# ELECTROMYOGRAPHY-BASED INVESTIGATION OF BILATERAL *EXTENSOR DIGITORUM COMMUNIS*, *ABDUCTOR DIGITI MINIMI*, AND *ABDUCTOR POLLICIS BREVIS* OF A PIANIST, AFTER PERFORMING SCARLATTI'S BAROQUE SONATA K.1

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**ABSTRACT**

*The changes in muscular activity can increase the risk for musculoskeletal disorders and also have a negative impact on the performance task itself.[1] Finger and arm techniques, of a professional pianist playing Scarlatti's baroque sonata K.1 were studied using the electromyograph (EMG) which recorded muscular activity of bilateral extensor digitorum, abductor digiti minimi and abductor pollicis brevis. Compared results of finger and arm technique reveal lower amplitude potentials in all of the muscles investigated, except in the left extensor muscle where amplitude increased. Also, the frequency of the potentials decreased in all of the muscles investigated, except for the left abductor pollicis brevis where such potentials remain constant. Such difference in muscle potentials may lead to muscle-joint disorders if long-term activity is observed. The aim of this investigation is to increase awareness of the benefit of applying a complex mix of pianistic techniques rather than a single playing technique in piano education.*

**Keywords**
EMG; piano; muscle; sonata; repertoire.

## INTRODUCTION

The specific literature regarding piano technique is as overtly thin as research is scant.[2] This investigation aims to augment the available information on piano technique. The investigation is aimed at the finger and arm techniques.

The finger technique in study implies finger muscular energy applied with low amplitude movement as well as moderate force that is actually a logical and necessary prerequisite for performing on keyboard instruments during Scarlatti's time.[3,4] Specifically C. P. E. Bach's *Essay on the True Art of Playing Keyboard Instruments* sets the standard for finger techniques.[5] The baroque technique for

keyboard instruments was also described by composers such as Fr. Couperin and D. Scarlatti.[6,7]

Pianist composer Fr. Liszt thoroughly developed the arm technique which became the true foundation for modern piano performance.[8] The arm technique as practiced by Liszt and later theorized by musicologist A. R. M. Breithaupt was based on compounding arm weight and muscular force in order to prevent muscular fatigue.[9] This investigation also aims to reveal the impact of the two piano techniques (finger and arm) upon the pianist's muscular system.

Electromyograph-mediated investigations of muscular activity in pianists were studied by various researchers.[10–12] However, some researchers used EMG as a primary method.[13–15] Many EMG muscle assessments also studied the forearm muscles, especially the *extensor digitorum superficialis* and *flexor digitorum superficialis* (in 23.8% of studies).[16]

Research published prior to August 2019[16] found that the musical material used in studies was *sound*, *intervals*, *arpeggios*, *a single chord*, *a 5-sound cluster*, *scales*, a *melody* within a one-hand octave range, Hanon drills, Hanon and Brahms drills, Cortot drills, a specific *scale and chord*, and *an arpeggio plus scale and cluster*. In some other research[16] the repertoire used was *free repertoire*; *not specified* repertoire; familiar *fast pieces* voluntarily selected by the subject; a 10-minute *song*, a 5-hour *free repertoire* followed by the *same song* the subject played at the onset; fragments in Medtner's Sonata *Reminiscenza* op. 38, Chopin' 4th *Ballade* and *Impromptu*; a specific passage in Mendelssohn's *Song Without Words* (op. 19, no. 2); Chopin *Scherzo* in B-flat Minor op. 31 and an excerpt in the 2nd movement of Judith Lang Zaimont's *Suite Impressions;* the first 1.5 minutes in Tchaikovsky piano *Concerto* in B-flat Minor, op. 23; and a complex mixture of repertoire such as chromatic scales, major scales, Beethoven, *Polonaise* op. 89 in C, and Babbitt's *Playing for time*. Baroque repertoire used in some past research consisted of 16 measures of J. S. Bach's *Minuet* repeated ten times[18] and his *Praeludium no. 1* in C repeated three times,[19] although the baroque repertoire was never investigated using EMG. The present research studies the two piano techniques using EMG as applied to a baroque repertoire.

## MATERIALS AND METHODS

The study took place at the Functional Explorations Neurophysiology Laboratory and written informed consent of the participant was secured before the study started. Materials used were: a digital Yamaha P-45 MIDI keyboard, a Domenico Scarlatti's

baroque Sonata K. 1 music score, a metronome, a stopwatch and an electromyograph.

