Muscles co-activation and wrist position during sustained grip in healthy subjects

Co-ativação muscular e posição do punho durante a preensão sustentada em indivíduos saudáveis

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Abstract

Objective – To evaluate surface electromyography activity (SEMG) of extensor carpi radialis (ECR) in relation to flexor digitorum superficialis muscles (FDS) during power sustained gripo task and to correlate this activity with wrist range of motion (ROM). **Methods** – Healthy female university students, right-handed students (N=34), mean age 23 years. The task was three grips with maximal isometric force using Jamar™ dynamometer. **Results** – Main outcome measures, we used surface electromyograpy and considered 100% maximum voluntary contractrion to represent the amplitude of electromyographic activity. ROM was measured with electrogoniometer Miotec™. Mean percentages of FDS and ECR activity were 92.41 (±4.84%) and 82 (±14.79%), respectively. Rate between FDS and ECR activation was 1:0.89. Mean ROM wrist extension during task was 13.92±9.18°. There was no significant correlation between ROM and SEMG activity for forearm muscles. **Conclusion** – The high EMG activity of extensor muscles found in this study reinforces its important synergistic role during a power sustained hand grip. The normality parameters can be considered in preventive and rehabilitation programs. The findings also suggest that there are different strategies of wrist extension ROM during grip.

Descriptors: Hands; Muscles; Electromyography; Rehabilitation

Resumo

Objetivo – Avaliar a atividade eletromiográfica de superfície (EMGs) do extensor radial do carpo (ECR) e do flexor superficial dos dedos (FDS) durante a preensão palmar, correlacionando essa atividade com a amplitude de movimento do punho (ADM). **Métodos** – Estudantes saudáveis do sexo feminino e destras (N=34), idade média de 23 anos. A tarefa consistiu em três preensões isométricas máximas usando dinamômetro Jamar®. **Resultados** – Foi avaliada a atividade EMGs e a ADM de punho durante as tarefas. A média de atividade FDS e ECR foram 92,41 (±4,84%) e 82 (±14,79%), respectivamente. A taxa de ativação entre FDS e ECR foi 1:0.89. A ADM média de extensão do punho durante a tarefa foi 13,92 ± 9.18°. Não houve correlação significativa entre ADM e atividade EMGs para os músculos estudados. **Conclusão** – A atividade EMGs elevada de músculos extensores encontrado neste estudo reforça o seu importante papel sinérgico durante a preensão palmar. Os parâmetros de normalidade podem ser considerados em programas de prevenção e reabilitação. Os resultados também sugerem que existem diferentes estratégias de ADM de extensão do punho durante a preensão.

Descritores: Mãos; Músculos; Eletromiografia; Reabilitação

Introduction

The grip function depends on the integrity of the structures from wrist to fingers. A muscle is called synergist when it contracts simultaneously with another to perform a specific action such as occurs with wrist extensors and finger flexors during grip tasks[1].

Wrist is the key joint and it has a strong influence on the long extrinsic muscle performance at the digital level. The maximal digital flexion strength is facilitated by the extension of the wrist. This particular movement maximizes the force of the digital flexors to press the object firmly against the palm while the thumb is closed tightly around the object. Conversely, the wrist flexion position will markedly weaken grasping power[1-2].

Many studies have observed different muscle activation patterns influenced by different wrist position[1,3-4] such as during orthosis use[5-7]. Nevertheless, the optimal wrist extension angle is not a consensus[4].

Any change in the synergism can alter the power grip. In order to understand such pathological changes in different disorders it is mandatory to analyse the normality parameters in synergistic muscle activity[8]. The surface electromyography analyses such synergism by electric signals from activating muscles. Electromyography is considered a reliable assessment method of the physiologic process that occurs in the muscles during the generation of force and movements[9]. It is often used to investigate the synergistic muscle activity in different body segments[10]. Many studies have aimed to examine muscle activation and posture during gripping tasks[1,3-6,11]. However, a few studies consider the correlation between the muscle activation and the wrist range of motion (ROM) during the free grip.

The purpose of this study was to evaluate the electromyography activity of the extensor carpi radialis (ECR) in relation to flexor digitorum superficialis (FDS) and to

