Intramuscular Pressure is Almost Three Times Higher in Fibromyalgia Patients:
A Possible Mechanism for Understanding the Muscle Pain and Tenderness

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Abstract

**Objective:** Widespread pain in the fibromyalgia syndrome (FMS) is conventionally viewed as arising from disordered central processing. This study examines intramuscular pressure in the trapezius as an alternative mechanism for understanding FMS pain.

**Method:** 108 patients who satisfied the ACR criteria for FMS and 30 patients who met the ACR criteria for another rheumatic disease comprised the study groups. Muscle pressure was measured in mmHg using a pressure gauge attached to a No. 22 needle inserted into the mid portion of the trapezius muscle. In addition, FMS patients and rheumatic disease controls had dolorimetry testing, digital palpation, and reported pain scores.

**Results:** Muscle pressure was substantially higher in patients with FMS with a mean value of 33.48±5.90 mmHg. Only 2 of 108 patients had muscle pressure of <23 mmHg. The mean pressure in rheumatic disease controls was 12.23±3.75 mmHg, with a range from 3-22 mmHg. FMS patients were more tender than controls based on both dolorimetry (p<0.001) and digital palpation (p<0.001). The mean pain score in patients with FMS and controls was 6.68±1.91 and 1.43±1.79 (p<0.001).

**Conclusion:** Pressure in the trapezius muscle of patients with FMS is remarkably elevated and may be an intrinsic feature of FMS that could be monitored as part of the diagnostic evaluation. The burden of the pressure abnormality may help explain the diffuse muscle pain of FMS. Therefore, FMS as a disorder of exclusively central pain processing should be revisited. Therapeutically, the reduction of muscle pressure may change the clinical picture significantly.

**Key Words:** fibromyalgia, intramuscular pressure, trapezius muscle, central sensitization, pain
Central sensitization theory, the prevailing account of chronic pain in fibromyalgia syndrome (FMS) [1], makes a fundamental distinction between the site of pain and the source of pain. According to the theory, they are not the same [2]. Abnormal processing of sensations by neural brain activity is the presumed mechanism for turning on pain at body sites that are at a distance from the source. This formulation guides treatment and influences the development of new medication. Currently the first line medications for pain in FMS are centrally acting, including pregabalin, duloxetine and milnaciprin. They either decrease glutamate or increase serotonin and norepinephrine to try to ease the presumed central nervous system effect on widespread musculoskeletal pain [3,4].

This study advances a new view of FMS pain that places the pain generator and the site of pain in the same peripheral location, the painful tender muscles. Specifically, this study challenges the prevailing theory of pain in FMS and seeks to show that pain over the muscles is linked to elevated pressure in the muscles.

At this point, there is no information on the normalcy of intramuscular pressure in FMS. The purpose of this study was to evaluate the level of muscle tenderness and intramuscular pressure in the trapezius muscle of FMS patients compared to controls. In some studies, over 90% of the FMS fibromyalgia sample report pain over the trapezius [5]; therefore, the trapezius muscle was chosen for study because it is a highly symptomatic site in FMS patients, easy to access, and likely to be representative of the pain they experience in other places around their body.

**Material and Methods:**

Participants in the study were recruited from a pool of consecutive patients in a high volume rheumatologic clinical practice at Rush University Medical Center. This study was approved by the
Rush University IRB ORA 17052205. The goals and procedures of the study were fully explained and informed consent was signed prior to initiation of any study activities.

All potential participants were screened for eligibility criteria. At screening, demographic data was collected on potential participants. Patients who were proposed for the FMS group also completed the Fibromyalgia Survey Questionnaire to determine if they satisfied the modified 2010 and 2016 American College of Rheumatology (ACR) criteria for FMS for inclusion or exclusion [6,7].

The 108 patients in the FMS group, ages 18 to 70, English speaking, were required to have an established clinical diagnosis of FMS confirmed by an experienced rheumatologist (RK) who performed a comprehensive clinical examination and also satisfied the ACR criteria for the diagnosis [6]. The rheumatologist was unaware of results of the tenderness examination or the patient’s score on the ACR criteria. Patients were required to have pain over the trapezius for inclusion.

A control group was recruited from a pool of patients without evidence of FMS, ages 18 to 70 and English speaking, and who fulfilled the criteria for other rheumatic diseases (including rheumatoid arthritis, systemic lupus erythematosus, psoriatic arthritis, and Sjogren’s syndrome), which were confirmed by a rheumatologist. All patients agreed to undergo intramuscular pressure testing.

Patients who scored above the cutoff for the ACR criteria for FMS were excluded. Inclusion criteria for the control group were met by 30 patients.