Scarlatti's baroque Sonata K. 1, usually present in the repertoire of both professional and young pianists was memorized since reading scores while playing adds extra tasks to the actual performance (i.e. the physical action of looking up and down at the score and to review the correct fingering).[17]

Sound intensity and tempo are basic variables which significantly impact the muscular load of the arm while interpreting a piano work.[10] We selected a value of 80 MIDI velocity for the *mf (mezzo forte)* dynamic that was also used in other research.[11,22] The metronome was set at a quarter=100/minute and a cell phone application served as a stopwatch.

The 2009-Neuro-MEP-Micro EMG was connected to a pair of bipolar surface electrode units, the signal frequency range being 200-100.000 Hz.

**Demographic Information**

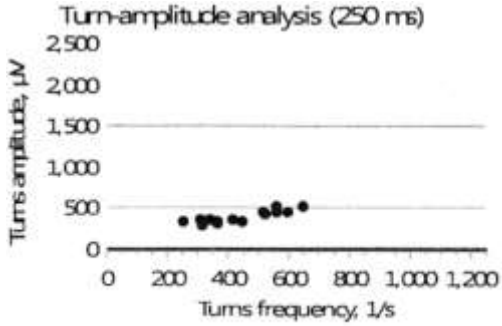
The pianist was a 26-year old female with 21 years of piano education; no musculoskeletal, psychiatric or neurological pathology; no drug, alcohol, caffeine or energizers use during the previous 5 days. A neurologist expert in electromyography performed the medical investigation, assisted by a professional nurse and an assistant who timed the actual piano playing.

**Investigation Procedure**

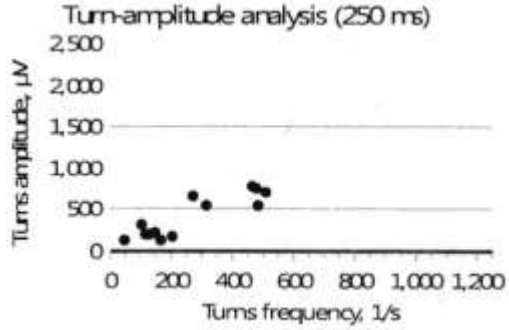
The preliminaries of the study included an induction session and a tegument treatment with alcohol in order to reduce the inter-electrode resistance prior to the attachment of the electrodes. The initial EMG testing (figures *a*) recorded the default muscular activity of the *extensor digitorum communis (EDC), abductor digiti minimi (ADM),* and the *abductor pollicis brevis (APB)* bilateral muscles. Afterwards, the subject performed the first instance of Scarlatti's baroque sonata using the finger technique for 10 minutes continuously, with quarter=100 metronome mark (tempo) and *mf* dynamic, followed by a 10-minute break. After the break, a second EMG evaluation (figures *b*) was performed. The sonata was performed again, using the arm technique this time, for another 10 minutes continuously, with the same metronome mark and dynamic range, followed again by a 10-minute break. After the second break, a third and final EMG testing (figures *c*) was performed.

**RESULTS**

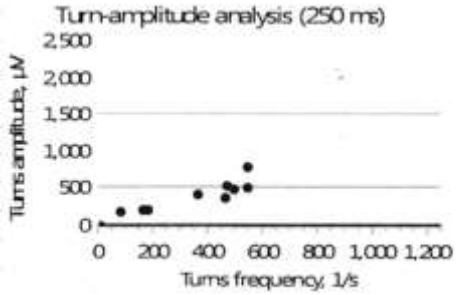
The EMG results are presented as initial evaluation (figures *a*), second evaluation (figures *b*), and third evaluation (*figures c*) for the bilateral *extensor digitorum communis, abductor digiti minimi* and *abductor pollicis brevis* muscles.



