86 - NEUROMUSCULAR ACTIVATION OF TRUNK MUSCLES DURING SIT-UP EXERCISES WITH AND WITHOUT AB ROLLER

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INTRODUCTION

Different sit-up techniques with and without special devices are practiced in fitness studios and rehabilitation clinics in order to strengthen the trunk muscles and to increase the stability of the trunk. Partial and oblique sit-ups with and without devices are applied for esthetic and therapeutic purposes. Many devices are commercialized with the promise to be more effective than exercises without devices and to guarantee a more intensive neuromuscular activity of the involved muscle groups. Therefore these commercial affirmations should be verified by scientific research. Various authors [1,9,10,12,13,14] investigated the neuromuscular innervation pattern comparing sit-up exercises in different situations and recommended further studies about this problem.

Therefore the aim of this study was to compare the neuromuscular innervation pattern of the trunk's muscles (m. rectus abdominis, m. obliquu externus, m. erector spinae), m. rectus femoris and the m. sterocleidomastoideus of two sit-up exercises, the partial and cross crunch sit-up, with and without the use of a roller.

The following hypotheses were tested: There are no significant differences of the rout mean square (RMS) and peak of innervation (PI) of the EMG of the investigated muscles (trunk muscles, m. rectus abdominis and m. sterocleidomastoideus) between sit-up exercises with and without the use of an AB roller.

METHODS

Characteristics of the subjects

The subjects of this study were six male solders with mean age of 22,3 $\pm$ 4,3 years, body mass 75,16 $\pm$ 9,6 kg and body height of 1.72 $\pm$ 0.04 m. No one of the subjects presented any pathology or pain of the trunk and spine. After the project had been approved by the Ethics Committee of the university, the individuals were informed about the objectives of the study and signed their consent to the procedure.

Execution of the sit-up exercises

The subjects were randomly divided in two groups (G1 and G2) of three individuals. Each group started with another sit-up exercise in order to avoid a possible influence of the order of the execution of the exercises on the result of the study. For every sit-up exercise, with and without roller, the two groups performed two series with 20 repetitions and 2 min rest intervals between the series. The frequency of repetitions was 0.5 Hz. This frequency corresponds to the frequency used in their physical training programs. Since the subjects already had been members of the army for more than 2 years, they were accustomed to the exercises without use of the roller. Therefore familiarization was only necessary for the exercises with the roller.

All sit-up exercises started in a lateral or dorsal position where the positions of the knees, hips, shoulders and elbows were adjusted according to each exercise.

Partial sit-up

Starting from the initial position with knees at 90º flexion, distance between the feet as hip width, left (right) hand at the right (left) shoulder, the individual flexes the trunk up to an approximately 40º angle between trunk and floor (scapular losing contact with the ground) and returns to the initial position.

Partial sit-up with Ab roller

Starting from the initial position with knees at 90º flexion, distance between the feet as hip width and the head supported by the headrest of the roller. The hands hold the grip above the headrest of the roller. The individual flexes the trunk up to an approximately 40º angle between trunk and floor (scapular losing contact with the ground) and returns to the initial position.

Cross crunch sit-up

Starting from the initial position with left knee at 90º flexion and the right ankle contacting the thigh (near left knee), the left hand touches the neck and the right elbow abducted in a 90º angle in relation to the ground, the individual rotates the trunk moving the left elbow to the right knee and returns to the initial position.

Cross crunch sit-up with Ab roller

Starting from the initial position with knees at 90º and hips at 120º flexion, the left foot contacts the right one and the left hip is slightly abducted. The head is supported by the headrest so that the trunk obtains a rotated position and the hands hold the grip above the headrest. The subject performs a rotation and lateral flexion of the trunk moving the left elbow to the right knee.

Materials

The exercises were performed on a board with a length of 120 cm and a width of 80 cm. The board had two windows in order to avoid contact of the electrodes fixed at the mm. erectus spinae with the surface. The frequency of the execution of the sit-ups was given by a digital metronome (Qwik time - quartz metronome QT-3, 0,5 - 4 Hz).

Data aquisition

The EMG signal was captured by superficial electrodes (Midi-Trace® 200 Foam) where the amplifiers were assembled to the cable (BIOVISION) and the software DasyLab 5.0. The A/D converter was a DaqPad 1200 (National Instruments) and the frequency of data acquisition was 1000 Hz. The locations where the electrodes were fixed on the surface of each muscle (m. rectus femoris, m. obliquu externus, m. rectus abdominis upper and lower portion, m. sterocleidomastoideus, m. erector spinae) are described by Cram (1998) [4] and Basmajan & DeLuca (1985) [5].

