Median Frequency Changes During Paraspinal Isometric Contraction in Different Age Groups

Maher Elkabalawe, Ragia Kamel, Fatma Sedeek and Manal Mahmoud
Department of Basic Science, Faculty of Physical Therapy, Cairo University.

ABSTRACT

The purpose of the present study was to investigate the relationship between electromyographic manifestations of fatigue and age during isometric contraction of Paraspinal muscles to the level of fatigue. Eighty healthy, back pain-free individuals. Were divided into four groups according to their age each group has 10 years difference from the previous one. Their ages were participated inthepresenl study ranged from 15 to 55 years old. Each group included 20 subjects. Using skin-surfac electrodes, electomyographic signals were recorded from third lumber (L3) region of paraspinal muscle during an isometric endurance test, the rate of change in median frequency (MFS), and initial median frequency (IMF) of the electromyographic power spectrum were calculated for all groups. The results showed that MFS decreased with increasing age from – 0.8322Hz/sec to 0.4405 Hz/sec up to the age of 45. therefore IMF increased with age from 134Hz to 118.06Hz. On the other hand MFS correlated with endurance time, as endurance time increased with increasing age from 68.7 sec in group Ito 84.5 sec. in group III and dcreased slightly in group IV to 72.1 sec. The finding revealed that age had a significant influence on paraspinal muscles fatigability and this theresis fance to fatigability was greater in younger than in older subjects. In addition, endurance time was increased slightly with age, up to age of 45 then decreased.

INTRODUCTION

Excessive fatigability of the back extensor muscles is a dysfunction frequently observed in chronic low back pain (LBP) sufferers[3], therefore it may represent a risk factor for the development of low back pain[4]. It was stated that because of back extensor fatigue, the trunk movement patterns are less controlled, and this may lead to lesion in the intervertebral discs as well as to back pain[17].

Excessive fatigability of the erector spinae leads to decrease endurance capacity of back muscle that associated with low back pain[7]. Therefore, back extensor endurance characteristics have an important role in the assessment of lumbar spinal function and dysfunction[8].

In a large population-based study, Biering-Sorensen used an isometric back endurance test (trunk holding test)[4]. The patient was asked to maintain the unsupported upper body in a horizontal position[4,12]. This test protocol has been widely used to asses paraspinal muscle function and fatigability[4,19].

On the other hand, Manion and Dolan (1994) stated that assessment of fatigability in the Sorensen test is based on measuring endurance time, but this hampered by subjective qualities, motivation and tolerance to discomfort or pain, they addedthat, Electromyographic (EMG) median frequency (mf) has been employed to overcome this problem through objective measurement of the back extensor fatigability in isometric endurance contractions[10].

According to Ng et al., EMG power spectral analysis is a more objective technique to examine endurance[16]. One of the unique features of this technique is that it is capable of measuring the endurance capacity of individual trunk muscles. This is an asvantage when trunk movements are produced by a number of muscle groups. Additionally, it requires only submaximal contraction for shorter periods of time, because it measures fatigue as a continuous process rather than as a cechanical fatigue point[16].

On the other hand median frequency is the most suitable, because it is less sensitive to noise and more sensitive to fatigue induced myoelectric modifications during voluntary contraction[18]. Previous work on limb muscles had shown that the rate of decline in median frequency is highly correlated with endurance time[9]. In addition, the decline in median frequency during isometric contraction is linearly correlated with the accumulation of certain muscle metabolites previously implicated in measurement of developing muscle fatigue[21].

Therefore, there is a great correlation between the fatigability of back extensors and muscle fiber composition including fiber type (I,II) and size. Muscles in which type I fibers predominate are more resistant to fatigue because it is slow twitch, high oxidative, low glycol tic and larger in size in comparison to type II[11]. So changes of median frequency have been shown to correlate with the percentage different of fiber type[10,11].

MATERLAS AND METHODS

Subjects

Eighty healthy, back pain-free individuals were divided into four groups according to their age. Sin which each group had 10 years difference from the other their ages ranged from 15 to 55 years. Each group included 20 subjects. They were recruited from students and employee of Faculty of Physical Therapy in Cairo University with the weight ranged from 60-90kgand height ranged from 160-180cm.

Instrumentation

Supporting belts: Three belts were used for secure holding of each subject into the fixed coach at the level of hip, knee and ankle joints.
Disposable surface electrodes: Silver-silver chloride (Ag-AgC1) electrodes used to pick up the EMG activity of selected muscles.
Vertical stand: A marker on a vertical stand was placed over the mid-thoracic level of each subject to maintain the horizontal position of the subjects.
EMG device: Consisted of the following:
Analogue to Digital converter (MP 100 module): Its function was the conversion of electrical signal into digital data.
Remote Monitoring System (TEL 200C model): Was used filtering the incoming signals.