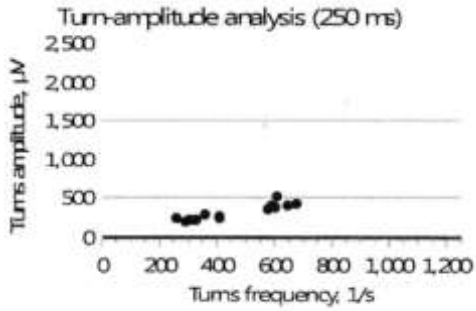

a. left abductor digiti minimi muscle



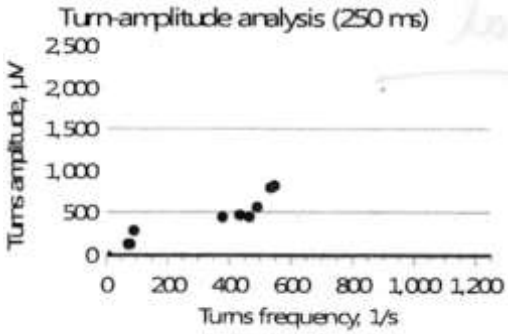

a. left abductor pollicis brevis muscle



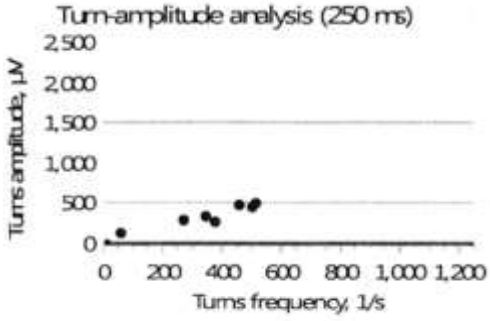

a. left extensor digitorum muscle



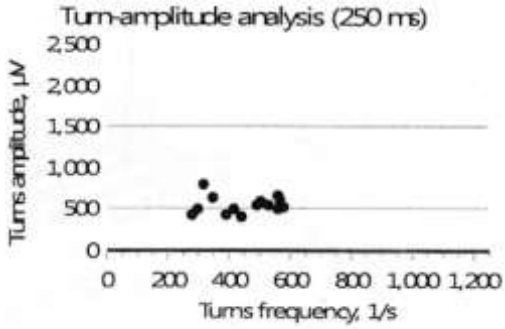

a. right abductor digiti minimi muscle



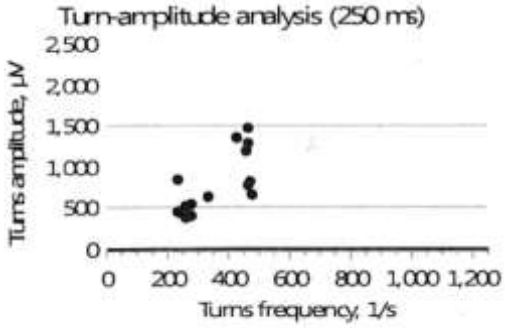

a. right abductor pollicis brevis muscle



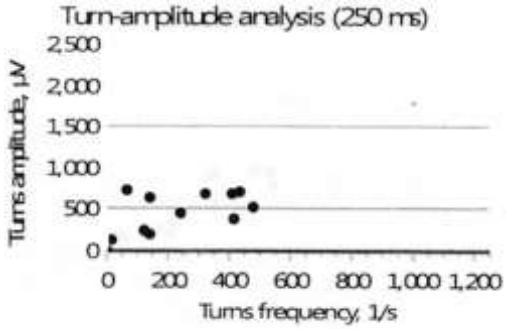

a. right extensor digitorum muscle



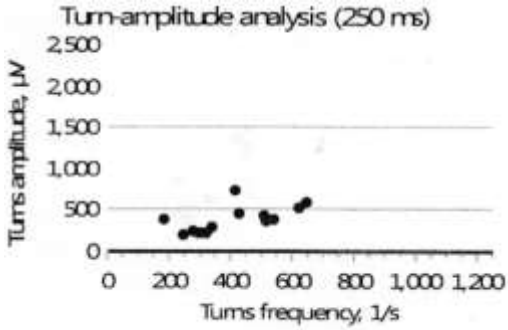

b. left abductor digiti minimi muscle



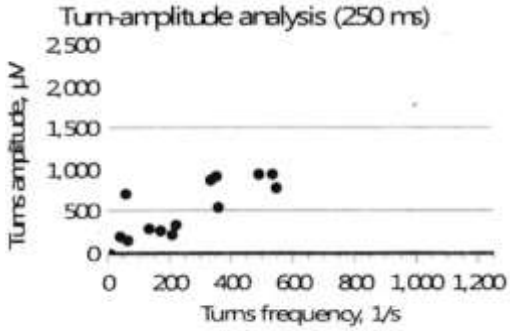

b. left abductor pollicis brevis muscle



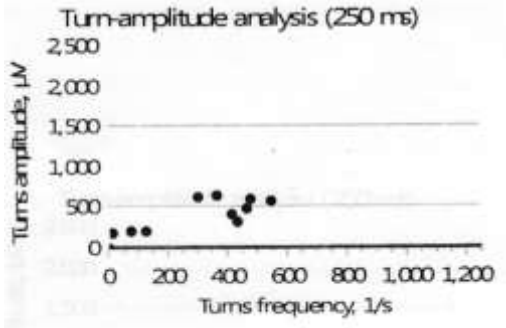

b. left extensor digitorum muscle



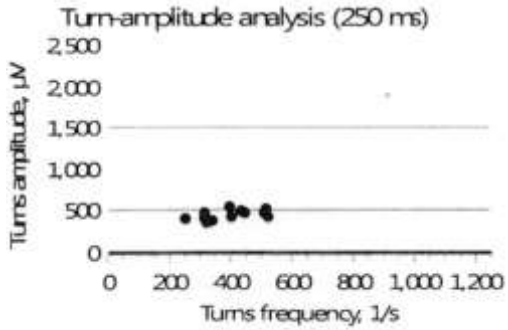

b. right abductor digiti minimi muscle



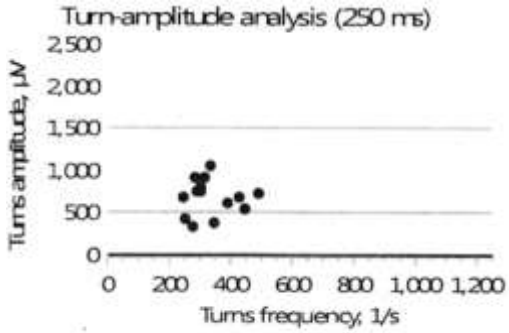