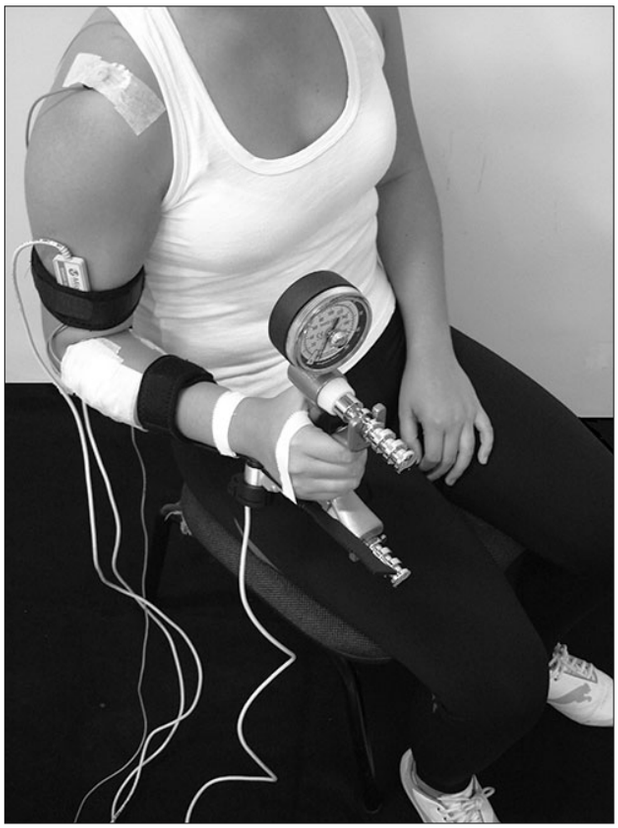

Figure 1. Predefined task with the dominant hand with dynamometer Jamar®

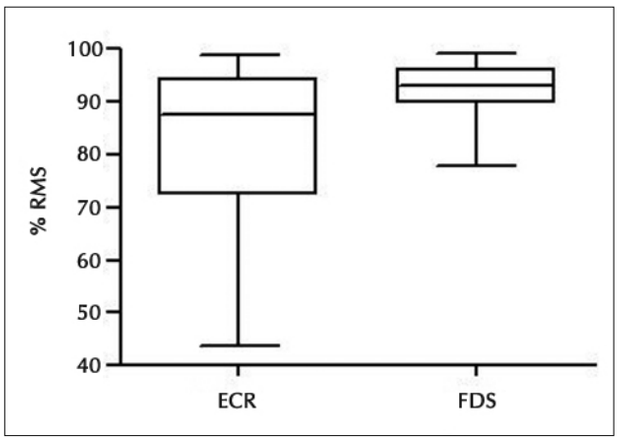

Figure 2. Mean amplitude of normalized values of electromyography activity (RMS)

correlate this activity with wrist ROM during a power sustained grip task aiming to know the normality parameters in healthy subjects.

Methods

Participants

Thirty four healthy female students, right-handed, mean age 23 years were recruited from a university campus and classified as sedentary or insufficiently active according to the International Physical Activity Questionnaire (IPAQ)[12]. Exclusion criteria in this study

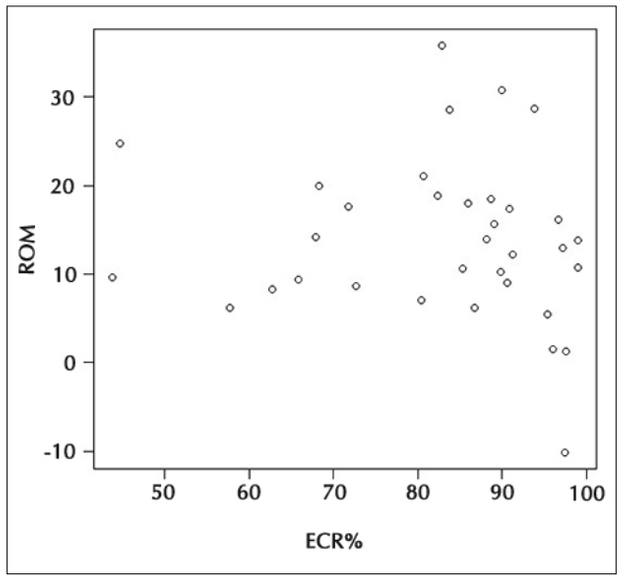

Figure 3. Average percentage of muscle activation of the extensor carpi radialis muscles (ECR) and flexor digitorum superficialis (FDS) during hand grip task

were pain and/or history of previous upper limb orthopaedic or neurological disorders.

All subjects signed a written consent prior to testing and the study was approved by the Ethics Committee of the Hospital Clinics of the Faculty of Medicine of Ribeirão Preto of the São Paulo University, SP, Brazil (No. 8379/2010).

EMG activity and wrist angle

Surface electromyography (SEMG) muscle activity was recorded by Miotool 400 System™, which has an A/D converter of 14 bits of resolution, a data acquisition board of 2000 samples per second, and 100dB of common-mode rejection and produced a 1000 times increase in signal amplification. The signals were band-pass filtered (10-500 Hz). Medtrace™ bipolar, adhesive, and disposable Ag/AgCl EMG surface electrodes were positioned with an interelectrode distance of 20 mm, and placed over extensor carpi radialis (ECR) and flexor digitorum superficialis muscle (FDS) according to Cram, & Kasman[13] recommendations and confirmed by using the clinical palpation method during muscle-specific movement of the wrist and fingers. Prior to electrode placement, skin was shaved and cleaned with 70% alcohol to minimize contact impedance. The reference electrode was positioned on the volunteer's ipsilateral acromion process. Adhesive tape was used to hold the active and reference electrodes.

