 5.68$) of the AT. Post hoc analysis, in comparison to the non-impaired limbs within the control group, indicated a significantly higher tendon thickness in both the midportion ($p = 0.034$) and calcaneal portion ($p = 0.005$) of the paretic limbs. The ANOVA results also demonstrated a statistically significant difference in PSFR (Figure 11) in the calcaneal portion ($p = 0.045$, $df = 2$, $F = 3.32$) of the AT. Post hoc analysis indicated a

significantly higher PSFR in the calcaneal portion of the control limbs compared to the paretic limbs (p=0.047). The ANOVA results demonstrated no statistically significant difference in CSA among the three limbs: proximal portion (p = 0.44, df = 2, F = 0.85), midportion (p = 0.29, df = 2, F = 1.29), and calcaneal portion (p = 0.57, df = 2, F = 0.58).

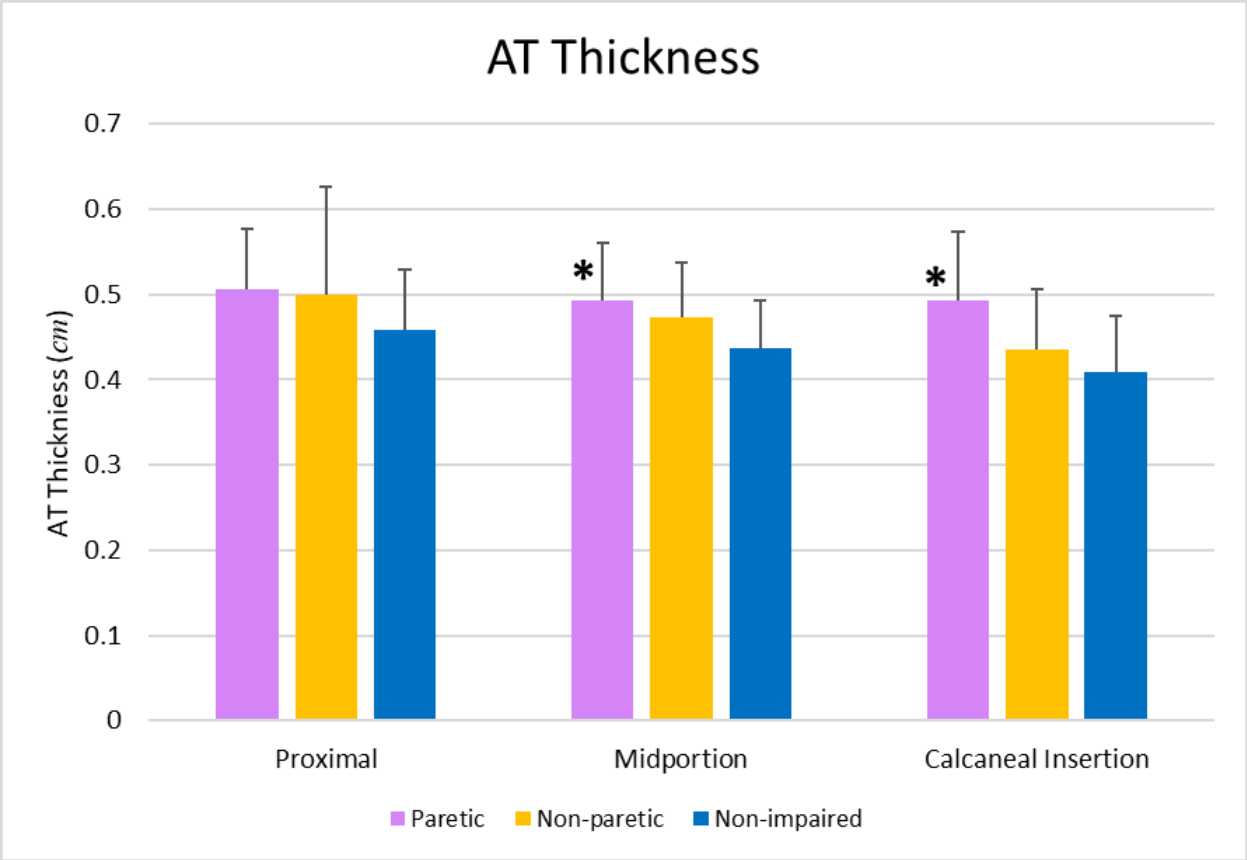

Figure 9. AT Thickness.
AT thickness (mean ± SD) assessed at each location in paretic, non-paretic, and non-impaired limbs**.**