The physical measurements followed a standard protocol. Measurements were carried out by an examiner, experienced in testing for muscle tenderness and pressure, standing behind the subject. Recordings were always taken at rest with the subject in a seated position, with the head in a neutral position staring straight ahead. The exam site was always the mid portion of the trapezius muscle.
Primary Measures:

Pain

Pain intensity in the trapezius muscle was measured on a 0-10 visual analogue scale (VAS) of pain intensity, with anchor points of 0 (no pain) and 10 (the most unbearable pain imaginable). The VAS is commonly used to assess pain with high reliability [8].

Muscle Tenderness

The level of muscle tenderness was graded according to two conventionally used measures; digital palpation and dolorimetry. Digital palpation of the trapezius muscle was carried out with subjects in the seated position. Digital pressure was steadily applied with two fingertips for a period of 4 seconds by a nurse highly trained in digital palpation who was not aware of patient diagnosis. The amount of discomfort was graded on a validated 4 point scale: 0- No tenderness – No discomfort or pain reported at the site of palpation; 1- Mild tenderness - Pain reported at the site of palpation – No observable reaction otherwise; 2 - Moderate Tenderness – Pain with grimace and/or flinch to palpation; and 3- Severe Tenderness - Pain with marked withdrawal to palpation [9].

Muscle tenderness was also assessed with a 30 lb. FDK forced gauge dolorimeter (Wagner Instruments, Greenwich, Connecticut 06836-1217 USA) calibrated in 0.25-pound increments with the disc head vertically positioned over the trapezius muscle. Pressure was applied at a slow rate with patients instructed to indicate when they experienced pain. The point at which applied pressure transitioned to pain, also known as the pressure/pain threshold (PPT), was recorded in pounds.
Intramuscular Pressure

Intramuscular pressure was measured with a Stryker pressure gauge (used to diagnose anterior compartment syndrome) attached to a No. 22 needle. 0.3 cc of saline was injected into the mid portion of the trapezius muscle at an angle of 70 degrees to a depth of 2 centimeters from the skin surface and muscle pressure was recorded in mmHg (Figure 1).

Statistical Analysis

The primary variables for analysis were age, gender, pain in the trapezius muscle, tenderness based on digital palpation and dolorimetry, and intramuscular pressure. Data are presented as mean plus minus (±) standard deviation. Differences between groups on continuous variables were analyzed by t-tests. Differences among more than two groups were analyzed by one-way analysis of variance. Associations between variables on categorical data were analyzed by the chi-square test. P values of less than 0.05 were considered significant. Sample size was not calculated for this study, as the analyses are intended for hypothesis generation, rather than confirmation. All p-values and summary statistics are intended to be descriptive.

Results

Patients in the FMS and control groups were well matched for age with mean ages of 48.3 ±13.9 and 47.9 ±10.3 respectively (p=0.87). In total, 84% (91/108) of the patients with FMS group were female. This is significantly higher than the 66.7% (20/30) in the control sample (p<0.05). Additionally, the control group contained 50% (15/30) patients who satisfied the ACR criteria for rheumatoid arthritis, 23% (7/30) who satisfied criteria for systemic lupus erythematosus, 17% (5/30) who satisfied criteria for psoriatic arthritis and 10% (3/30) who satisfied criteria for Sjogren’s syndrome.
Pain was moderately high in the FMS group with a mean score of 6.68±1.91. Pain in the control group was substantially less with a mean score of 1.43±1.79. The significantly higher pain score in the FMS group (p<0.001) was expected, as pain was an inclusion criterion for the FMS group.

Tenderness was significantly higher in the FMS group whether measured by dolorimetry or digital palpation. The mean pressure/pain threshold score (measured by dolorimetry) was 14.5 pounds less in the FMS group compared to the control group (8.03 versus 22.54; p<0.001). The lower the value at which pressure shifts to pain, the greater the tenderness. On digital palpation, patients with FMS had an average score of 2.09±0.73 while controls had an average score of 0.47±0.78; p<0.001. High scores on digital palpation indicate significant tenderness.

Pressure in the trapezius muscle was extremely elevated in patients with FMS, with an average pressure of 33.48 ±5.90 mmHg. Trapezius muscle pressure in controls was significantly lower with an average pressure of 12.23±3.75 mmHg (p<0.001). Intramuscular pressure in the FMS group ranged from 8 to 58 mmHg, with only 2 values less than 23 mmHg. Intramuscular pressures in controls ranged from 3-22 mmHg (Table 1). The higher the pain score, the greater the pressure in the trapezius muscle (Figure 2).