b. right abductor pollicis brevis muscle



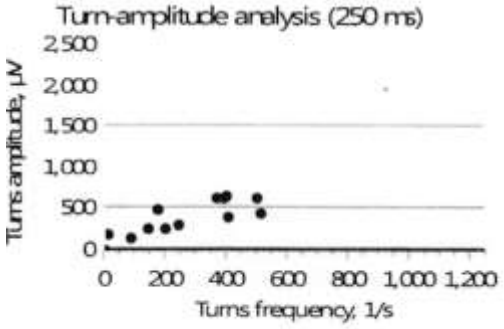

b. right extensor digitorum muscle



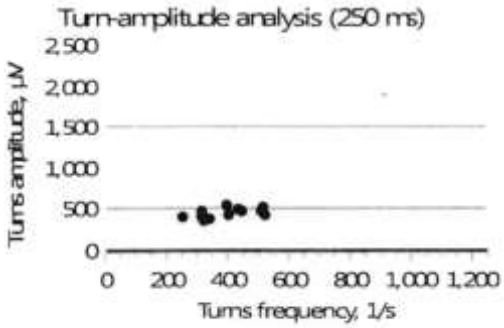

c. left abductor digiti minimi muscle



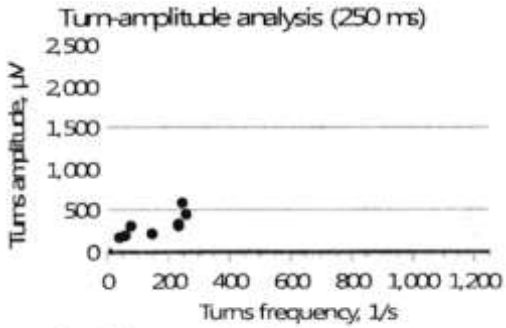

c. left abductor pollicis brevis muscle



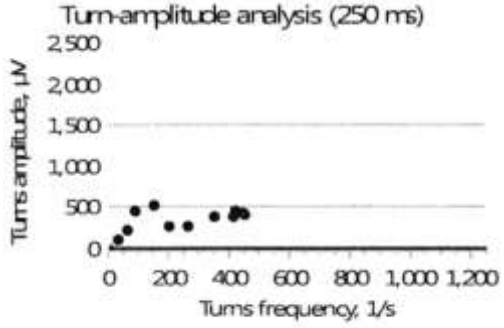

c. left extensor digitorum muscle




c. right abductor digiti minimi muscle




c. right abductor pollicis brevis




c. right extensor digitorum muscle

**DISCUSSION**

Investigations by electromyography indicated that pianists with focal dystonia typically display abnormal elevation of co-activation of an antagonistic pair of muscles.[15] Furuya et al. (2012) observed that a majority of the pianists with focal dystonia showed a considerable increase in the finger muscular load when striking stronger and faster.[10]