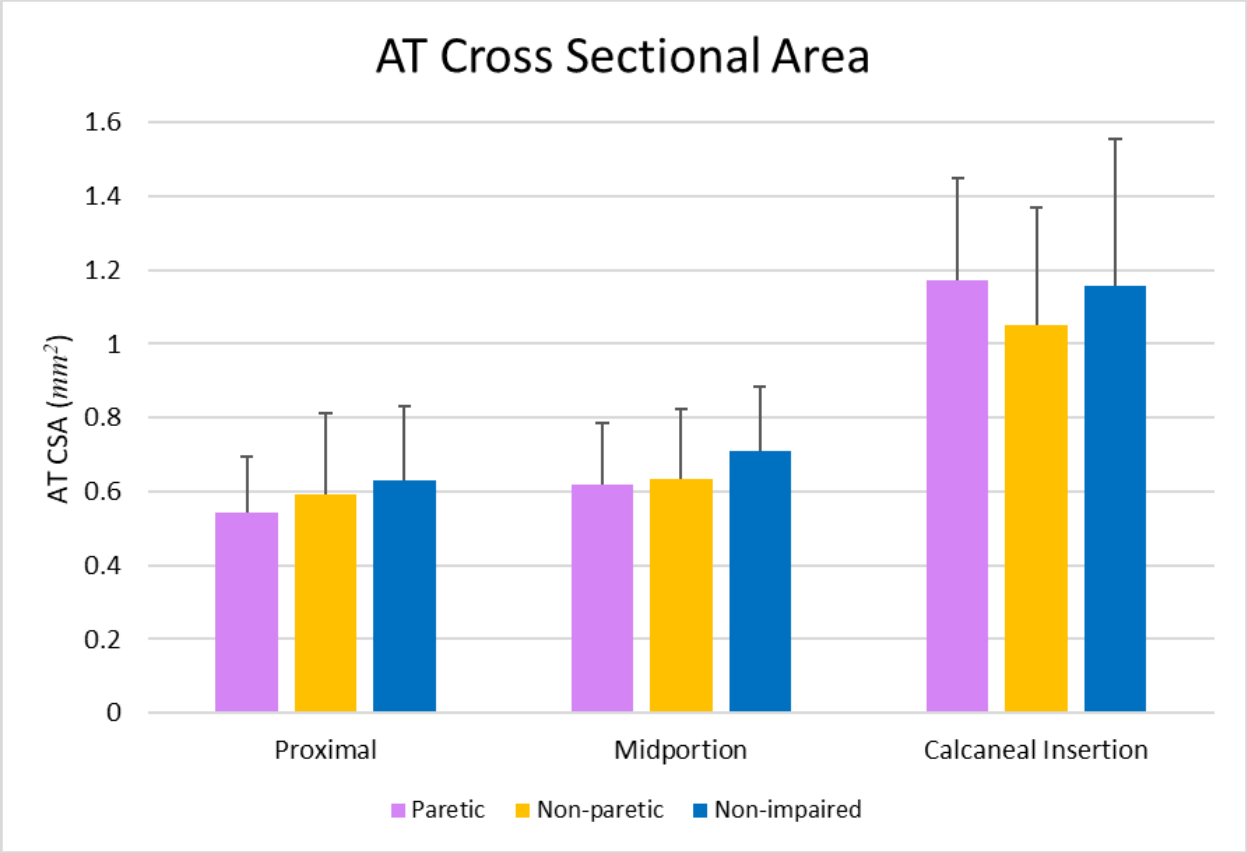

Figure 10. AT cross sectional area.
AT cross sectional area (mean ± SD) assessed at each location in paretic, non-paretic, and non-impaired limbs.

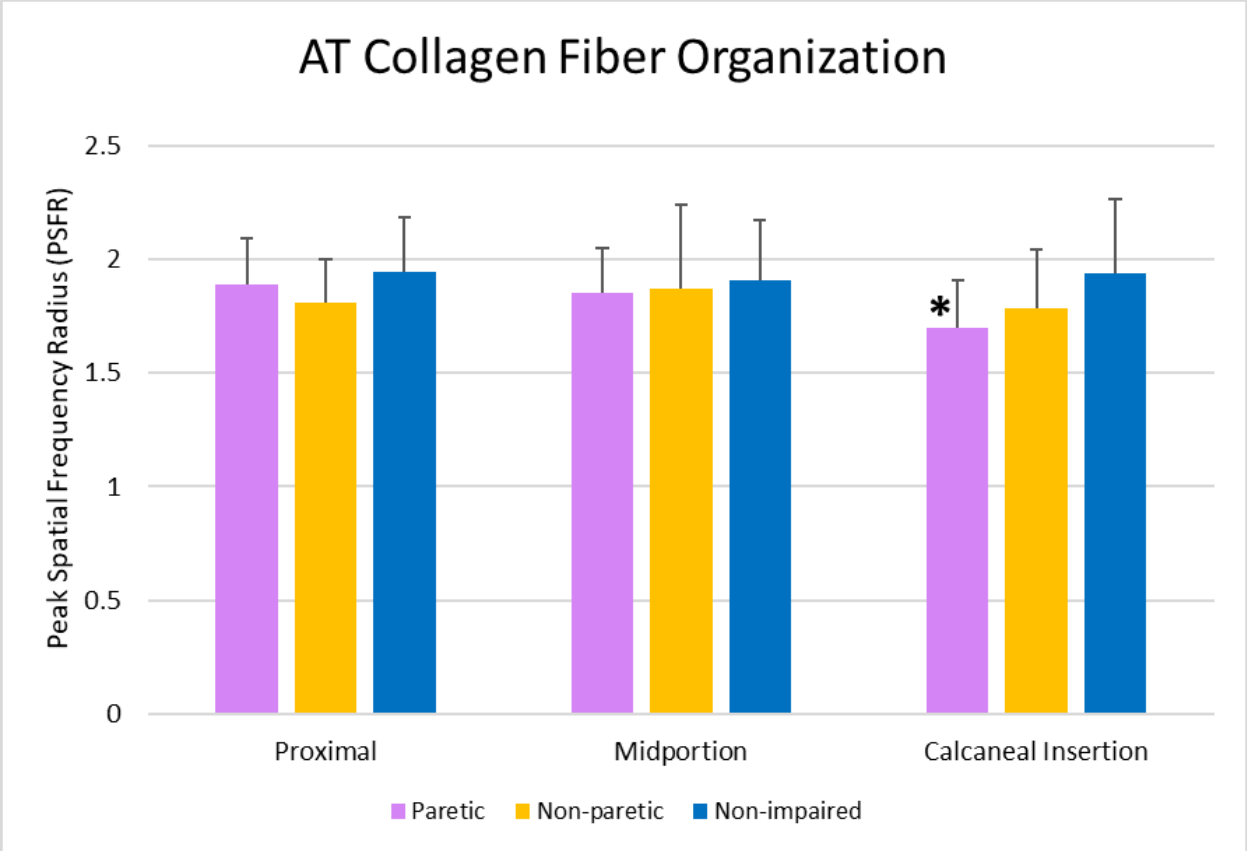

Figure 11. PSFR.
AT collagen fiber organization (mean ± SD) assessed at each location in paretic, non-paretic, and non-impaired limbs.