There was no morbidity associated with the determination of muscle pressure with a pressure gauge and needle. Although pneumothorax could be a complication of the procedure, it was not seen in our study. Some patients had a temporary increase in muscle soreness from the procedure, which includes injecting a small amount of saline into the trapezius muscle. Muscle pressure determination was similar to the tender point injections we occasionally give our FMS patients. Patients were able to tolerate the procedure with little or no complaints.
An assumption can be made that measuring muscle pressure in areas throughout the body, including the lower extremities, would also demonstrate a higher muscle pressure than in controls, but the trapezius muscle was chosen because of convenience.

Gender did not affect results as there were no significant differences in muscle pressure for males and females. The average muscle pressure of males and females was 34.4 ±4.8 and 33.3 ±6.1 respectively, p=0.48.

Muscle pressure in the trapezius did not vary significantly with age for the study population. For those in the 3 age categories (<40, 40-59, >59), the average pressure values were 34.0±5.7, 33.3±6.6, 33.1±4.2 mmHg respectively, p=0.70.

There was an excellent correlation between muscle pressure, pain level, dolorimetry, and manual muscle tenderness (Table 2).

Discussion
In the most striking finding, the magnitude of pressure in the trapezius of patients with FMS at rest was almost 22 mmHg greater than the pressure of controls. In 98% of FMS cases, a pressure reading of 23 mmHg or above was recorded. A resting value in the area of 8 mmHg is considered normal based on an older study but using a different technique [10]. Surprisingly, patients with FMS may be functioning with a large increase in pressure over normality, yet this burden has no visibility in the large volume of studies addressing muscle pathology in FMS [11].

The distribution of values in the two groups had almost no overlap. Intramuscular pressures in the FMS group ranged from 8 to 58 mmHg, with only two values less than 23 mmHg. Pressures in the controls ranged from 3 to 22 mmHg. The differences are sufficiently large to consider muscle
pressure as a potential diagnostic discriminator. In this study, elevated intramuscular pressure was specific to FMS among the rheumatologic population. If hyper pressure in the trapezius can be confirmed by other investigators, then quantifying intramuscular pressure may be of value as a potential biomarker for FMS.

Abnormal pain tenderness was also observed in association with increased pressure in the trapezius muscle of FMS patients. The pressure/pain threshold score (measured by dolorimetry) for FMS patients is much lower than in controls using both digital and dolorimeter testing. The findings are in line with previous findings showing pain and tenderness to be common in the trapezius muscle of FMS [12]. Pain in the FMS sample was also elevated, but the study design biased this result. However, pain and muscle tenderness have been observed in association with hyperpressure in other body sites, suggesting a critical linkage [10,13]. Understanding the overlapping nature of these variables may be key to unlocking a greater understanding of muscle pain in FMS.

The trapezius is a large muscle that runs from the upper back to the neck and shoulders [14] and covers areas of the body that are considered primary pain sites in FMS [15]. Considering the compressing effects of extended pressure on the small capillaries in muscle, elevated pressure in the trapezius could be a mechanism for diffuse muscle pain. Abnormally high intramuscular pressure is known to compress capillaries which in turn obstructs blood flow thereby preventing adequate oxygenation of muscle tissue, a condition well known to set off and maintain pain sensations [10,16]. Muscle biopsy studies have shown evidence of hypoxia and no inflammation [11,16,17]. It is possible that increased muscle pressure could be compressing capillaries and reducing blood flow to muscle. The burden of hyper-pressure in the trapezius over time is likely to impact health more broadly and could be the mechanism for the muscle pain and fatigue that so characterize FMS [18,19, 20].
Contrary to current beliefs that reject muscle abnormality in FMS [11], the conspicuous elevation in intramuscular pressure at rest raises the possibility that pain and other symptoms of FMS arise from ongoing pressure anomalies in the trapezius muscles of people with FMS and not at the level of central sensitization. In our view, myalgias are associated with elevated muscle pressure, rather than primarily damage or central sensitization. Based on the current data, central sensitization theory may aim investigators at only one treatment target. This study directs attention to a peripheral target for both diagnosis and treatment that is not routinely monitored in clinical practice; intramuscular pressure, and hopefully provides a revised roadmap for a better understanding of pain in FMS.

However, the finding of increased intramuscular pressure does not disprove the major current pathophysiological hypothesis of central sensitization. There certainly may be both peripheral and central mechanisms causing the pain of FMS. In any case, increased muscle pressure might represent a diagnostic aid in FMS, and also a target for treatment to reduce muscle pressure.

Although muscle pressure measurement is an important procedure in the diagnosis and possible etiology of FMS, dolorimetry might be substituted as an easier, less invasive quantitative measure once we determine that muscle pressure is elevated using the pressure gauge.