The EMG signals were first filtered by a Butterworth filter (4th order) with cutting frequencies of 410 Hz and 16 Hz (LaPier, 2000)[9] and a notch filter of 60 Hz, and then rectified [2, 14,15]. The initial 5 contractions were not considered for analysis, but the EMG signals of the next 10 contractions were normalized by the mean of RMS and the peak of innervation (PI) of each contraction [13].

For the m. rectus femoris, m. obliquu externus and m. rectus abdominis the beginning and end of each innervation was determined as proposed by DiFabio (1997) [6], based on the intensity of the signal's noise during rest period. Since the activity of m. sterocleidomastoideus e m. erector spinae was not interrupted by a rest period which made it impossible to apply the criterion suggested by DiFabio (1997) [6], concentric and eccentric phases were distinguished by the duration (frequency) of each movement cycle.

After the determination of the beginning and end of each activation phase RMS and PI were determined [9]. RMS is usually used for analyses of EMG amplitude during dynamic contractions because it represents the performance of the motor units during muscular contraction [5,7], whereas the PI informs quantifies the major recruitment of motor units [8,11].

Statistics

In order to identify differences of RMS and PI between the exercises, the WILCOXON test was applied using SPSS 10.0.

RESULTS

The tables 1 and 2 show the results of the Wilcoxon test comparing RMS and PI of the analyzed muscles during partial sit-up with and without Ab roller (tab. 1) and during cross crunch sit-up with and without Ab roller (tab.2).

Table 1 Difference RMS [mV] and PI [mV] between partial sit-up with and without ab roller.

Muscle	RMS	PI
sterno	0,48	0,82
rectus up	1,00	1,00
rectus lo	0,69	0,82
obl ex	0,69	0,94
rectus fem	0,82	0,70
erector sp	0,69	0,82

*p<0,05

Table 2 Difference RMS [mV] and PI [mV] between cross crunch sit-up with and without ab roller.

Muscle	RMS	PI
sterno	0,08	0,01 *
rectus up	0,82	0,82
rectus lo	0,24	0,24
obl ex	0,09	0,04*
rectus fem	0,82	0,39
erector sp	0,93	0,93

*p<0,05

sterno - m. sternocleidomastoideus
rectus up - m. rectus abdominis upper portion
rectus lo - m. rectus abdominis lower portion
obl ex - m. obliquu externus
rectus fem - m. rectus femoris
erector sp - m. erector spinae

No significant differences of RMS and PI of the analyzed muscles could be found between sit-up with and without ab roller, whereas PI of m. sternocleidomastoideus and m. obliquu externus represent significant differences between cross crunch sit-up with and without ab roller.

DISCUSSION

Partial Sit-up with and without ab roller

Concerning RMS and PI there are no differences between partial sit-up with and without Ab roller. The intensity of the innervation signal of the trunk muscles is very similar with and without using an Ab roller, which was also proved by Vaz et al. (1999) [13] who did not find significant differences of RMS of m. rectus abdominis, m. obliquu externus e interno and who stated that the electric activity of the analyzed muscles is very similar if different devices are used. The results of Beim et al. (1996) [3] who compared the IEMG of 6 sit-up exercises with and without using a device also found out that there were no significant differences concerning the m. rectus abdominis and m. obliquu. LaPier et al. (2000) [9] however concluded that partial sit-up is characterized by a higher peak of activation than ab roller curl-up because of the effect of the gravity that affects the head.

Cross crunch sit-up with and without ab roller.

For the cross crunch sit-up significant differences of peak innervation could be found between the exercise with and without ab roller. These differences affect the m. sternocleidomastoideus and m. obliquu externus which have higher peaks of innervation without ab roller, whereas no differences were detected concerning RMS. The higher peaks are observes at the initial phase of the exercise because of the higher inertial forces. This means that the exercise without ab roller seems to be more effective.

CONCLUSION

It can be concluded that for trained individuals there are nearly no differences of innervation patterns of partial sit-up and cross crunch sit-up if they are executed with or without ab roller. Significant differences could only be identified between cross crunch sit-up with and without ab roller concerning the peak innervation of m. sternocleidomastoideus and m. obliquu externus.

At least for trained individuals the ab roller might be useful for motivation purposes and to provide more comfortable postural conditions during the execution of the exercises.

In future studies a greater number of subjects should be analyzed. Possible differences between male and female subjects of different performance levels and other sit-up exercises should be investigated.

