Altered Biomechanical Properties of the L3-L4 Myofascial Tissue in Ankylosing Spondylitis Patients

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Abstract – Ankylosing spondylitis (AS) is a degenerative rheumatological disorder that mainly affects the spine. It has been reported that different degrees of human resting myofascial tone (HRMT) would affect spinal stability and may predispose to the respective curvature deformities of adolescent idiopathic scoliosis (AIS) and the enthesopathy of ankylosing spondylitis (AS). Although osteoligamentous impacts are prominently recognized in many chronic spine and low back conditions, no research has been performed on the possible role of passive axial (spinal) myofascial tone as a causative factor. In this particular study, the passive muscle properties of the lower lumbar regions of 24 healthy adults and 24 adult AS subjects were examined. Our recent publications examined the stiffness among normal and AS subjects. In this study, those analyses are expanded to include detailed analysis and correlations of all three biomechanical properties of stiffness, tone (frequency) and elasticity (decrement). Analyzed data supports the hypothesis that resting muscle properties of the lower lumbar muscles hold significance in differentiation of human back health between healthy and diseased subjects, but more experimentation should be performed to strengthen this study's results.

I. Introduction

Although osteoligamentous complications are standardly associated with musculoskeletal disorders – such as ankylosing spondylitis (AS) – very little research has been conducted to determine whether passive axial myofascial tone also plays a role in the development of such disorders [1]. Human resting myofascial/muscle tone (HRMT) is an intrinsic viscoelastic property and assists majorly in maintaining the spine's stability. Current studies focus on active, contracting muscles; however, very little research has been recorded or published on HRMT and its effects [1]. Due to the current lack of quantified HRMT data, more research needs to be done to uncover the significance of HRMT and its effects on the biomechanics of human muscles, specifically those of the lower lumbar region.

Ankylosing spondylitis (AS) is a chronic disease that primarily affects the spine and tends to manifest in the later teen or young adult years [2]. Later stages of AS – over 10 or more years of disease – can exhibit clear manifestations of loss of function and spinal damage [1]. In contrast, early features of AS may be only symptomatic, and definite diagnosis may be delayed for a period of 5 to 7 years or longer [1]. Our recent clinical study on AS patients indicated increased muscle stiffness in the L3-L4 lumbar regions as measured by the MyotonPro [2].

The aim of this study is to analyze the biomechanical properties of stiffness, tone (frequency) and elasticity (decrement) of the L3-L4 myofascia as measured by the MyotonPro. Additionally, correlation analyses are done to investigate the effect of age and disease duration on these biomechanical properties. This study will provide a better understanding of how these biomechanical properties play an important role in the early recognition of AS and possibly other forms of chronic low back pain.

II. Methods

All research protocol received the approval from our institutional review board, and all subjects consented to participating in the project after being properly informed about the study. The Assessment of SpondyloArthritis International Society's criteria for axial spondyloarthritis was used to select AS subjects. Subjects with previous spine surgery or a body mass index (BMI) $\geq$35kg/m^2 were excluded [2]. 19 male and 5 female age-comparable subjects were chosen within each group (healthy controls and AS). Subjects that were feeling pain or stiffness at the time of the interview, suffered from chronic neurological or musculoskeletal conditions, had a past spine surgery, or had a BMI $\geq$35kg/m^2 were excluded [2].

Measurements were collected using the MyotonPro to assess the properties of the lower lumbar (L3-L4) erector spinae muscles. MyotonPro (Myoton AS, Tallinn, Estonia) is a non-invasive device that can quantify the dynamic stiffness, tone (frequency), and elasticity (decrement) of tissue [1]. Extensive data on the reliability of the device on a number of tissues has been reported [1, 2]. Measurements were performed when surface electromyography (sEMG) values were within the acceptable range of passive muscle state values ($< 5\ \mu V$) [1, 3]. Individual measurements were recorded at an initial point in time, as well as after 10 minutes of resting, on both the left and right sides of the subject's lower back (L3-L4) to quantify the biomechanical properties of stiffness, tone (frequency) and elasticity (decrement).

Nonparametric statistical analyses were performed using IBM SPSS Version 20. The Mann Whitney U independent variables test was conducted on stiffness, frequency, and decrement values between the different groups. The Wilcoxon dependent variables test was performed to analyze data within groups (left vs. right side, initial vs. 10-min). Bivariate correlations were performed between the three biomechanical properties, and the additional variables of age, body mass index (BMI), subjective stiffness, and years passed since the AS patient was diagnosed with the disease (years duration). Comparisons and correlations which generated a p-value within the accepted range of significance ($p < 0.05$) were marked as significant.

III. Results

Total AS subjects (N=24) had significantly higher (median) stiffness (N/m) than healthy subjects (272.2 vs 240.2, respectively, $p = 0.012$), especially female subjects (274.2 vs 194.4, respectively, $p = 0.008$) [Table1]. Mean stiffness did not differ significantly in males ($p = 0.130$). Right-sided measurements were greater in AS subjects on initial measurements (280.0 vs 229.8, $p = 0.009$) and after a 10-min prone rest interval (290.3 vs 231.2, $p = 0.003$), but not different on the left-side initially or after 10-min ($p = 0.073$ and $p = 0.101$, respectively). Significant differences of averaged right and left measurements were seen at initial ($p = 0.021$) and 10-min ($p = 0.009$) intervals.