Procedure

Each subject was placed in a prone lying position over examination couch stool was supported the upper body with the lower body from the superior border of the iliac crest downward was strapped to the couch. The pelvis and the legs were firmly stabilized by three belts over the hips, knees and ankles. The subject's arms were crossed in front of his chest[4]. After cleaning the skin with alcohol, a set of bipolar silver/silver chloride electrodes were attached to the subject's skin at the level of the third lumber vertebra, approximately 3-4 cm from the mid line of the back and with an inter-electrode spacing of approximately

20mm for each pair. The ground electrodes were positioned over inferior angel of scapula. At the commencement of the task, the couch which was supporting the upper part of the body was removed, and each subject was asked to maintain the unsupported upper body in a horizontal position as long as possible. The EMG signals from the two recording sites were band-bass filtered between 5 and 300 Hz amplified, analogue-to- digital converted at a sampling rate of 1,024Hz. The EMG power spectral density was computed for 1-Sec. Sampling at 10Sec. Intervals throughout the test, using a Fourier Transform algorism.

RESULTS

In each group, median frequency (MF) EMG signals were investigated during isometric contraction up to the level of fatigue of paraspinal muscles. Regression analysis was performed on MF data to draw regression line. From this line it was calculated initial median frequency (from y intercept of the regression line) and slope of median frequency (rate of change of median frequency). Comparison between different ages, median frequency slopes and initial MF was conducted by one-way analysis of variance (one way ANOVA). There was almost no difference between the activity of the left and that of the right paraspinal muscles in the same individual. Accordingly, the EMG data from the right side in this study was recorded. The results of regression analysis were as followed.

In group one it was noticed that the mean of initial median frequency was 134 Hz. And standard error was ± 2.4154 Hz. Among the means of median frequency slops (%/sec) was-0.8322%/sec with standard error ± 0.670%/sec. (ANOVA within group showed significant differences for both initial MF and MF slops p <0.0001) as shown it Table 1.

Table (1): Initial MF and Mf slop in group I.

Term	Mean	SE	P
Initial MF(Hz)	134	±2.415	<0.0001*
MF slope (%/sec)	-0.8322	±0.670	<0.0001*

SE: Standard error *: Significant

In group II median frequency was 120.99 HZ. And standard rror was ± 2.3218 Hz. Among the means of median frequency slops (%/sec) was –0.6012%/sec with standard error ±0.0644%/sec. ANOVA within group showed significant differences for both initial MF and MF slops (P<0.0001) as shown in Table 2.

Table (2): Initial MF and MF slope in group II.

Term	Mean	SE	P
Initial MF(Hz)	120.99	±2.3218	<0.0001*
MF slope (%/sec)	-0.6012	±0.0644	<0.0001*

SE: Standard error *: Significant

In group three it was noticed that the mean of initial median frequency was 118.0630Hz. and standard error was ±2.2339 Hz. Among the means of median frequency slops (%/sec) was –0.4405%/sec with standard error ±0.0620%/sec. On the other hand it was shown a significant differences for both initial MF and MF slops (P<0.0001) Table3.

Table (3): Initial MF and MF slope in group III.

Term	Mean	SE	P
Initial MF(Hz)	118.063	±2.233	<0.0001*
MF slope (%/sec)	-0.4405	±0.062	<0.0001*

SE: Standard error *: Significant

In group four it was noticed that the mean of initial median frequency was 117.6501 Hz and standard error was ±2.7870 Hz. Among the means of median frequency slops (%/sec) was –0.4763 %/sec with standard error ±0.0773%/sec. ANOVA within group showed significant differences for both initial MF and MF slops (P<0.0001) as noticed in Table 4.

Table (4): Initial MF and MF slope in group IV.

Term	Mean	SE	P
Initial MF(Hz)	117.6501	±2.7870	<0.0001*
MF slope (%/sec)	-0.4763	±0.0773	<0.0001*

SE: Standard error *: Significant

To compare between age groups and initial MF data was used test and the results were presented in Table 5 and Fig. 1. From this table it was shown that there was significant difference between group 1 and group 2, group 1 and group 3, and between group 1 and group 4 ($P<0.05$). While this difference was non significant between the other groups.

Table (5): Comparison between different age groups and initial MF.