The ANOVA results demonstrated that there was no significant difference in H_{max}/M_{max} ratio when comparing the H_{max}/M_{max} ratio of right legs of non-neurologically impaired individuals (N=8) with non-paretic legs (N=12), and paretic legs (N =13) of individuals post-stroke ($p = 0.42$, $df = 2$, $F = 899$) (Figure 12). The ANOVA also revealed that when comparing the H_{max}/M_{max} ratio of non-paretic (N = 12) and paretic legs of individuals post-stroke (N = 13), there was no significant difference between the two legs ($p = 0.284$, $df = 1$, $F = 1.206$).

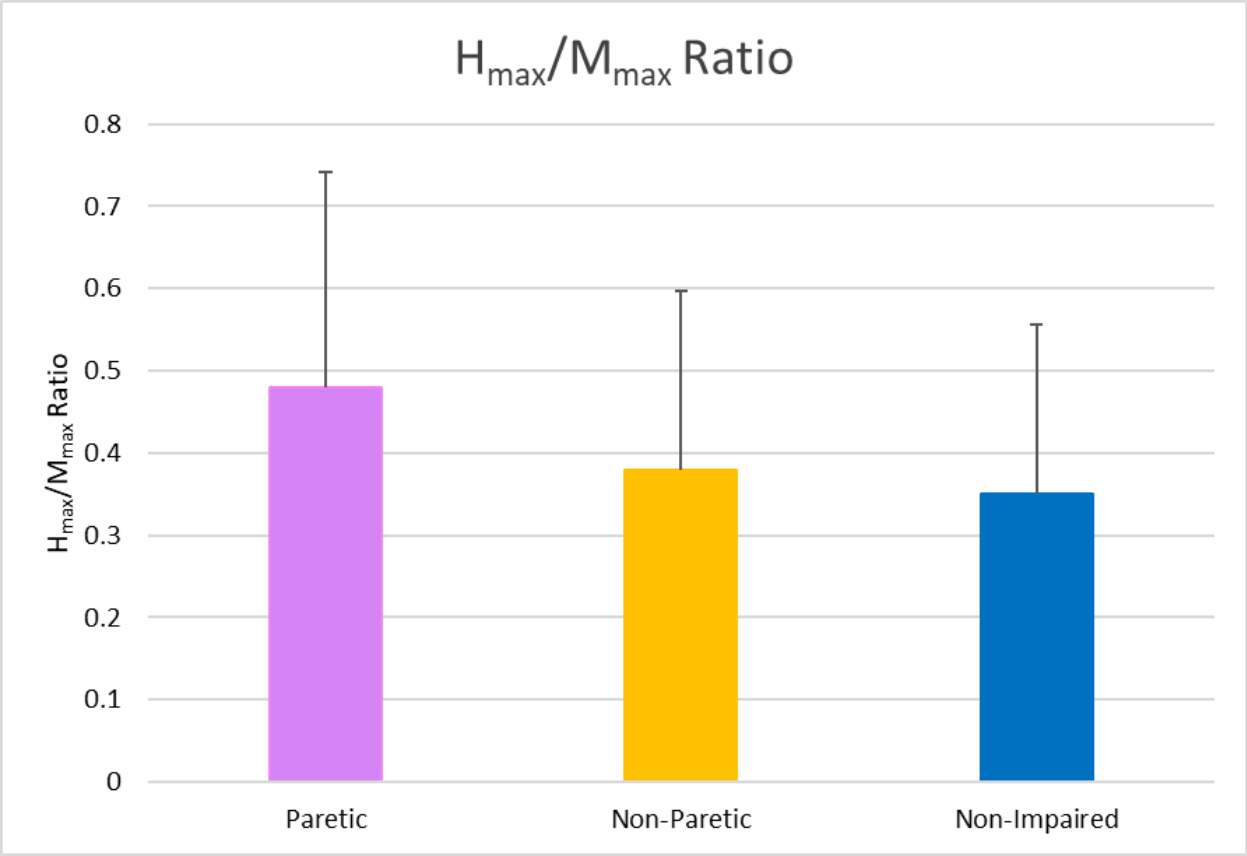

Figure 12. H_{max}/M_{max} ratios.
H_{max}/M_{max} ratios (mean±SD) for each loading condition, for the paretic, non-paretic and non-impaired legs.

4. DISCUSSION

The aim of this study was to analyze the adaptations of AT morphology and H_{max}/M_{max} ratios among individuals with post-stroke hemiparesis and non-neurologically impaired individuals. It was hypothesized that individuals chronically post-stroke would demonstrate an increased value in the H_{max}/M_{max} ratio, increased tendon CSA, increased tendon thickness, and a lower PSFR value in the paretic leg versus the non-paretic leg when compared to non-neurologically impaired individuals. The null hypothesis was partially supported by the results, as it was found increased tendon CSA and thickness. However, there were not any statistically significant differences in H_{max}/M_{max} ratio.

Extrinsic factors, such as repetitive abnormal forces during functional activities (15, 18), and intrinsic factors such as genetics, biomechanics, strength, and central adiposity, have been shown to contribute to changes in the morphology of the AT(29). In this study, differences in tendon thickness were evident at the tendon insertion among individuals post-stroke, particularly in the paretic limbs and non-neurologically impaired individuals. In addition, the captured PSFR in the paretic limbs of individuals post-stroke when compared to non-neurologically impaired individuals at the AT insertion was significantly lower, suggesting collagen fiber disorganization. A decreased PSFR signifying atypical collagen fiber organization is consistent with the representation of tendinopathy(18, 19). The results support the hypothesis that the paretic limbs of individuals post-stroke have greater AT thickness, specifically at the insertional site, than their control counterparts. Similar findings have been reported in a previous case report(17). Previous research indicates repetitive abnormal forces lead to changes in AT morphology, which may explain the insertional tendon changes seen in the

paretic limbs of the post-stroke individuals (18, 29). These AT changes have resulted from increased spasticity and tone, leading to insufficient propulsive force and slow walking speed in this cohort(12).

