Muscular hypertonicity: a suspected contributor to rheumatological manifestations observed in ambulatory practice
Alfonse T. Masi1, Sona Kamat2, Richard Gajdosik3, Naila Ahmad4, Jean C. Aldag1

Abstract

Objective: The objective of this retrospective study of non-inflammatory rheumatic disease patients was to investigate if the individuals clinically identified with muscular hypertonicity (MHT) had increased clinical manifestations compared with those of age- and gender-matched patients with the same disorders.

Material and Methods: The MHT status was clinically identified in the rheumatologist’s myofascial protocol examination as relatively increased passive resistance of relaxed muscle on a slow gentle stretch. Clinical and laboratory data were abstracted on a pre-coded form, including symptom and physical examination features, serum assays, and medications.

Results: The 19 MHT cases complained of greater subjective stiffness (p=0.010) and tiredness (p=0.018) at initial encounters and increased aching pain (p=0.049) and were prescribed more (p=0.003) mild narcotic analgesics than the 19 comparison patients. The cases had higher (p=0.027) serum creatine kinase levels, and patients with diffuse MHT had greater frequency of heavy (30+pack-years) cigarette smoking (p=0.002) than comparison subjects. Narcotic usage was also greater in cases with diffuse involvement.

Conclusion: Non-inflammatory rheumatic disease patients with MHT had an overall similar profile as that of comparison patients but had greater musculoskeletal complaints, and those with diffuse involvement had greater narcotic usage. Further research, including quantitative measurements of muscle stiffness, are required to determine whether MHT is a documented entity associated with increased rheumatological manifestations.

Keywords: Skeletal muscle, myofascia, hypertonicity, creatine kinase, stiffness, fibromyalgia syndrome

Introduction

Muscular hypertonicity (MHT) is recognized in neurological practice as occurring in various pathological conditions, e.g., post-stroke spasticity (1-3) or rigidity in Parkinson’s disease (4). In rheumatologic and physiatric practices, MHT may also be observed in patients with pericranial and cervical muscle stiffness of tension-type headache (TTH) (5, 6) or associated with other painful syndromes of the neck and shoulders (7). Increased trapezius muscle hardness or tightness has been observed in TTH patients compared with that in control patients (5, 6); however, quantitative measurements remain limited.

Muscular hypertonicity is generally believed to be either an associated or secondary consequence of various pain generating or other underlying abnormalities (1-5, 8) but has not been viewed as a form of primary, constitutional MHT (9, 10). Human resting muscle tone/tonus or tightness (HRMT) is a challenging intrinsic physical property, independent of the central nervous system (6, 9-11). Consequently, a differentiation of passive HRMT from central nervous system (CNS) activated tension is challenging (6, 9-13).

Actively contracted muscle stiffness can be detected by electromyography (EMG) (14). However, even without concurrent EMG monitoring, reliable clinical evaluation of passive tonus can be performed, provided that proper techniques are used in the maneuvers (Table 1). Among juveniles and young adults, phenotypic variations (polymorphisms) in muscular hypertonicity are known to affect various regions of the body, e.g., hamstring tightness. Increased tonus may be related to the individual’s build, gender, or degree of flexibility training (15, 16). Athletic coaches and directors have expressed beliefs that sports injuries can be increased when overloaded muscles are either too tight or insufficiently strengthened (15). A wide range of muscle tightness vis-à-vis extensibility or flexibility has been documented among young sports participants, which tends to correlate with the chosen type of athletic competition (15, 16). Different degrees of constitutional muscular tonicity (or tightness) may be advantageous in one or another sport (17), as is observed for strength and physical endurance (18).