Comparison	Mean difference	t	P value
Group I vs. group II	13.279	3.835	P<0.01*
Group I vs. group III	16.209	4.681	P<0.001***
Group I vs. group IV	16.622	4.800	P<0.001***
Group II vs. group III	2.929	0.8460	P>0.05
Group II vs. group IV	3.342	0.9652	P>0.05
Group III vs. group IV	0.4129	0.1192	P>0.05

* Significant

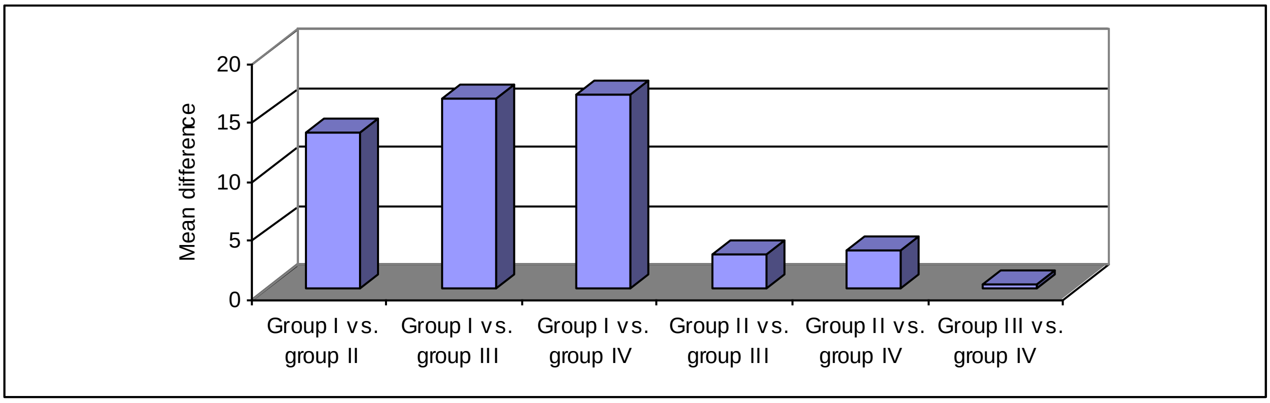

Fig. (1): Comparison among the four groups in initial MF.

On the other band, to compare between age groups and MF slops was use t test and the results were presented in Tables (6) and Fig. (2). As revealed from this Table it was show that the difference between group 1 and group 3, and between group 1 and group 4 was highly significant ($P<0.05$) while were the difference between other groups non significant.

Table (6): Comparison between different age groups and Mf slops.

Comparison	Mean difference	t	P value
Group I vs. group II	-0.2310	2.405	P<0.05
Group I vs. group III	-0.3917	4.079	P<0.001***
Group I vs. group IV	-0.3559	3.705	P<0.01**
Group II vs. group III	-0.1607	1.673	P>0.05
Group II vs. group IV	-0.1249	1.300	P>0.05
Group III vs. group IV	-0.03580	0.3727	P>0.05

* Significant

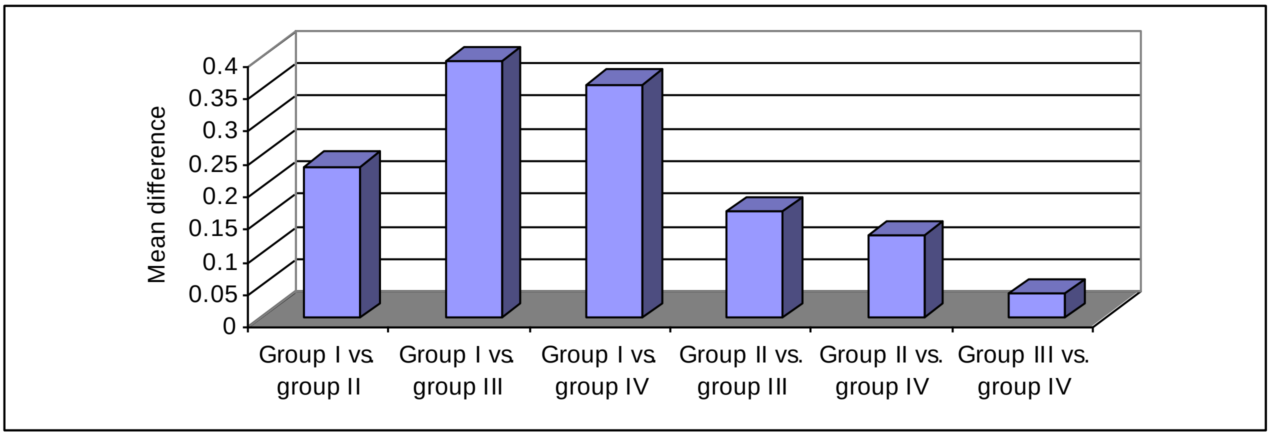

Fig. (2): Comparison among the four groups in MF slop.