Although longitudinal thickness was significantly greater at the midportion and calcaneal portion of the AT, there was not a significantly larger CSA in that region. There are two possibilities to explain the significant difference in the longitudinal view, but not the transverse view at the AT insertion. It may be due to the increased difficulty of attaining a complete transverse view of the AT that accurately represents the CSA. The lowest ICCs were obtained when measuring CSA (ICC=0.418), which supports this theory. Secondly, the AT could potentially be getting thicker and not necessarily getting wider.

No statistically significant difference in H_{max}/M_{max} ratio between non-paretic, paretic limbs, and non-impaired limbs were observed, despite contrasting findings reported in other studies. Typically, an increased H_{max}/M_{max} would be noted suggesting greater tone and spasticity of the paretic limb. In previous studies, conflicting results have been found regarding the H-reflex amplitude in the paretic soleus. Some studies have reported a higher H-reflex amplitude in the paretic soleus, while others have found no significant difference in H-reflex amplitude between the paretic and non-paretic limb(28, 30-32). Our finding may be due to the lower observed MAS scores and higher FMA-LE scores in individuals with post-stroke hemiparesis, which suggests that the majority of the selected subject pool contained higher-functioning individuals whose degree of impairments many not elicit the same results as lower-functioning individuals with a greater degree of hypertonicity and hyperreflexia.

Although H_{max}/M_{max} ratios were not significant, the AT morphological differences may contribute to the decreased walking speeds observed in individuals post-stroke(17-19). Increased thickness and reduced collagen content at the AT insertion may increase the laxity and reduce propulsive forces in the paretic limbs, reducing overall normal and fast speeds as supported by this study's 10MWT results as supported by this study's 10MWT results(18). There were limitations faced during the study. The most notable limitation was the small sample size among the groups. With a larger sample size, the populations could potentially be more accurately represented, and type II error would be decreased. Another limitation is the inherent subjectivity of scoring the FMA-LE and MAS. As done in this study, it is recommended that the same clinicians perform the same assessments to minimize interrater differences. Additionally, there was a bias towards recruitment of higher functioning individuals with post-stroke hemiparesis due to the study's demands; long periods of standing were needed to gather H-reflex data, and for the 10MWT was performed. Future research should include lower-level functioning individuals to improve the external validity. Based on these findings, future research on a larger sample size with more variability in functional level of this population is justified to confirm the AT morphology and SOL H-reflex amplitude findings in individuals with chronic post-stroke hemiparesis.

5. CONCLUSION

This study examined the chronic changes in AT morphology and SOL H-reflex amplitude in individuals with chronic post-stroke hemiparesis and compared the results to those with a non-neurologically impaired nervous system. The findings suggest that stroke survivors have greater AT thickness at the midportion and calcaneal portion, as well as a lower PSFR at the calcaneal portion of the AT, supporting that these morphological changes can lead to decreased propulsive forces and decreased walking speed. Furthermore, there was no significant difference when comparing H_{max}/M_{max} ratio in the three groups; however, there was an observable increase in H_{max}/M_{max} ratio in the paretic legs of individuals post-stroke compared to their non-paretic legs and the legs of non-neurologically impaired individuals which supports the higher tone/spasticity in individuals post-stroke. More research is needed to determine how the H_{max}/M_{max} ratio and adaptations in spinal circuitry contribute to the decrease in propulsive force that develops in the Achilles tendon post-stroke. Additionally, future research should identify if the lack of exercise is a primary contributing factor of insertional AT tendinopathy as both those chronically post-stroke and those with central adiposity and metabolic disorders all share this attribute(33, 34). Furthermore, future research on the effects of specific interventions that target collagen fiber organization in the AT and increase motor neuron recruitment of the SOL muscle in stroke survivors may be warranted to improve clinical practice regarding propulsive forces of the paretic limb and increase gait speed.

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9. **Liang JN, Ho K-Y, Lee Y-J, Ackley C, Aki K, Arias J, and Trinh J**. Slow Walking in Individuals with Chronic Post-Stroke Hemiparesis: Speed Mediated Effects of Gait Kinetics and Ankle Kinematics. *Brain Sciences* 11: 365, 2021.
10. **Lee YJ, and Liang JN**. Characterizing intersection variability of butterfly diagram in post-stroke gait using Kernel Density Estimation. *Gait Posture* 76: 157-161, 2020.
11. **Liang JN, Ho K-Y, Hung V, Reilly A, Wood R, Yuskov N, and Lee Y-J**. Effects of augmented somatosensory input using vibratory insoles to improve walking in individuals with chronic post-stroke hemiparesis. *Gait & Posture* 86: 77-82, 2021.
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CURRICULUM VITAE

Trevor Robert Diez, SPT

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Education

- 2021-2024 DPT University of Nevada, Las Vegas Physical Therapy
- 2016-2020 BSHS University of Nevada, Las Vegas Kinesiological Sciences

Research

Graduate Research Project

- Co-investigator: “A comparison of spinal reflex function and morphological adaptations of the Achilles tendon between individuals chronically post-stroke and healthy controls”, 2024 Jing Nong Liang, PT, PhD, Diez, Trevor, SPT

Employment

January 2020 – Present – CATCH Seafood, Sushi and Steak at ARIA Resort

- Deliver exceptional customer service by greeting and serving customers in a timely, professional, and friendly manner
- Skillfully anticipate and address guests' service needs, adhering to quality expectations and standards.

- Maintain knowledge of current menu items, garnishes, ingredients, and preparation methods.

January 2024 – March 2024 – Encompass Health Rehabilitation Hospital

- Developed an individualized plan of care and discharge recommendations for patients with a variety of musculoskeletal, neurological, integumentary, and cardiopulmonary conditions in the inpatient hospital setting.