Wrist ROM was measured with electrogoniometer Miotec™. The axis was positioned at ulnar styloid process and the arms aligned in the hand and at the forearm edge.

Procedure

The subject position for grip task followed the American Society of Hand Therapists[14] using Jamar hand

dynamometer (Jamar Inc. Jackson, MI™) in position 2. The predefined task was three isometric grips sustained, with maximal voluntary contraction (MVC) with the dominant hand, during six seconds and two minutes of rest between contractions (Figure 1). The volunteers were also instructed to maintain the trunk in the upright position and the feet in the neutral position.

Data analysis

SEMG data and electrogoniometer signals were processed by Miograph software™. The mean percentages of the RMS (Root Mean Square) values of the 6 seconds[11] were normalized with MVE (maximal voluntary electrical activation) by manual resistance for ECR. Peak FDS muscle was determined by the same grip task. Pearson coefficient was used to correlate the peak of wrist ROM and mean of EMG activity through SAS® 9.1™ software[15].

Results

The results of this experiment showed that the mean amplitude of normalized values of electromyography activity from the participants were high for both muscle groups during the grip sustained task (Figure 2).

The electrogoniometry analysis of ROM shows an average of 13,92º + 9,18º for wrist extension (minimum -10,1º; maximum 35,8º). There was no significant correlation between ROM in degrees and % SEMG activity for extensor carpi radialis (0,12).

Discussion

In this study, subjects were asked to exert maximum strength during isometric sustained grip without any wrist joint support. The FDS was more activated than ECR during the task in a ratio of 1:0.89 respectively. However, Mogk, & Keir[1] showed that the extensor muscles were much more active than flexors while simply holding the dynamometer especially with pronated forearm. These authors analysed others extensor and flexor forearm muscles than this present study.

The high activity of ECR, almost the same of FDS, reinforces the importance of the synergism between these muscles during the power grip task. Co-activation between wrist extensors and digital flexors is reported by De Serres, & Milner[16] as a control strategy to increase joint stability and minimise deviation from the desired position with grip exertion.

Shimose, Matsunaga, & Muro[4] showed the importance of wrist extensor muscles during gripping. After a training that consisted of 30 repetitions equal to 70% MVC of isometric wrist extension for 8 weeks (5/week) on the right side, the gripping force on the trained side increased significantly. EMG activation of forearm extensors also increased whereas flexors decreased.

In the present study the wrist movement was free and no support was used to fix the wrist position. The results have not found a correlation between wrist range of motion and extensor muscle activity. It is believed that the optimal length-tension relationship of extensor muscle does not depend on reaching high wrist angle amplitude. The ROM mean was 13,92º, but the standard deviation was high, ranging 10º of flexion to 35º of extension. Li, & Caton[17] correlated the grip strength and wrist angle in their study and the results showed that the peak of grip strength was produced at 20º of extension. However, Bhardwaj, Nayak, & Sabapathy[2], recorded maximum average grip strength when the wrist was held at 45º of extension. Shimose, Matsunaga, & Muro[4] founded maximal gripping force at around 30º of extension, but there was a large difference between individual (from 10º to 70º extension wrist) similar to our data. They suggest that this difference in range of motion is most related to an optimal individual wrist angle during gripping. These finding can be considered in situations that the wrist must be splinted or fixed, like in arthrodesis operations.

Johanson, James, & Skinner[18] measured grip strength in ten healthy individuals to analyse muscle activation pattern by submaximal force, concluding that subjects use different motor strategies specific to different patterns of timing. However, the study was composed of a small sample, no difference between genders and with great difference in age, factors that could influence the results.

According to Johnston, Bobich, & Santello[19], if a hand gripping task requires the exertion of constant fingertip forces, the Central Nervous System (CNS) may respond with changes in wrist angle by modulating the neural drive to extrinsic or intrinsic muscles alone or co-activating both sets of muscles.

The imbalance of forearm flexors and extensor muscles is one of pathophysiological factors of lateral epycondilitis. Alizadekhaiyat, *et al.*[20], showed a decrease of extensor carpi radialis activation in these patients compared with healthy men during gripping.

Others pathological conditions can change the grip force. Synergistic muscle activity suggested in this study can be considered in rehabilitation programs when the purpose is improve the grip function or prevent disorders caused by imbalance between flexor and extensor forearm muscles.

The limitation of this study is related to no predefined standardization in literature related to maximal voluntary electrical activation for forearm muscles. So, we predefined them by preview tests and according to Cram, & Kasman[13] recommendations, confirmed by clinical palpation method during muscle-specific movement of the wrist and fingers.

Conclusions

The high EMG activity of extensor muscles during the power sustained hand grip found in this study reinforces its important synergistic role during a power sustained hand grip. The normality parameters can be considered in preventive and rehabilitation programs. The findings also suggest that there are different strategies of wrist extension ROM during grip. Others studies

should be performed aiming to analyse the influence of others extensor muscle in this parameters.

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