The clinical assessments of resting muscle tonus are influenced by the muscle length, which affects joint range of movement (ROM). The resistance an examiner feels on passive stretching could also be attributed...
Reassure the patient | Yes | Yes | Yes, for calves, but supine or prone for hamstring and back examination
Facing the patient | Yes, patient is sitting | Yes, patient is sitting | Not routinely
Preparatory ROMs | Yes | Ipsilateral palm on top of shoulder to stabilize the scapula, allowing extended thumb and fingers to feel the deltoid muscle for consistency. Contralateral hand supports the elbow for passive abduction | In grading hip joint stiffness, the patient is supine with hips and knees flexed 90 degrees. The left hand stabilizes the flexed knee and hip. Right (or dominant) hand rotates the leg at the ankle
Placement of hands | Examiner’s thenar eminences on mandibles and fingers extended to occiputs to hold the head firmly during passive neck movements | Ipsilateral palm on top of shoulder to stabilize the scapula, allowing extended thumb and fingers to feel the deltoid muscle for consistency. Contralateral hand supports the elbow for passive abduction | Hamstring resistance is tested in straight leg raising, and terminal elevation is recorded as well as the palpable degree of firmness
Slow and gentle passive movements | Short-range: arcs of rotation; lateral bending; flexion; extension, and combined directions, and repeated twice | The arm is abducted in ramp-up stretch to the horizontal (and tested 5–10 degrees extra, as is normal). Internal and external rotation is tested in abduction to evaluate ROM but is not graded for stiffness | Paralumbar firmness is tested in the prone, relaxed supported position on the exam table. Calf firmness is palpated in sitting position while the ankle is passively dorsi-and plantar-flexed
Assessment of stiffness | Resistance is graded from static balanced head position to the minimal, comfort passive arcs of movements. Localized resistance can be detected in muscle groups on one or both sides | Resistance is graded at end-stretch or near the terminal end-range of movement (circa the horizontal level) | Resistance is graded at end-stretch or near the terminal end-range of movement (circa the horizontal level)
Patients reactions | Grading not performed if discomfort occurs | Typically relaxed for testing resistance | Typcially relaxed for testing resistance
Can asymmetrical tightness be assessed? | Yes | Yes | Yes

ROMs: range of movement

Stiffness of normal and diseased joints is largely a result of elastic (velocity independent) and viscoelastic (velocity dependent) resistance of soft tissues, particularly muscles (9-11, 22). Besides studies on young athletes (15, 16), little attention has been given to the possible consequences of phenotypic variations in adult muscle tone (9, 10, 23).

Material and Methods

Patients studied

The recorded data on adult patients with non-inflammatory conditions included in this study were acquired by a senior attending rheumatologist (ATM) in the course of clinical care from 1980 to 2001. Patients with any medical or neurological condition, which could have been predisposed to MHT, were systematically excluded from study, e.g., hypothyroidism, hypocalcemia, hyperventilation, use of statin drugs, Parkinson’s disease, CNS ischemic events, stiff-person’s syndrome, Persian Gulf War syndrome of myalgia, and consistently elevated muscle enzymes (1, 8, 24-27). To reduce bias, the comparison subjects were selected from a complete index of patients who had the same categories of non-inflammatory rheumatic disorders, were of the same gender, and were closest in age to the cases but without notations of muscular hypertonicity. The analyzed data were abstracted from medical records of study subjects, during 2001–2003, by two residents of the Rheumatology service (SK&NA, now practicing rheumatologists). Preliminary results were presented at the 2004 American College of Rheumatology meetings (28). The research was approved and is in compliance with the Institutional Review Board (IRB) requirements (Community IRB UICOM-P, exempt study #01-107).

Assessment of muscular hypertonicity as a clinical rheumatological finding (Table 1)

Muscular hypertonicity (i.e., increased passive stiffness or tightness) was defined as an unexpected degree of physical resistance to manual movement of a joint(s) on slow, gentle stretching, e.g., rotation of the neck or abduction of a shoulder. During assessments, the patients were encouraged to psychologically relax to diminish self-guarding or segmental stretch reflexes. Cervical and shoulder girdle muscle tightness were routinely and systematically assessed by a myofascial protocol (Table 1). The senior author (ATM) executed the protocol as part of the full diagnostic musculoskeletal examination during the initial and follow-up visits of all referred patients with such localized pain. Lower extremity muscle tightness was generally assessed in patients with symptoms in the pelvic girdle or lower limbs (Table 1).

The ease by which tissues can be physically deformed is compliance (10). It was assessed by the degree of resistance felt on firm palpa-
tion or pressure. Decreased muscle compliance (i.e., hardness) can be clinically referred to in qualitative degrees of firmness. In physical terms, compliance is the reciprocal of stiffness (10). Compliance of the proximal deltoid was routinely assessed by palpation as part of the shoulder examination. The lower back, hamstring, and calf muscle firmness was also assessed when clinically warranted.