September 2023 – December 2023 – Sunrise System - Southern Hills Hospital

- Utilized my expert knowledge of anatomy, tissue healing, movement, and positioning to develop an individualized plan of care for each patient
- Promoted wound healing and improve patient's quality of life with proper wound evaluations, dressing selections, and removing bacterial infection that destroys tissues located underneath the skin with wound debridement
- Provided patient education regarding gait training, exercise, range of motion, stretching, and strengthening

July 2023 – September 2023 – Optimal Physical Therapy – Lake Mead

- Displayed passion about helping patients recover range of motion, strength and endurance and overcome the aches and pains of aging
- Worked closely with the geriatric population to evaluate and address their unique issues and challenges to improve their quality of life
- Utilized a holistic physical therapy approach to create specific treatment programs for patients based on their individual needs

June 2022 – July 2022 – Rapid Rehab Physical Therapy – W Charleston Blvd

- Practiced a multifaceted approach to physical therapy and utilize my creativity to help patients heal more quickly, safely, and with more success
- Coalesced traditional orthopedic physical therapy techniques with more progressive and innovative methods involving Pilates equipment
- Treated patient symptoms and underlying causes of their conditions to not only treat current impairments, but also prevent future injuries once healed

Volunteer Work

August 2022 – APTA SSIG Group

- Attended APTA NV SSIG meeting where we discussed Travel PT with guest speaker Yonas Tekeste

September 2022 - Desert Vista Community Center

- Volunteered at a Fall Risk Assessment and Screening Fair where we screened individuals for balance and cognitive impairments.

September 2022 - APTA - Core Values Self-Assessment

- Utilized the resources of the APTA Core-Value Assessment to raise awareness of my core values and identify any weakness I may need to improve on

May 2020 – August 2022 – Little League Baseball

- Helped coach my friend's son's little league baseball team where I taught them the value of sportsmanship, teamwork, and the correct fundamentals of the game of baseball

November 2020 and 2021 – Las Vegas Rescue Mission

- Donated food for the homeless for Thanksgiving and helped pack over 1400 dinners for them to eat
- Donated clothes and furniture to the shelter and helped unpack and organize donated resources for the holidays

Membership in Scientific/Professional Organizations

- 2020 - present - Member American Physical Therapy Association
- 2020 - present - Member Nevada Physical Therapy Association
- 2020 - present - Member APTA Orthopedic Academy SIG

Membership in School Organizations

August 2022 - APTA SSIG Group

- Attended APTA NV SSIG meeting where we discussed Travel PT with guest speaker Yonas Tekeste

September 2021- Present - Diversity, Equity, and Inclusion Club

- Attended a club meeting where we spread awareness regarding “Ableism”

September 2021- Present - Sports Medicine Club

- Attended multidisciplinary didactic meeting with Dr. Erik Meira where we discussed how to draw clinically relevant conclusions from research and unique concepts related to critical thinking and decision making

- Attended multidisciplinary didactic meeting with Rick Joreitz of the University of Pittsburgh D1 football, basketball, and academia programs where we discussed the unique needs of athletes and the importance of having a physical therapy program on university campuses for D1 athletes
- Attended multidisciplinary didactic meeting with Kyle Moore of the Las Vegas Golden Knights where we discussed the unique needs of hockey athletes and the day in the life of an athletic trainer for a professional sports team
- Attended multidisciplinary didactic meeting with Dr. Liz Wellsandt where we discussed shared decision making and the psychological factors affecting rehabilitation and the return to sport
- Attended multidisciplinary didactic meeting with Dr. Glenn Barnes where we discussed emergency situations on the sports field such as heat exhaustion, heat stroke, heart attack, and life-threatening clavicle injuries.
- Attended multidisciplinary didactic meeting with Dr. Brianna Millsaps where we discussed athletes with Type I diabetes.

2016 - 2020 - Member Pre-Physical Therapy Honor Society

2016 - 2020 - Member National Collegiate Scholars Honors Society

Continuing Education

- September 2022 - STEADI Balance and Memory Screening – 6 hours
- February 2022 - American Physical Therapy Association Combined Sections Meeting, San Antonio, TX - 22 hours

Mira Seekins, SPT

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Education

DPT	University of Nevada, Las Vegas	2021-2024
BA	University of Nevada, Reno, Psychology-Research Specialization	2015-2018
	Graduated Magna Cum Laude	
	Minored in Military Science	

Publications

Journal Papers

Liang J, Ho K, Seekins M, Mendez J, Contreras M, Diez T. *A comparison of spinal reflex function and morphological adaptations of the Achilles tendon between individuals chronically post-stroke and healthy controls.* In progress

Lytchenko T, Seekins S, Huntamer S, White T, Caplovitz G and Mruczek R. *Attention: Your Brain's Superpower.* Front. Young Minds. 2021

Book Chapter

Duckworth, M.P., Radenhausen, M, Seekins, M, Iezzi, T. Modern Prejudice. In: Prejudice, Stigma, Privilege, and Oppression. A Behavioral Health Handbook. Springer, Cham., pg. 39-58. 2020

Work Experience

Physical Therapy Student, Apex Performance Wellness and Rehab 2024

- Devised programming for a diverse patient population including post-partum, pediatric/adolescent athletes, post-TBI, hypermobility, and neuropathy
- Leveraged tools such as blood flow restriction, hand-held dynamometry, force plates and frames to enhance assessment precision and optimize outcomes
- Researched and developed an informative pamphlet regarding exercise parameters in antepartum and postpartum periods for educational workshops

Physical Therapy Student, Providence Portland Medical Center 2023

- Assessed the safety and functional capabilities of individuals following orthopedic surgery and neurological injury
- Implemented evaluations and cotreatments with OT colleagues for complex and high-assist level patients, enhancing session efficiency and outcomes
- Gained experience working alongside a PT in the emergency department to assess a broad scope of patients and observed five orthopedic surgeries

Physical Therapy Student, Renown Inpatient Rehabilitation 2023

- Designed exercise interventions with an emphasis on motor learning principles for patients with complex trauma, neurological conditions, and amputees
- Collaborated with interdisciplinary teams of physicians, occupational/speech therapy, nursing, and case management to facilitate discharge planning
- Researched and led presentation on virtual reality neurologic rehabilitation for 13 physical and occupational therapist and therapist assistants