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NEUROMUSCULAR ACTIVATION OF TRUNK MUSCLES DURING SIT-UP EXERCISES WITH AND WITHOUT AB ROLLER

Abstract

Different sit-up techniques with and without special devices are practiced in fitness studios and rehabilitation clinics in order to strengthen the trunk muscles and to increase the stability of the trunk. Partial and oblique sit-ups with and without devices are applied for esthetic and therapeutic purposes. The aim of this study was to compare the neuromuscular innervation pattern of the trunk's muscles (m. rectus abdominis, m. obliquu externus, m. erector spinae), m. rectus femoris and the m. sterocleidomastoideus of two sit-up exercises, the partial and cross crunch sit-up, with and without the use of a roller. Six male with mean age of 22,3 ± 4,3 years, body mass 75,16 ± 9,6 kg and body height of 1.72 ± 0.04 m, performed 2 series with 20 repetitions of each exercise. The EMG signals were measured by bipolar surface electrodes. Ten contractions of each muscle were choice to be analyzed to each abdominal exercise. To save, filter and rectify the collected data used The DasyLab 5.0 software. The beginning and end of each innervation for the m. rectus femoris, m. obliquu externus and m. rectus abdominis was determined by the intensity of the signal's noise during rest period. The activity of m. sterocleidomastoideus e m. erector spinae was not interrupted by a rest period which made it, concentric and eccentric phases were distinguished by the duration (frequency) of each movement cycle. The data normalization was calculated by the average of the subject's RMS and PA within each muscle group. There aren't differences of innervation patterns of partial sit-up and cross crunch sit-up if they are executed with or without ab roller. Significant differences could only be identified between cross crunch sit-up with and without ab roller concerning the peak innervation of m. sternocleidomastoideus and m. obliquu externus.

Key words: Electromyography, abdominal exercises, muscle abdominal

ÉTUDE COMPARATIVE de l'ACTIVATION NEUROMUSCULAIRE des MUSCLES du TRONC, du RECTUM FEMORAL Et de l'ESTERNOCLEIDOMASTÓIDEO PENDANT l'EXÉCUTION de DEUX EXERCICES ABDOMINAUX AVEC Et SANS APPAREIL

Résumé

Techniques différentes d'exercices abdominaux avec ou sans l'usage de vêtements ils sont exécutés dans les académies et dans cliniques de la rééducation avec objectif de l'invigoration et il va mieux de la stabilité du tronc. Les exercices l'exercice abdominal partiel et oblique est le plus utilisé par les individus sains et aussi pour malades avec plusieurs diagnostics. Le but de l'étude était comparer l'activation neuromusculaire du rectum des muscles fémoral, droit abdominal, oblique externe, en élevant de la colonne vertébrale et esterocleidomastóideo pendant l'exécution de deux exercices abdominaux, exercice abdominal partiel et oblique avec et sans usage de vêtement abdominal. Six individus sains avec âge de 22,3 + 4,3, ils ont accompli 2 séries de 20 répétitions avec intervalle de 2 minutes parmi la série et parmi les exercices. L'activation neuromusculaire a été capturé à travers l'eletromiografia de la surface avec les électrodes bipolaires. Le commencement et la fin de chaque contraction ont été trouvées initial de la pioche d'activation du signe du reste pour les muscles rectum fémoral et oblique abdominal, droit externe. Pour l'esternocleidomastóideo et élever de la colonne vertébrale la fréquence d'exécution de 0,5 Hz qui correspond au mouvement a été utilisée. Dix contractions de chaque muscle ont été choisies car ils soient analysés. Le programme Dasylab 5.0 a été utilisé sauver, filtrer, rectifier et analyser l'eletromiogramas. La normalisation des données a été accomplie par la moyenne de RMS et pour la pioche maximale de l'activation des individus pour chaque groupe musclé. L'épreuve de Wilcoxon a été utilisée pour comparer RMS et la PA des muscles parmi les exercices. Il n'y avait pas différence considérable dans le valos de RMS des muscles étudié pendant l'exécution des exercices abdominaux différents. Pour l'exercice oblique, il y avait la différence considérable dans la PA de l'esternocleidomastóideo des muscles et trait oblique externe, soigne la plus grande pioche quand il/elle a lieu l'exercice sans vêtement. La plus grande pioche a été observée au début du mouvement.

Les mots accordent: Eletromiografia, Exercices abdominaux, Muscles abdominaux.