Muscle stiffness was graded by perceived resistance to passive movements on the following ordinal scale: none or 0, being no perceived increase in resistance; mild or 1, being a slight increase or giving a catch; moderate or 2, being definitely resistant but relatively easily maneuvered; and marked or 3 (the highest category), being considerable resistance to passive motion. The gradations were personally modified from the scale of Ashworth (29, 30), and any patient suspected of Parkinson’s disease during follow-up was excluded from the study.

Stiffness of neck myofascia on rotation and other passive slow, gentle movements were assessed in a most limited comfort range of a few degrees (Table 1). The maneuvers did not exceed any limitation of movement (LOM) elicited by reflex or joint pain. Neck stiffness was routinely assessed following the evaluation of its range of movements (ROMs) to further relax and stretch these muscles and achieve a baseline status of stiffness. Thus, the feel of a stiffened muscle in the restricted arc could be differentiated from a shortening or from a reflex muscle contraction. The maneuvers are consistently free from induced pain.

Muscle stiffness was graded by perceived resistance to passive movements on the following ordinal scale: none or 0, being no perceived increase in resistance; mild or 1, being a slight increase or giving a catch; moderate or 2, being definitely resistant but relatively easily maneuvered; and marked or 3 (the highest category), being considerable resistance to passive motion. The gradations were personally modified from the scale of Ashworth (29, 30), and any patient suspected of Parkinson’s disease during follow-up was excluded from the study.

Categorization of MHT cases into the subgroups of TMS vs. TBS

The MHT cases were patients generally diagnosed with either fibromyalgia [localized (LF) or generalized (FMS)] or osteoarthritis (OA) and who were clinically assessed to have increased muscle tonicity without a recognized underlying contributory condition or factor. Such patients had consistent hypertonicity on multiple visits, generally at the neck of moderate or greater degree or at a combination of other sites of mild or greater degree (Table 2). The total 19 MHT cases had either localized (n=14) tight muscle syndrome (TMS) or more generalized (n=5) tight body syndrome/generalized form (TBS), depending upon the degree and extent of clinically ascertained MHT. The patients with TBS (nos. 1, 4, 8, 12, and 16) had chronic and persistent MHT of greater degrees than the 14 TMS patients (Table 2), and both their subjective and objective stiffness hardly varied between visits.

Comparison subjects (controls)

Comparison patients also had primary diagnoses of either fibromyalgia (LF or FMS) or OA but without recognized MHT of moderate or greater degree at one or more sites over their

<table>
<thead>
<tr>
<th>Pair and gender</th>
<th>Entry Age</th>
<th>Neck</th>
<th>Other MHT</th>
<th>Diagnoses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - M</td>
<td>50</td>
<td>3</td>
<td>shoulders-1, axial-1</td>
<td>FMS, TBS</td>
</tr>
<tr>
<td>2 - M</td>
<td>75</td>
<td>3</td>
<td>-</td>
<td>FMS, TMS</td>
</tr>
<tr>
<td>3 - F</td>
<td>32</td>
<td>1</td>
<td>trismus-3</td>
<td>LF, TMS</td>
</tr>
<tr>
<td>4 - M</td>
<td>43</td>
<td>3</td>
<td>axial-2</td>
<td>FMS, TBS</td>
</tr>
<tr>
<td>5 - M</td>
<td>54</td>
<td>2</td>
<td>axial-2</td>
<td>LF, TMS</td>
</tr>
<tr>
<td>6 - M</td>
<td>72</td>
<td>2</td>
<td>shoulders-1</td>
<td>LF, TMS</td>
</tr>
<tr>
<td>7 - M</td>
<td>60</td>
<td>2</td>
<td>shoulders-1, axial-1, calves-1</td>
<td>OA, TMS</td>
</tr>
<tr>
<td>8 - M</td>
<td>61</td>
<td>0</td>
<td>shoulders-1, axial-1, calves-1</td>
<td>OA, TBS</td>
</tr>
<tr>
<td>9 - F</td>
<td>48</td>
<td>2</td>
<td>shoulders-1</td>
<td>LF, TMS</td>
</tr>
<tr>
<td>10 - F</td>
<td>52</td>
<td>0</td>
<td>axial-1, hamstrings-1</td>
<td>FMS, TMS</td>
</tr>
<tr>
<td>11 - F*</td>
<td>29</td>
<td>2</td>
<td>axial-1</td>
<td>FMS, TMS</td>
</tr>
<tr>
<td>12 - M</td>
<td>59</td>
<td>2</td>
<td>shoulders-1, axial-1, calves-1</td>
<td>FMS, TBS, also OA</td>
</tr>
<tr>
<td>13 - F</td>
<td>66</td>
<td>2</td>
<td>shoulders-1, axial-1</td>
<td>LF, TMS</td>
</tr>
<tr>
<td>14 - M*</td>
<td>39</td>
<td>0</td>
<td>shoulders-1 hamstrings-1</td>
<td>FMS, TMS</td>
</tr>
<tr>
<td>15 - F</td>
<td>42</td>
<td>0</td>
<td>shoulders-1 axial-2</td>
<td>FMS, TMS</td>
</tr>
<tr>
<td>16 - M</td>
<td>46</td>
<td>1</td>
<td>shoulders-1, axial-3, calves-3</td>
<td>LF, TBS</td>
</tr>
<tr>
<td>17 - F</td>
<td>42</td>
<td>0</td>
<td>shoulders-1 axial-1</td>
<td>LF, TMS</td>
</tr>
<tr>
<td>18 - F</td>
<td>78</td>
<td>1</td>
<td>axial-2</td>
<td>OA, TMS</td>
</tr>
<tr>
<td>19 - M</td>
<td>46</td>
<td>0</td>
<td>shoulders-1</td>
<td>TMS</td>
</tr>
</tbody>
</table>