Physical Therapy Student, Rehab Services of Winnemucca 2022

- Developed plans of care for a variety of patients including patients with neurologic, amputee, pelvic health, and spine conditions
- Created and delivered a presentation on pain neuroscience education for seven physical therapists and one occupational therapist
- Documented multiple initial evaluations as well as daily SOAP notes for 25% of clinical instructor's caseload

Leadership Experience

S3 Assistant, 421st Regional Training Institute 2021-2022

- Coordinated logistical operations in collaboration with the supply officer to ensure operational readiness and fulfill regimental commander's needs
- Devised operations orders and ensured all annual requirements were met

Executive Officer, 150th Support Maintenance Company 2020-2021

- As second in command, facilitated seamless coordination among four platoon leaders and the company commander, ensuring operational efficiency
- Conducted comprehensive administrative duties for the unit, including operations orders and awards

Platoon Leader, Ground Support Platoon 2018-2020

- Led and cultivated all operations and physical training initiatives for 28 Soldiers
- Planned, coordinated, and led a successful six-day maintenance mission with team of eight Soldiers from Reno to Las Vegas, Nevada

Presentations

APTA CSM Boston, "Morphological Changes in the Achilles Tendon in Individuals Chronically Post-Stroke", February 2024

University of Nevada, Reno ROTC, "Welcome Back Ceremony", January 2018

University of Nevada, Reno Poster Presentation**, "**Priming Effects in the Gender Classification of Toys", May 2017

Honors and Awards

UNLV Department Scholarship, University of Nevada, Las Vegas 2021-2024

APTA Nevada Student Scholarship, Washington, DC 2023

Dr. William H. and Patricia O'Grady Scholarship, UNLV 2023

Army Commendation Medal, Army National Guard 2021

State of Nevada Governor's Award, University of Nevada, Reno 2018

MSIV Cadet of the Year, University of Nevada, Reno ROTC 2018

Reserve Officer's Association Award, University of Nevada, Reno ROTC 2018

Distinguished Military Student, University of Nevada, Reno ROTC 2017

LTC (Ret) Sharlee W. Smith Scholarship, University of Nevada, Reno ROTC 2017

Dean's List, University of Nevada, Reno 2015-2018

Volunteer Experience

Western Semi-finals, U.S. Wheelchair Rugby Association 2023

- Assisted with set-up of adaptive equipment and scorekeeping games for teams across the west coast

Gigi's Fit Acceptance Challenge Walk, Las Vegas, Nevada 2023

- Assisted with set up and encouragement of children with down syndrome and their families engaging in running and walking activities

Nevada Senior Games, Las Vegas, Nevada 2022

- Assisted with setup and conduction of shot put and disc throw for older adults

Balance and Falls Screenings, Las Vegas and Henderson, Nevada 2022

- Conducted balance and memory screenings for older adults and connected them to resources within the Las Vegas and Henderson community

Rock Steady Boxing, Las Vegas, Nevada 2022

- Supported boxing classes for older adults with Parkinson's Disease

UNLV PT Day of Service, University of Nevada, Las Vegas 2021

- Constructed a letter to an older adult as part of the 'Letters Against Isolation' initiative and created a motivational poster for children with disabilities receiving adaptive bicycles

Continuing Education

APTA Combined Sections Meeting, APTA 2022-2024

Stop the Bleed Course, American College of Surgeons Committee on Trauma 2023

Tai Ji Quan: Movement for Better Balance, Level One Instructor Course 2022

Nevada Association of Behavior Analysis Conference, Reno, NV 2017

Johanna Mae Mendez, SPT

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Education

DPT | 2021-2024 | University of Nevada - Las Vegas

- Major: Physical Therapy

BS Kinesiology | 2014-2019 | University of Nevada - Las vegas

- Major: Kinesiology

Certifications and Training

OTAGO Exercise Program: Fall Prevention Certification | Sept 2022

- Carolina Geriatrics Workforce Enhancement Program (CGWEP)

STEADI Training | Sept 2022

- Center for Disease Control (CDC)

Basic Life Support Certification (BLS) | April 2022

- American Heart Association (AHA)

PT Clinical Rotations

Centennial Hospital | Jan 2024 – May 2024

- Performed duties with acute care patient caseload by providing wound care services, physical therapy interventions, and various forms of patient education for 10 weeks.
- Provided services and developed treatment plans to maximize function, range of motion, and improve endurance and activity tolerance.
- Performed interventions to prevent complications due to prolonged bedrest, immobility, or surgery.

Equilibrium Physical Therapy | Sept 2023 – Dec 2023

- Evaluated and treated individuals with balance and vestibular deficits, performed various functional outcome measures to determine levels of disability, and educated patients on their deficits as well as how to address them while applying interventions for home exercises.
- For 10 weeks, created treatment plans and performed interventions to reduce functional and activity impairments to eventually improve patient participation and quality of life.

Sunrise Hospital Rehabilitation | July 2023 – Sept 2023

- Performed evaluations and treatments for patients with varying diagnoses to improve overall function, strength, balance, and endurance for 10 weeks.
- Provided education and training for safe and appropriate use of assistive devices and patient transfers.
- Perform interventions to progress patient ambulation abilities, bed mobility, transfer ability, and activity tolerance.

Associated Experience (PT Shadowing)

Dignity Health Physical Therapy - Henderson, NV | Nov 2022

- Shadowed Dr. Jynelle Arches, PT, DPT and observed treatment interventions and assessments of patients with vestibular dysfunctions.

Centennial Hills Hospital NICU | Oct 2022

- Shadowed Dr. Jennifer Doyle, PT, DPT and observed the role of the physical therapist in the neonatal ICU and various interventions for premature neonatal patients.

Dignity Health – Outpatient Neuro Program | Oct 2022

- Shadowed Dr. Doug Eck, PT, DPT, MHI and observed interventions and exercises for patients with spinal cord injuries.

FYZICAL Therapy and Balance Center | Sept 2022

- Shadowed various physical therapists in the clinic, observed various interventions for patients with vestibular and balance disorders.