ESTUDIO COMPARATIVO DE LA ACTIVACIÓN NEUROMUSCULAR DE LOS MÚSCULOS DO TRONCO, RECTO FEMORAL E ESTERNOCLEIDOMASTÓIDEO DURANTE LA EJECUCIÓN DE DOS EJERCICIOS ABDOMINALES CON Y SIN APARELHO

Resumen

Diferentes técnicas de ejercicios abdominales con o sin la utilización de aparatos son ejecutados en gimnasios y en clínicas de rehabilitación con el objetivo de fortalecer y mejorar la estabilidad del tronco. Los ejercicios sit-up parcial y oblicuo son los más utilizados por individuos saludables y también por pacientes con varios diagnósticos. El propósito del estudio fue

comparar la activación neuromuscular de los músculos recto femoral, recto abdominal, oblicuo externo, erectores de la espina y esternocleidomastoideo durante la ejecución de dos ejercicios abdominales, sit-up parcial y oblicuo con y sin la utilización de aparato abdominal. Seis individuos saludables con edad de 22,3 +_ 4,3, realizaron 2 series de 20 repeticiones con intervalo de 2 minutos entre las series y entre los ejercicios. La activación neuromuscular fue captada a través de la electromiografia de superficie con electrodos bipolares. El inicio y el final de cada contracción fueron encontrados a partir del pico de activación de la señal de reposo para los músculos recto abdominal, recto femoral y oblicuo externo. Para el esternocleidomastoideo y erectores de la espina se utilizó la frecuencia de ejecución de 0,5 Hz correspondiente al movimiento. Diez contracciones de cada musculo fueron escojidas para ser analizadas. El programa Dasylab 5.0 fue utilizado para salvar, filtrar, rectificar y analizar los electromiogramas. La normalización de los datos fue realizada por la media de RMS y por el pico máximo de activación de los individuos para cada grupo muscular. El test de Wilcoxon fue utilizado para comparar las RMS y el PA de los musculos entre los ejercicios. No hubo diferencia significativa en los valores de RMS de los musculos estudiados durante la ejecución de los diferentes ejercicios abdominales. Para el ejercicio oblicuo, hubo diferencia significativa no PA de los músculos esternocleidomastoideo y oblicuo externo, teniendo el mayor pico cuando se realiza el ejercicio sin aparato. El mayor pico fue observado en el inicio del movimiento.

Palabras clave: Electromiografia, Ejercicios abdominales, Músculos abdominales.

ESTUDO COMPARATIVO DA ATIVAÇÃO NEUROMUSCULAR DOS MÚSCULOS DO TRONCO, RETO FEMORAL E ESTERNOCLEIDOMASTÓIDEO DURANTE A EXECUÇÃO DE DOIS EXERCÍCIOS ABDOMINAIS COM E SEM APARELHO

Resumo

Diferentes técnicas de exercícios abdominais com ou sem a utilização de aparelhos são executados em academias e em clínicas de reabilitação com objetivo de fortalecimento e melhora da estabilidade do tronco. Os exercícios sit-up parcial e oblíquo são os mais utilizados por indivíduos saudáveis e também por pacientes com várias diagnoses. O propósito do estudo foi comparar a ativação neuromuscular dos músculos reto femoral, reto abdominal, oblíquo externo, eretores da espinha e esterocleidomastóideo durante a execução de dois exercícios abdominais, sit-up parcial e oblíquo com e sem utilização de aparelho abdominal. Seis indivíduos saudáveis com idade de 22,3 ± 4,3, realizaram 2 séries de 20 repetições com intervalo de 2 minutos entre as séries e entre os exercícios. A ativação neuromuscular foi captada através da eletromiografia de superfície com eletrodos bipolares. O início e o final de cada contração foram encontrados a partir do pico de ativação do sinal de repouso para os músculos reto abdominal, reto femoral e oblíquo externo. Para o esternocleidomastóideo e eretores da espinha utilizou-se a freqüência de execução de 0,5 Hz correspondente ao movimento. Dez contrações de cada músculo foram escolhidas para serem analisadas. O programa Dasylab 5.0 foi utilizado para salvar, filtrar, retificar e analisar os eletromiogramas. A normalização dos dados foi realizada pela média de RMS e pelo pico máximo de ativação dos indivíduos para cada grupo muscular. O teste de Wilcoxon foi utilizado para comparar as RMS e o PA dos músculos entre os exercícios. Não houve diferença significativa nos valos de RMS dos músculos estudados durante a execução dos diferentes exercícios abdominais. Para o exercício oblíquo, houve diferença significativa no PA dos músculos esternocleidomastóideo e oblíquo externo, tendo o maior pico quando se realiza o exercício sem aparelho. O maior pico foi observado no início do movimento.

Palavras chave: Eletromiografia, Exercícios abdominais, Músculos abdominais.