The study had several limitations. It was conducted on patients in treatment at a large tertiary medical center. The results may have been different with a wider spectrum of people with FMS. Second, measurement of intramuscular pressure was carried out at a single site, whereas pain presents across the trapezius muscle. Pressure at different sites may vary. Third, results regarding pain intensity differences between groups are notably exaggerated due to requiring FMS patients to have existing pain in their trapezius muscle for inclusion into the study. Finally, the control sample was fairly small relative to the FMS sample; however, the difference between groups was very substantial and unlikely to change by adding additional subjects to the control group.
Conclusions

This is the first evidence of an abnormality in muscle pressure in FMS. Appreciation of elevated trapezius muscle pressure as a mechanism for hypoperfusion and diffuse muscle pain in FMS is important and suggests a target for both evaluation and intervention. Hyper-pressure in the trapezius could become a useful test in evaluating FMS. In addition, therapeutic attempts to reduce muscle pressure, using a muscle pressure gauge as a guide, might help to evaluate more effective therapies for this widespread pain syndrome. Methods to reduce intramuscular pressure may be therapeutic.
References


Table 1.

Clinical features of 108 patients with fibromyalgia and 30 non-fibromyalgia controls.

Values are mean ± SD

a Pain in trapezius was an inclusion criterion for the fibromyalgia sample.

95% CI = 95% confidence interval.

Table 2.

NOTE: Spearman correlations are used when at least one of the variables is ordinal.
Pearson correlations are used when both variables are continuous (in the case of dolorimetry & muscle pressure

Interpretation: A correlation coefficient of ~ 0.6 is considered a moderate positive relationship between two variables. A correlation coefficient of ~0.8 is considered a fairly strong positive relationship. The highest correlation is between pain and tenderness, which is intuitive.
The highest of the muscle pressure vs XX correlations was between muscle tensions and dolorimetry (~0.7, a moderately strong negative relationship).
The correlation is negative, which indicates that as muscle tension increases, dolorimetry score decreases.
The confidence intervals around all of the correlation coefficients DO NOT include zero, therefore they’re considered statistically significant correlations.

Figure 1

Line drawing demonstrating muscle pressure measurement technique

Figure 2

FMS Pain Score vs Muscle Pressure (ALL FMS Patients)
Table 1.

Clinical features of 108 patients with Fibromyalgia and 30 non-fibromyalgia controls.

<table>
<thead>
<tr>
<th></th>
<th>Fibromyalgia</th>
<th>Controls</th>
<th>95% CI</th>
<th>p</th>
</tr>
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<tbody>
<tr>
<td>Pain&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.68 ± 1.91*</td>
<td>1.43 ± 1.79</td>
<td>4.47, 6.01</td>
<td>&lt;0.001</td>
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<td>Tenderness</td>
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<td>Digital</td>
<td>2.09 ± 0.73</td>
<td>0.47 ± 0.78</td>
<td>1.32, 1.93</td>
<td>&lt;0.001</td>
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<tr>
<td>Dolorimeter</td>
<td>8.03 ± 4.06</td>
<td>22.54 ± 8.45</td>
<td>-16.67, -12.35</td>
<td>&lt;0.001</td>
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<td>Intramuscular Pressure</td>
<td>33.48 ± 5.90</td>
<td>12.23 ± 3.75</td>
<td>19.0, 23.5</td>
<td>&lt;0.001</td>
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<table>
<thead>
<tr>
<th>Table 2</th>
<th>Muscle Tension vs Pain (Spearman Correlation)</th>
<th>Muscle Tension vs Tenderness (Spearman Correlation)</th>
<th>Muscle Tension vs Dolorimetry (Pearson Correlation)</th>
<th>Pain vs Tenderness (Spearman Correlation)</th>
<th>Pain vs Dolorimetry (Spearman Correlation)</th>
<th>Tenderness vs Dolorimetry (Spearman Correlation)</th>
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<tr>
<td>Correlation Coefficient</td>
<td>0.63</td>
<td>0.61</td>
<td>-0.70</td>
<td>0.73</td>
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<td>Fisher-Transformed Correlation</td>
<td>0.74</td>
<td>0.70</td>
<td>-0.86</td>
<td>0.93</td>
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<td>Total Pairs (n)</td>
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<td>Fisher-transformed s (s')</td>
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<tr>
<td>t</td>
<td>9.30</td>
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<td>Fisher-transformed lower 95% Confidence Interval</td>
<td>0.57</td>
<td>0.53</td>
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<td>Correlation 95% upper Confidence Interval</td>
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Figure 1

Line drawing demonstrating muscle pressure measurement technique
Pain Score vs Muscle Pressure (All FMS Patients)

\[ R^2 = 0.1912 \]