When the endurance time (ET) was calculated in different age groups it had been found that ET increased with age from 68.7 ± 2.22 sec in group 1 to 82.5 ± 4.766 sec in group II, and to 84.5 ± 4.23 sec in group III. While in group IV the endurance time was decreased again to 72.1± 3.08 sec. As revealed from Table (7).

Table (7): Comparison between different age groups and endurance time.

Groups	Endurance time (sec)	
	Mean	SD
Group I	68.7	±2.22
Group II	82.5	±4.766
Group III	84.5	±4.23
Group IV	72.1	±3.08
All Groups	76.95	±3.866

SD: Standard Deviation

DISCUSSION

Within the limitation of the present study, the performance of trunk holding test (Sorensen isometric endurance test). Produced significant decline in median frequency with fatigue (P<0.0001) the rate of decline in median frequency (slope %/sec) decreased with age (increased endurance capacity) from group one to group three and then this rate of decline increased slightly in group four. This decrement was significant (P<0.05) between group one and group three, and between group one and group four which may be due to large differences in age between these age groups. The results of the study also reveled decrement in initial median frequency value with age from group one to group four, but this decrement was significant between group one and group two, group one and group three, group one and group four endurance time differ from one group to another. In the present study the endurance time was 68.7±2.22 sec in group I , 82.5±4.766 sec in group II , and to 84.5±4.23 sec in group III, in group IV the endurance time decreased again to 72.1±3.08 sec. While the ET for the all groups was 76.95±3.866. but in general it was less than endurance time reported in the reviewed articles. As the ET reported by Mannion et al., 1994, which was 139±54 sec.

This finding in agreement with NG et al. (1997) who studied electromyographic amplitude and frequency changes in the iliocostalis lumborum and multifidus muscles during trunk holding test and they found that there was compression or shift on frequency of EMG power spectrum towards lower frequency values during fatiguing contraction, as the rate of decline in MF (MFS was 0.32±0.34 %/sec).

The present previous study is in agreement with the studies in that the spectral shift towards lower frequencies is associated with localized muscle fatigue but the rate of decline in MF (MFS) in the present study are higher than these previous two studies.

The significant decline in MF during isometric back extension as found in the current study has been attributed to a decline in the action potential cnduction velocity, either due to decrease in the intramuscular PH (Moritani et al, 1984), or concentration of potassium ions in the extracellular fluid during sustained muscle contraction because the blood flow in a muscle is prevented by the contraction.

The decline in MF during isometric back extension as found in the current study has been also attributed to changes in synchronization and firing rate of motor units. That the work. Manion and dolan (1994) electromyographic median frequency changes during isometric contraction of back extensors to fatigue and they found that the lubar region exhibited greater decline in MF with time (MFS) as the lumbar region contain lower percentage of type i than thoracic region of the erector spinae (Horita and Ishiko, 1987).

The rate of decline in MF during fatigue reflect differences in the metabolic profiles of individual muscle fibers by accumulation of metabolicbyproduct (e.g., lactate), the accumulation of lactic acid decreases the PH in a contracting Muscles and inhibit the excitability of the muscle membrane which cause a gronounced reduction in the action potential conduction velocity (Horita and Ishiko, 1987).

The lower-back muscle fatigue using electromography, mechanomyography, and near-infrared spectroscopy (NIRS) from the center of the erector spinae at the level of L3 was investigated by Yoshitake et al., (2001). NIRS was measured to determine the level of muscle blood volume. The results of this study indicated that the restriction of blood flow due to high intramuscular mechanical pressure is one of the most important factors underling muscle fatigue.

The results findings of the current study has on agreement with the work of Kankaapaa et al., (1998) who studied the effect of age, sex, and body mass index as determinants of back and hip extensors fatigue in the isometric Sorensen back endurance test. On the other hand, in the present study.

The results of the present study has and agreement with earlier study performed by Biering- Sorensen (1984) who studied physical measurement as risk indicators for low-back trouble over a one year period. He divided subjects into age groups 30-39, 40-49, 50-60. the results of this work study suggested that back muscle endurance capacity increases slightly with age.