*HLA-B27 positive, †0=Not detected, 1=Mild, 2=Moderate, 3=Marked.
‡Sh strain: shoulder strain; FMS: fibromyalgia syndrome; LF: localized fibromyalgia; MHT: muscular hypertonicity; OA: osteoarthritis; TBS: tight body syndrome/generalized form; TMS: tight muscle syndrome
course of follow-up. Typically, control patients had either no clinical evidence of hypertonicity or a mild and localized degree intermittently. If present, it may have affected the neck and often was associated with stressful states. Six controls had mild muscular hypertonicity at two separate sites over their follow-up course. Because secondary MHT could be associated with or result from trigger point(s), as found in the myofascial pain syndrome (8, 31), such patients were excluded from both the case and control groups. To increase comparability, control subjects were paired based on gender and matched to the cases within 5 years of age, except for pairs 1 and 3 (7 years) and the oldest 72-year-old patient (10 years). One of the MHT patients was an African American, who was matched to a Caucasian control subject.

Laboratory variables analyzed
Recorded laboratory data in the study subjects’ clinic records were abstracted as relevant to excluding diagnoses (e.g., rheumatoid factor and HLA-B27 status), degree of inflammation (hemogram, ESR, serum albumin and globulin), muscle enzyme levels (CK, AST/SGOT, ALT/SGPT), and other relevant variables (serum calcium, cholesterol, and TSH levels) on entry (or earliest value) and at the last visit (or most recent value).

Statistical analysis
A pre-coded data retrieval form was used to extract predefined items retrospectively from the clinic charts by the physician research assistants (SK and NA). Screening for variables of interest was performed on unpaired sets. Data analysis began with examining descriptive statistics (means, standard deviations, frequencies, ranges, and correlations). Differences in dichotomous variables were tested using the chi-square test, unless the cells were small (n=5 or less). In addition, Fischer’s exact test was computed for comparisons of either two or three subject groups (<http://vassarstats.net/fisher2x3.html>). When the variable was ordinal (e.g., none, mild, moderate, or marked), the Mann–Whitney U test was used to assess differences between two groups. When an interval variable was normally distributed, t-tests were used to assess differences between two groups. The study groups were also stratified as ordinal gradients of muscular tonicity, CN=0, TMS=1, TBS=2. Those subgroups were further analyzed with selected variables by Pearson partial correlations (adjusted for gender). All computations were accomplished with Statistical Package for the Social Sciences SPSS version 12.0 (SPSS Inc., Chicago, IL, USA). Alpha was set at p≤0.05, and no correction was made for multiple comparisons because the sample sizes were relatively small (32).