Muscular evaluation is known to have been used in the assessment of pianist movement pathology such as focal dystonia, cervical dystonia, and writer's cramp;[20] however, the present investigation uses EMG evaluation of a healthy subject mostly with a prophylactic goal. Information obtained from individual pianists may be useful for detecting muscles with a high-risk potential for performance-related musculoskeletal disorders (PRMDs),[10] thus allowing for both prevention of PRMD occurrence and accurate diagnosis of PRMD's cause(s).[10] PRMDs are described as "any pain, weakness, lack of control, numbness, tingling, or other symptoms that interfere with musicians' ability to play piano at the level they are accustomed to, without taking into account very mild symptoms."[21]

The present investigation demonstrates the relationship between a pianist's muscular activity and the use of two piano techniques applied to a specific repertoire that does not particularly require intense muscular effort.[8,9]

The present study reveals a much greater muscular discomfort experienced by the subject while using the finger technique as opposed to the arm technique, and the decreasing effect of the neuro-muscular action potential amplitude and frequency, leading eventually to stiffness of adjacent joints (Furuya et al.).[10]

The compared results regarding the *finger technique* (the *b* figures) and the initial EMG recordings (the *a* figures) indicate increased potential discharge per motor unit for all of the bilateral muscles investigated, respectively *extensor digitorum communis* (EDC), *abductor digiti minimi* (ADM) and *abductor pollicis brevis* (APB); they also demonstrate how the potential discharge amplitude frequency increases for the right EDC (*b. right extensor digitorum communis muscle)*, the left ADM (*b. left aductor digiti minimi muscle)* and the right APB muscle (*b. right pollicis brevis muscle)*, the discharge potential frequency dropping for all other muscles.

The compared results of this investigation regarding the arm technique (the *c* figures) and the EMG initial recording (the *a* figures) indicate wide variability: amplitude drops for the right ADM (*c. right abductor digiti minimi muscle*) and the right APB (*c. right pollicis brevis muscle*) remain constant for the left ADM (*c. left abductor minimi muscle)* and increases bilaterally for the EDC (*c. left extensor digitorum communis muscle* and *c. right extensor digitorum communis muscle)* and the left APB (*c. left pollicis brevis muscle)*. The frequency of potential discharge decreases for all of the muscles investigated.

The compared results between finger (the *b* figures) and arm technique (the *c* figures) reveal a drop in potential amplitude for all of the muscles investigated, except for the left extensor muscle where amplitude increases (*c. left extensor digitorum communis muscle*); also, a drop in potential frequency for all the muscles investigated, except for the left APB, where the potential discharge frequency remains constant.

This study took place in a controlled environment. However, public performance would highly increase the muscular activity stress of a pianist performing using the finger technique, as observed by Yoshie et al. who demonstrated that the mean normalized MUPs (Motor Unit Potential) amplitude of all of the muscles investigated significantly increased during the evaluation.[1] Philipson et al. also observed in a group of violinists that elevation of muscle tension during performance can be a risk factor for performance-related musculoskeletal disorders.[22]

The changes in muscular activity can increase the risk for musculoskeletal disorders and also have a negative impact on the performance task itself.[1] The relevance for piano education would consist of a heightened awareness regarding the use of a complex mix of piano techniques rather than a singular specific technique. The results in this study measure short-term performance; however, long-term performance might prove that a pianist's distal muscles are more readily fatiguable than the proximal muscles,[10] which could explain why the fingers and wrist muscles have shown the greatest incidences of performance-related musculoskeletal disorders among pianists.[10,23]

A literature review by Martens[24] suggests that a decrease of unnecessary muscle tension should lead to improved performance. In order to prevent muscular issues, musicians should learn to fully control their muscles during performance[25] and to include muscle-relaxing exercises in their practice routine.

## CONCLUSIONS

The pianist musculoskeletal pathologies affect most frequently the hand and the forearm muscles,[26,27] the wrist being especially susceptible to injury.[28] While long-term performance might be targeted for further research of the variability of MUP discharge amplitude and frequency, a larger group of subjects and an EMG-MIDI correlation, might also prove beneficial. The results may be more accurate by using a concert piano whose key weighs 10-20% more than that of an electronic keyboard.[2]

The experiment showcased a relatively small increase in MUP amplitude over a short period of time; if, however, such increase continues over longer periods of time, such incrementation can augment the risk of developing such disorders.[1] Moreover, further consideration of the same sonatas, or of sonatas from a different music style or period, might reveal a direct variance of MUP amplitude rise with heightened loudness and tempo, as suggested by Furuya et al.[10]

The present study found that from a prophylactic standpoint it is preferable to apply a complex mix of pianistic techniques rather than a single performing technique in piano performance and education.

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