Furthermore, Alerenta et al., (1994) studied non-dynamic trunk performance tests: reliability and normative data. They sample of males and females aged from 35 to 54 years. Applied their workin asampl evaluated to determine reliability of static back endurance and another dynamic tests to detect determinants of trunk muscle performance. The results of their stud indicated that the endurance of back muscle was increased with age up to the age of 50 years.

However Ali et al., (2000) evaluated the reliability of electromyographic power spectral analysis of the paraspinal muscles. Fifteen volunteer subjects with age ranged from 18 to 38 with no history of low back pain were tested by the unsupported trunk holding test to measure initial median frequency and MF slope. They found no significant correlation between age with initial MF and MF slope. The main reason for finding this might be related to small sample size and young population of that study.

Median frequency slope shows the decline of the MF over time and reflict the fatigue rate, while the initial median frequency ma be an indication of the muscle fiber composition (Biderman et al., 1991). Beliead that. It has been suggested that the initial MF correlates with the percentage of fast twitch (type II) fiber in the muscle. An initial increase in MF may be caused by the recruitment of fast twitch motor units with larger fibers that have higher conduction velocity.

The influence of age on fiber type distribution and size of back muscle has been studied by. They founded that gross muscle cross sectional area correlated inversely with age due to atrophy of type II (fast twitch) muscle fiber that leads to increase in area occupied by type I (slow twitch) muscle fiber that are more resisted to fatigue than type II.

The metabolic and physiologic profile of the slow twitch (Type I) fiber not only provides it with a higher oxidative potential, but gives it the capacity to sustain an isometric contraction with an economy of tension maintenance that is greater than that of fast twitch (Type II) fibers (Ng et al., 1997).

Conclusion

The results of this study demonstrated that the Sorensen muscle endurance test conmbined with EMG power spectral analysis is an objective procedure for the evaluation of fatigr performance of Paraspinal muscles. On the other hand parspinal muscles resistance to fatigue increased (have a higher muscle endurance) as the age increased until the age of 45 years old, then the resistance to fatigue begin to decrease. Endurance time reported in this study was less than endurance time reported in other literatures that may be might due to lack of training and the sedentary life.

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الملخص العربي

التغيرات في الترددات المتوسطة أثناء الانقباض الساكن للعضلات الموازية للعمود الفقري في الأعمار المختلفة

الغرض من الدراسة الحالية هو تحديد العلاقة بين الظواهر جهاز رسم العضلات الكهربي في حالات الإجهاد والعمر أثناء الانقباض الساكن للعضلات الموازية للعمود الفقري لدرجة الإجهاد . شملت الدراسة الحالية على ثمانون مشاركًا من الأصحاء تراوحت أعمارهم بين 15 و 55 عامًا تم تقسيم هؤلاء الأشخاص إلى أربع مجموعات عشوائيًا وذلك حسب أعمارهم حيث تفصل كل مجموعة عن الأخرى عشرة أعوام . وقد شملت كل مجموعة عشرون شخصًا . وقد تم استخدام أقطاب سطحية توضع على الجلد لالتقاط إشارات جهاز رسم العضلات الكهربي من العضلات الموازية للعمود الفقري وذلك من العضلات التي تقع فوق الفقرة القطنية الثالثة وذلك أثناء قيام المشارك بعمل انقباض ساكن لمدة تصل للإجهاد أثناء استلقائه على وجهه وصدره خارج مائدة العلا ومحافظته على استقامة الجسم لأكبر وقت ممكن .

وقد تم حصر التردد المتوسط والتردد الأولى المتوسط للمجموعات الأربعة . وقد أظهرت النتائج انخفاض التردد المتوسط مع تزايد المراحل العمرية 0.8322– تردد / ثانية إلى 0.4405– تردد / ثانية وذلك حتى 45 عامًا . ومن ثم التردد الأولى المتوسط يزيد بزيادة العمر من 134 تردد/ ثانية إلى 118.06 تردد / ثانية . ومن ناحية أخرى فإن التردد المتوسط أظهر علاقة بمدة قوة التحمل ، حيث أن مدة قوة التحمل تزيد بزيادة العمر 68.7 ث في المجموعة الأولى إلى 84.5ث في المجموعة الثالثة وتقل تدريجيًا في المجموعة الرابعة إلى 72.1ث بالإضافة إلى أن العمر له تأثير واضح على قابلية الإرهاق. حيث أن مقاومة هذه القابلية للإجهاد تزيد عن الأعمار الصغيرة وتقل لزيادة العمر حتى 45 عامًا .