Additional Employment History

Administrative Assistant/HR coordinator | Comprehensive Health Service, LLC | Feb 2017 – April 2021

- Coordinated calendars and schedules for management team meetings and candidate interviews. Created and maintained processes for administrative operations to improve accuracy and efficiency of workflow.
- Created and designed PowerPoint presentations, patient start of care booklets, and company brochures for marketing and business development. Completed special

projects to meet and exceed the goals of both the human resources department and the overall business organization.

- Documented human resources actions by completing forms, reports, logs, and records. Managed and regularly updated HR reports regarding professional licensing, background checks, and required documentation for employment.

Research

Poster Presentation | Combined Sections Meeting | Feb 2024

- "Characterizing adaptations in spinal Ia afferent loop excitability and Achilles tendon morphology in individuals post-stroke"

Professional Organization Memberships

- Member – American Physical Therapy Association | 2021 – Present
- Member – APTA Academy of Orthopaedics | 2022 - Present
- Member – APTA Academy of Neurology | 2022 - Present

Community Service

Equilibrium Physical Therapy Balance Screening | Sept 2023

- Performed balance screening for community members to assess fall risk and determine needs for skilled need. Provided education and professional resources for those seeking out treatment for balance deficits as well as addressing any safety concerns.

Rock Steady Boxing | April 2023

- Assisted with exercise classes by working with clients directly, providing movement cues when necessary, and providing support for patient safety and guarding.

Texas Hold'em Wheelchair Rugby Tournament | Nov 2022

- Helped set up for event the night before and acted as scorekeeper.

Drive to Thrive | Nov 2022

- Coordinated volunteer opportunity for fellow classmates, helped to set up for event, mingled with Driven gym members, and assisted event coordinator with varying tasks.

UNLVPT Interviews | Nov 2022

- Mingled with UNLVPT interviewees, answered questions about the program, and assisted with any necessary tasks.

PT day of Service: Nevada Senior Games | Oct 2022

- Assisted with setup and shagger for shot put events.

UNLVPT Balance and Memory Screening | Sept 2022

- Screened community members for fall risk and possible cognitive impairments, performed balance testing, reviewed screening results for participants along with education to reduce risk, and offered professional resources for those that needed or requested it.

Honors and Awards

- UNLVPT Scholars Award | 2021 – 2024
- Dean's Honor List | FA 2018 – SP 2019
- Dean's Honor List | FA 2017 – SP 2018

- Dean’s Honor List | FA 2015 – SP 2016
- Dean’s Honor List | FA 2015 – SP 2016

Continuing Competencies/Education Attended

The Power Within: Treating Powerlifters | UNLV PT Sports Club Webinar | Oct 2022

- Mike Taylor PT, DPT

Tales of the Heart Inspiration to Motivate Change in Clinical Practice and Education | UNLVPT Distinguished Lecture Series | Oct 2022

- Ellen Hillegas PT, EdD, CCS, FAPTA

Eccentric Training: The Best Way to Build Strength | UNLVPT Brown bag Lecture | Sept 2022

- Bob Donatelli PT, PhD

Travel Therapy: A Life on Your Terms | APTA NV Student SIG Lecture | Aug 2022

- Yonas Tekeste PT, DPT, CSCS

Interrupting Microaggressions | UNLVPT Brown bag Lecture | April 2022

- UNLV Social Justice and Student Diversity Office

Teaching People about Pain | UNLVPT Special Lecture | March 2022

- Adriaan Louw PT, PhD

Performing Arts Medicine | UNLVPT Brown Bag lecture | March 2022

- Logan Ponce PT, DPT, CSCS

Evidence-Based Physical Therapy for Patients with Low Back Pain: Past, Present and Future | UNLVPT Distinguished Lecture Series | Nov 2021

- Julie Fritz PT, DPT, FAPTA

Pain Management in a Time of Dueling Pandemics | UNLVPT Distinguished Lecture Series | Nov 2021

- Julie Fritz PT, DPT, FAPTA

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EDUCATION

- DPT University of Nevada Las Vegas 2021-2024 Physical Therapy
- BSKin University of Nevada Las Vegas 2016-2020 Kinesiology

CERTIFICATIONS

- October 2022 - The Otago Exercise Program: Falls Prevention Training
- April 2022 - Basic Life Support (CPR & AED)
- October 2021- Collaborative Institutional Training Initiative (CITI) Program - Human Research, Biomedical IRB, Basic Course
- July 2021 - Online Bloodborne Pathogens Training

RESEARCH

Liang JN, Ho KY, Contreras M, Diez T, Mendez J, Seekins M. A comparison of spinal reflex function and morphological adaptations of the Achilles tendon between individuals chronically post-stroke and healthy controls. June 2024.

- APTA CSM Poster Presentation February 2024

EMPLOYMENT/CLINICAL HISTORY

January 2024-March 2024 - Student Physical Therapist, Select Physical Therapy - Walnut Creek, CA

- I served as a student physical therapist in this outpatient orthopedic setting. I performed evaluations, developed plans of care, and provided treatment to a variety of patients ranging from high school and college athletes, orthopedic injury, and post-operative rehabilitation. I performed manual therapy and a wide variety of therapeutic exercises to the patient. I also provided patient education in order for the patient to better understand their condition and recovery. I helped create patient-centered goals, and a discharge plan that was efficient and effective to the best needs of the patient.

September 2023-December 2023 - Student Physical Therapist, Trellis - Paradise, Las Vegas, NV

- I served as a student physical therapist in this skilled nursing facility setting. I performed gait training, transfer training, strength training, safety education and bed mobility training with the patients. I created goals for the patient that would improve their quality of life and independence. I collaborated with occupational therapists and speech therapists on staff to ensure that we were all on the same page in treating our patients, and providing the best line of care that the patients deserved.

July 2023-September 2023 - Student Physical Therapist, Renown Regional Medical Center, Reno, NV

- I served as a student physical therapist in this inpatient rehabilitation setting. I performed evaluations, and developed plans of care for patients. I also provided patient and

caregiver education on their pathology, as well as proper assistive device fitting and use, proper transfer techniques, gait training and bed mobility. I developed goals for the patient to improve mobility and quality of life, and provided a discharge plan from the facility once they met those goals.