Table 3. Comparable clinical features between study groups*

<table>
<thead>
<tr>
<th>Clinical features</th>
<th>MHT (n=19)</th>
<th>Controls (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers (Percent)</td>
<td>Means</td>
<td>Numbers (Percent)</td>
</tr>
<tr>
<td>Entry age (years) mean</td>
<td>50.8</td>
<td>52.0</td>
</tr>
<tr>
<td>Localized (vs. more diffuse) presenting complaints</td>
<td>10 (52.6)</td>
<td>11 (57.9)</td>
</tr>
<tr>
<td>Widespread pain by FM criteria (need ref)</td>
<td>11 (57.9)</td>
<td>7 (36.8)</td>
</tr>
<tr>
<td>Cramping or spasms by history</td>
<td>9 (47.4)</td>
<td>6 (31.6)</td>
</tr>
<tr>
<td>Poor sleep quality</td>
<td>13 (68.4)</td>
<td>8 (42.1)</td>
</tr>
<tr>
<td>Anxiety or depression recorded by attending</td>
<td>8 (42.1)</td>
<td>13 (68.4)</td>
</tr>
<tr>
<td>Anxiety or depression treated by attending</td>
<td>3 (15.8)</td>
<td>5 (26.3)</td>
</tr>
<tr>
<td>Functional modifications</td>
<td>9 (47.4)</td>
<td>7 (36.8)</td>
</tr>
<tr>
<td>Chronic headaches</td>
<td>7 (36.8)</td>
<td>7 (36.8)</td>
</tr>
<tr>
<td>Chronic fatigue</td>
<td>1 (5.3)</td>
<td>3 (15.8)</td>
</tr>
<tr>
<td>Irritable bowel symptoms</td>
<td>6 (31.6)</td>
<td>5 (26.3)</td>
</tr>
<tr>
<td>Body mass index, mean</td>
<td>27.5</td>
<td>27.3</td>
</tr>
<tr>
<td>Body mass index 30+</td>
<td>8 (42.1)</td>
<td>4 (21.1)</td>
</tr>
<tr>
<td>Tender points, mean</td>
<td>9.9</td>
<td>7.2</td>
</tr>
<tr>
<td>11 or more tender points</td>
<td>11 (57.9)</td>
<td>6 (31.6)</td>
</tr>
<tr>
<td>Years of illness, mean</td>
<td>14.3</td>
<td>7.9</td>
</tr>
<tr>
<td>Improvement noted in response to initial therapy</td>
<td>9 (47.4)</td>
<td>13 (68.4)</td>
</tr>
</tbody>
</table>

*No variable differed significantly between the MHT vs. CN groups.

Results
All five cases with TBS are males, as opposed to 6 (43%) of the 14 TMS counterparts (p=0.044) (Table 2). Among the 19 MHT cases, 10 (53%) had moderate (=2) or marked (=3) resistance to passive neck rotation on repeated visits, which was not noted in any control patient (Table 2). Five of the remaining nine MHT patients had mild bilateral shoulder muscle tightness on passive abduction associated with axial firmness, which was not observed in any control. The four remaining MHT cases, who had absent or mild neck stiffness, had either combined regional or moderate (=2) or marked (=3) tightness in other muscle groups. One control male patient (pair #12) had chronic mild (=1) shoulder tightness and calf muscle stiffness (=1) on one visit when perceived to be anxious and tense. No control patient showed persistent indication of MHT, as assessed in this study.

The MHT cases and control patients had similar clinical diagnoses by conventional criteria and by study design (Table 2). Accordingly, many clinical features were comparable in the MHT and CN patients, as summarized in Table 3. None of the listed features differed significantly between the groups (Table 3). Several clinical features differed significantly between the total 19 MHT and 19 control patients (Table 4). The MHT cases had greater degrees of subjective complaints of feeling stiff (p=0.010) at the initial encounter as well as increased tiredness (p=0.018) compared with those of the control subjects (Table 4). Muscle mass was palpably or visually assessed to be somewhat increased or more bulky in the MHT cases (p=0.027), although body mass index (Table 3) was closely comparable (p=0.917) between the groups. A ratio of the highest serum creatine kinase (CK) levels recorded in patients’
In clinical research on symptomatic disorders, selection bias is also a serious concern general-
ly in clinical research on symptomatic disorders (14). Consistency in clinical mea-
ments or the comparative results. Future studies of MHT may incorporate quantitative
similar in both study groups (Table 3).