Table 1: Median stiffness (N/m) in combined AS and control men and women

Measurements (Sides, Times, and Sex)	AS (N=24, M=19, F=5)	Control (N=24, M=19, F=5)	P*
Initial Right (N=24)	280.0 (254.9-321.2)	229.8 (197.7-283.8)	0.009
Initial Left (N=24)	254.7 (233.5-298.1)	253.8 (182.1-274.4)	0.073
Averaged (Right, Left) Initial (N=48)	268.9 (246.1-302.4)	238.9 (191.6-280.4)	0.021
10-Min Right (N=24)	290.3 (254.9-355.9)	231.2 (211.2-278.7)	0.003
10-Min Left (N=24)	259.2 (236.7-321.3)	255.6 (191.8-280.7)	0.101
Averaged (Right, Left) 10-Min (N=48)	281.0 (246.0-307.6)	241.4 (201.4-277.7)	0.009
Total (M and F, Both Sides and Times, N=96)	272.2 (247.9-305.0)	240.2 (196.5-277.2)	0.012
Males (Both Sides and Times, N=76)	270.2 (243.1-346.3)	266.3 (203.7-279.3)	0.130
Females (Both Sides and Times, N=20)	274.2 (249.4-303.3)	194.4 (187.5-218.5)	0.008

*Mann-Whitney U Test values have significance level of 0.05.

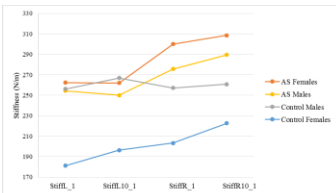

Fig. 1. Median stiffness values of AS and CN subjects by sex at left and right sides, initially and after ten minutes.

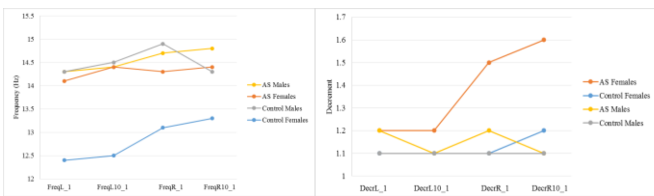

Fig. 2. Median frequency and decrement values of AS and CN subjects by sex at left and right sides, initially and after ten minutes.

Figures 1 and 2 indicate differences in biomechanical property measurements between AS and control subjects. Within AS subjects, the 10-min right side stiffness measurements were significantly ($p < 0.003$) higher than initial values, and right side stiffness measurements were significantly ($p < 0.047$) higher than left side values. Within CN subjects, the 10-min stiffness measurements on both sides were significantly ($p < 0.010$) higher than initial values. Within AS subjects, the 10-min right side frequency measurements were significantly ($p < 0.007$) higher than initial values, and right side frequency measurements were significantly ($p < 0.019$) higher than left side values. Within CN subjects, the 10-min frequency measurements on both sides were significantly ($p < 0.030$) higher than initial values, and right side frequency measurements were significantly ($p < 0.012$) higher than left side values. Analyses of decrement values showed no significant differences.

Bivariate correlational analysis between the three biomechanical properties indicated a highly significant positive correlation ($p = 0.000$) between stiffness and frequency values within both the AS and CN groups. A significant positive correlation ($p < 0.028$) was observed between stiffness and decrement values within CN subjects only. No significant correlations were observed between stiffness and age or frequency and age. However, a significant positive correlation ($p < 0.008$) of all decrement values with age was found within AS subjects, and a significant positive correlation ($p < 0.018$) of right side decrement values with age was found within CN subjects.

In combined AS subjects, years of disease duration significantly correlated positively ($p < 0.013$) with decrement values. However, in combined AS subjects, disease duration showed no significance in relation to stiffness or frequency.

IV. Discussion

The biomechanical properties of stiffness, frequency (tone), and decrement (elasticity) values, averaged over sides and times, were all higher in AS subjects compared to the healthy CN subjects, confirming our initial hypothesis that subjects with AS have altered biomechanical properties in comparison to healthy subjects. However, significant differences were not always observed when comparing between sides, times, and sexes. Within healthy controls, male subjects always had higher stiffness and frequency values compared to the female subjects, probably because of differences in muscle masses and morphological traits.

The 10-min right side stiffness measurements were significantly greater than the initial values within AS subjects, and 10-min stiffness measurements on both sides were significantly greater than initial values within CN subjects. Within AS subjects, right side stiffness measurements were significantly greater than left side values, but this trend was not seen within CN subjects. 10-min right side frequency measurements were significantly greater than the initial values within AS subjects, and 10-min frequency measurements of both sides were significantly greater than initial values within CN subjects. Right side frequency measurements were significantly greater than left side values within both AS and CN groups. These trends may be due to the fact that all of the subjects were predominantly right-handed, and the additional resting time is known to cause a tightening in the muscles [1].

The correlation analysis indicated that within AS and CN groups, stiffness and frequency values had a highly significant positive correlation. This trend may be due to the fact that as a muscle's stiffness increases, its frequency (tone) – the intrinsic tension on the cellular level in a muscle's passive state – increases as well. Stiffness and decrement values had a significant positive correlation within CN subjects. Decrement characterizes a tissue's elasticity and is inversely proportional to elasticity. As stiffness increases, a muscle becomes less elastic, which explains the simultaneous increase in decrement that results. A significant positive correlation was indicated between age and decrement values within AS and CN groups, although it was found only between right side decrement values and age within CN subjects. This trend may be a result of how muscles become less elastic and stiffer with age, which results in an inversely proportional increase in decrement. In combined AS subjects, years of disease duration significantly correlated with decrement values, which could be due to the fact that, as the disease progresses, the muscles would atrophy, causing a reduction in their elasticity. Further studies with larger samples, especially in female subjects, are needed to help better characterize the variation in the biomechanical properties of lumbar myofascial with age and disease duration.

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