June 2022-July 2022 - Student Physical Therapist, Movement For Life Physical Therapy - San Luis Obispo, California - Aerovista

- I served as a student physical therapist in this outpatient orthopedic setting. I enhanced my knowledge of different diagnoses and different interventions to treat said diagnoses. I performed evaluations, developed plans of care, manual therapy interventions, provided patient education, wrote efficient and clear documentation, and demonstrated and provided therapeutic exercise to patients. I also provided inservice presentation on the m-trigger biofeedback device for intervention use. I worked with a variety of patients ranging from workers comp, post-surgery, geriatrics, high school and college level athletes.

June 2016-August 2021 - PT Technician, Good Shepherd Rehabilitation, Las Vegas, Nevada

- I would check patients' vitals, as well as help patients with their exercises under the direction of the physical therapist, nurse, or respiratory therapist. I also trained in in-putting patient billing into the system through the medisoft program. I would also assist with cleaning and sanitizing the equipment, as well as the entire facility.

Additional Employment

January 2021-Present - Freelance NBA Writer, NetsRepublic

- I write articles in relation to the NBA and more specifically, the Brooklyn Nets. I communicate with editors upon article ideas. This job helped improve my communication, documentation skills, and research article writing, relevant to the physical therapy field.

December 2018-May 2019 - Sports Writer, UNLV Scarlet & Grey Free Press

- I wrote sports related articles weekly. I also Collaborated with the editor to brainstorm article ideas. Did thorough research to provide accurate reported information and analysis for articles that were written. This job helped improve my communication, research article writing and documentation skills relevant to the physical therapy field.

Honors and Awards

- 2020 School of Allied Science Dean's List Spring 2020
- 2019 School of Allied Science Dean's List Spring 2019
- 2017 School of Allied Science Dean's List Fall 2017
- 2016 Governor Guinn Millennium Scholarship 2016-2020

Volunteer Work

October 2022 - Nevada Senior Games

- I was the lead liaison and coordinator for the UNLVDPT program in assisting the Nevada Senior Games Track and Field event. I communicated with team leaders on logistical matters of events and recruited many of my classmates to come participate in this volunteer event. Outside of logistical matters and event set up, I helped with the

smooth running of the event, whether that was scorekeeping, shagging track and field equipment, or measuring throwing distances.

September 2022 - Balance and Memory Screenings

- I participated in two balance and memory screenings, one at Sun City Summerlin, and the other at the Downtown Senior Center in Henderson, Nevada. I would administer the STEADI program, which consisted of the TUG, 30 second sit-to-stand, and 4 stage balance test. I would also administer the mini-cog test. I also provided patient education on the results of these tests and provided resources the patients needed to address any concerns or questions they had in regard to those plans.

January 2022, November 2022, November 2023 - UNLVPT Interview Day

- Assisted in mingling, lab tours, escorting interviewees to faculty offices.

Professional Memberships/Organizations

- Member American Physical Therapy Association (2021 to present)
- Member Nevada Physical Therapy Association (2021 to present)
- Member Academy of Orthopaedic Physical Therapy (2022 to present)
- Member American Academy of Sports Physical Therapy (2022 to present)
- Member College & Professional Sports SIG, American Academy of Sports Physical Therapy (2022 to present)
- Member Shoulder SIG, American Academy of Sports Physical Therapy (2022 to present)
- Member Knee SIG, American Academy of Sports Physical Therapy (2022 to present)
- Member Acute Care Section (2023 to present)

School Memberships/Organizations

- Member UNLVPT Sports Medicine Club (2022 to present)
- Member UNLVPT DEI Club (2022 to present)
- Member UNLVPT Spanish Club (2022-2023)

Continuing Education

- November 2021: Pain Management in a Time of Dueling Pandemics
- November 2021: Evidence-Based Physical Therapy for Patients with Low Back Pain: Past, Present and Future
- February 2022: From Gameday to Post-Season: Shoulder Injuries in Football Players along the Continuum
- February 2022: The Scientific and Clinical Rationale of the Comprehensive Examination of the Shoulder Complex in Athletes
- February 2022: Decolonizing Physical Therapist Practice, Education, and Research
- February 2022: Is Modern Physical Therapy Pain Management Socially Equitable, and Does It Need to Change?
- September 2022: STEADI: Empowering Healthcare Providers to Reduce Fall Risk (Web-based)- 0.1 CEU units
- September 2022: Eccentric Loading: the Best Way to Build Strength
- October 2022: Beyond standard care: How to adapt your PT practice to support special populations. PT for teens and adults with Down syndrome

- October 2022: Setting up Your Career as a Student Physical Therapist
- October 2022: Tales of the Heart: Inspiration to Motivate Change in Clinical Practice and Education
- February 2023: Don't Get Hamstrung By Hamstring Strains: From Assessment to Rehabilitation and Return to Sprinting
- February 2023: NBA Medical Director: The Job Behind The Title
- February 2023: Nonoperative Management of Rotator Cuff Tendinopathy
- February 2023: Offseason Programs for Women's Professional Basketball Players
- February 2023: Return to Performance after Anterior Cruciate Ligament Reconstruction in a Division 1 Basketball Player
- February 2023: Spotlight on Research: What to Measure and Treat in the Lumbar Spine
- February 2023: Behavioral Economics The Rehabilitation Edition
- February 2023: The OPTIMAL theory of motor learning: Applied
- April 2022, 2023: Teaching People About Pain, Pain Neuroscience Education
- April 2023: Stop The Bleed Training
- February 2024: The tangled web we treat: navigating complex relationships between brain and muscle after ACL injury
- February 2024: Athletic Performance Matters: The PTs guide to keeping Older Adults in the Game
- February 2024: CRPS: Unlocking the Mystery of Complex Regional Pain Syndrome
- February 2024: Treating Peripheral Nerve Injuries in Overhead Athletes: Don't Be Nerve-ous Suprascapular Nerve Injuries