To increase comparability, control patients were selected with comparable chronic pain disor-
ner of inherent joint hypermobility is

tions or other manifestations. More definitive
and viscoelasticity (35, 36) as well as monitor active

either incomplete relax-

eed to be differentiated from the
greater chronic pain com-

cantly at determining the differences found

In this study, muscle stiffness was not believed
to be velocity-related or related to reflex spasm
because of the technique involved in slow,
gentle, limited stretching (Table 1). Exagger-
ated stretch reflexes could result from trigger
points or neurological causes (1-3, 11); how-
ever, these factors are not believed to have
operated meaningfully in the described as-
persists or neurological causes (1-3, 11); how-
ever, these factors are not believed to have
operated meaningfully in the described as-

charts of greater than two times (>2.0x) the lab-

ous normal limits for such testing was more

10 times of cigarettes than the controls (p=0.023).

had more frequently smoked 30 or more pack-
years of cigarettes than the controls (p=0.003). In addition, the TBS subgroup
prescribed with codeine, containing analge-
sics (p=0.003). In addition, the TBS subgroup
had more frequently smoked 30 or more pack-
years of cigarettes than the controls (p=0.023). In addition, they had higher (p=0.024) serum
levels of entry creatine kinase (Table 5).

Discussion
This study deals with the passive component of myofascial tone/stiffness, as assessed by re-
sistance to standardized slow, gentle, limited stretching movements (Table 1). The spectral
disorder of inherent joint hypermobility is

a commonly recognized syndrome (20, 21), which is genetically determined (33, 34). A
question therefore arises: can MHT also be differ-
entiated as a constitutional variant?

The novel findings raise the possibility that a
minority of adults may have evidence of MHT
clinically, which is possibly inherent, and may
have contributed to greater chronic pain com-
plaints or other manifestations. More definitive
future studies can include developing instru-
mentation facilities to measure the muscle’s
passive properties of stiffness, tension, and

In the clinic, muscle tone is conventionally
assessed by the degree of tonic resistance to
passive movement (28, 29). Manual assess-
ments of muscle tone are challenging. They
are only as reliable as the degree of standardiz-
ation and experience of the examiners (Table
1), which have been variously reported to be
both good (1-3, 15, 16) and poor (4, 30). As far
as possible, it should be differentiated from the
variable degrees of extraneous contractions
(i.e., EMG-active) due to either incomplete re-
laxation or activation from pain, including ac-
tive or latent trigger points (8, 12).

In this study, muscle stiffness was not believed
to be velocity-related or related to reflex spasm
because of the technique involved in slow,
gentle, limited stretching (Table 1). Exagger-
ated stretch reflexes could result from trigger
points or neurological causes (1-3, 11); how-
ever, these factors are not believed to have
operated meaningfully in the described as-
sessments or the comparative results. Future
studies of MHT may incorporate quantitative
measures of stiffness or pressure compliance
using myotonometry (4, 37), and their accuracy
can be further enhanced with the use of EMG
monitoring (14). Consistency in clinical mea-
ures of resting muscle stiffness and tightness
requires patients to relax to maximal degree in
comfortable, balanced postures (13, 38).

Selection bias is also a serious concern gener-
ally in clinical research on symptomatic disorders

- SEM: standard error of the mean; CK: creatine kinase

Table 4. Clinical features which differed between study groups

<table>
<thead>
<tr>
<th>Clinical features</th>
<th>Muscular hypertonicity (n=19)</th>
<th>Controls (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number (%)</td>
<td>Mean (SEM)</td>
</tr>
<tr>
<td>Degree of subjective stiffness at entry*</td>
<td>1.76 (0.24)</td>
<td>0.88 (0.21)</td>
</tr>
<tr>
<td>Degree of tiredness complaint at entry*</td>
<td>1.68 (0.17)</td>
<td>1.26 (0.15)</td>
</tr>
<tr>
<td>Clinical assessment of increased muscle mass†</td>
<td>0.67 (0.22)</td>
<td>0.25 (0.11)</td>
</tr>
<tr>
<td>Entry CK ratio &gt;2.0x the upper normal limit</td>
<td>5 (26.3)</td>
<td>0</td>
</tr>
<tr>
<td>Entry cholesterol (mg/dL)</td>
<td>205.1 (5.60)</td>
<td>220.6 (7.25)</td>
</tr>
<tr>
<td>Entry cholesterol &lt;200 mg/dL</td>
<td>10 (52.6)</td>
<td>3 (15.8)</td>
</tr>
</tbody>
</table>

*0=None, 1=Mild, 2=Moderate, 3=Marked.
†0=Normal, 1=Increased, 2=Bulky, based upon clinical judgment of palpation and visual examination.

Table 5. Differences in clinical features of subjects by degree of muscular hypertonicity

<table>
<thead>
<tr>
<th>Clinical features</th>
<th>Controls (n=19)</th>
<th>TMS (n=14)</th>
<th>TBS (n=5)</th>
<th>p†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited lumbar spine mobility</td>
<td>4 (21.1)</td>
<td>2 (14.2)</td>
<td>4 (80.0)</td>
<td>0.023†</td>
</tr>
<tr>
<td>(Shober’s test)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate or marked pain at last visit</td>
<td>4 (21.1)</td>
<td>7 (50.0)</td>
<td>4 (80.0)</td>
<td>0.026†</td>
</tr>
<tr>
<td>Codeine containing analgesics</td>
<td>1 (5.3)</td>
<td>3 (21.4)</td>
<td>4 (80.0)</td>
<td>0.03†</td>
</tr>
<tr>
<td>prescribed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cigarettes smoked (30+ pack-years)</td>
<td>3 (15.8)</td>
<td>3 (21.4)</td>
<td>4 (80.0)</td>
<td>0.023†</td>
</tr>
<tr>
<td>Muscle Enzyme Ratio:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entry creatine kinase &gt;1.0x ULN</td>
<td>5 (26.3)</td>
<td>4 (28.6)</td>
<td>4* (100.0)</td>
<td>0.024†</td>
</tr>
</tbody>
</table>

*One TBS case had a missing CK value.
†p values in the table were estimated by Fisher’s exact test (see Methods). In addition, Pearson’s partial correlation (adjusted for gender) of the degree of assessed muscle toxicity by subgroup categories: CN=0, TMS=1, TBS=2; provided the following probabilities: 1=0.007; 2=0.006; 3=0.001; 4=0.030, and 5=0.019.
TBS: tight body syndrome/generalized form; TMS: tight muscle syndrome; ULN: upper limit of normal
(39) and even in the current study. Accordingly, our findings should be interpreted cautiously. The data were not collected prospectively to test a predefined hypothesis by structured interviews or protocol examinations. The possibility exists that some control patients may also have had MHT, particularly of lower body regions, which cannot be overlooked. However, such misclassification would have decreased the significance of the observed statistical differences. The possibility also exists that cases had greater overall severity of their respective rheumatologic conditions than the controls.

The largest study group differences were observed between the five TBS cases and the 19 controls or the 33 other combined patients (Table 5). Some of the TBS patients stated that cigarette smoking seemed to lessen their muscle discomfort, and limited data suggest that nicotine is a pharmacological skeletal muscle relaxant (40). The mean (±SEM) pack-years smoked by study subjects was 11.0 (4.3) for 17 CN, 15.5 (7.5) for 12 TMS, and 42.6 (9.3) for the five TBS patients (p=0.030). All five TBS cases had smoked more than 20 pack-years versus 8 (24%) of the 33 combined TMS and CN patients (p=0.003). The TBS patients indicated having had tight muscles since teen or young adult ages.

Presently, regional variants of MHT are recognized in young athletes (16) and in individulas with tight hamstring muscles (22, 41). However, studies have yet to confirm whether such muscles are measurably tight or short. To our knowledge, a more diffuse, inherent TBS has not been reported in juveniles or adults, as to our knowledge. Some related physical properties.

Recognition of the observed clinical associations in patients with MHT would suggest that they could benefit from additional personalized guidance and physical management techniques (exercise, stretching, relaxation) during their course of treatment. Further research is required to confirm the present observations and associations using the current clinical examination techniques as well as additional recently available instrumentation for quantifying myofascial stiffness, tightness, and other related physical properties.

Ethics Committee Approval: Ethics Committee approval was received for this study from Institutional Review Board University of Illinois (#01-107 annual approval).

Informed Consent: Informed consent was not received due to the retrospective nature of the study. Exempt study based upon review of medical records.

Peer-review: Externally peer-reviewed.


Conflict of Interest: No conflict of interest was declared by the authors.

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