EVALUATION OF SHOULDER INTERNAL AND EXTERNAL ROTATION EXERCISES USING THERABAND: ELECTROMYOGRAPHY ANALYSIS

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Introduction
The prescription of exercises for functional recovery after muscular lesions, postoperative and fractures emphasize exercises of passive and active mobility, following by exercises with low invigoration level during the initial phase of recovery. The exercises, during this process, are addressed to increase the muscle's capacity to generate tension, flexibility and resistance, restoring the kinematics of the movement, making possible the patient's return for their daily and esportive activities.

Theraband is a device of elastic resistance commonly used to increase the muscular force. According to HINTERMEISTER (1998) the use of an elastic resistance propitiates to patients the execution of exercises, in a slow and controlled way, with a low muscular load in both concentric and eccentric conditions. SIMONEAU (2001) also points as advantages for the use of elastic bands its low cost and great versatility when using in programs of therapeutic exercises. HUGHES (1999) also evidences the portability and the non-dependence of the gravity.

Several studies have been showing the use of electromyography (EMG) to document the activity of the shoulder muscles. The results from these studies together with the knowledge of functional anatomy, biomechanics and shoulder's clinical exam, can aid to develop preventive exercises, rehabilitation protocols and surgical procedures, all based on scientific data found in researches previously accomplished. The relative knowledge of the level of muscular activity (EMG), the perpendicular distance, the resistance offered by Theraband (force's magnitude), and the angle between the mobile segment and the direction which the resistance force acts, makes possible the therapist to prescribe appropriate exercises in a rehabilitation program (LIEBER et al. 1993, apud HUGHES, 1999).

Thereby, the present study had the objective of evaluate the electromyographical activity of muscular groups in the shoulder's area during the execution of exercises accomplished with the aid of Theraband.

Methodology
Two exercises were executed, internal and external rotation of the shoulder. For each exercise were made two variations in the place of fixation of Theraband. The load of Theraband was evaluated through the resistance torque offered by it.

Sample: The sample was composed by 10 healthy individuals, all male, with age between 22 to 28 years (with mean age of 23.6±2.3) years without history of recent shoulder. All participants consented their participation in the research formally through the signature of a Term of Informed Consent.

Protocol of Exercise: The protocol is constituted in the accomplishment of two external rotation (ER) and internal rotation (IR) exercises of the shoulder, always using a silver Theraband with 30 cm of initial length. Each exercise began in the joint's neutral position and it continued to the maxim possible width, without abduction of the shoulder. The execution speed, stipulated in eight seconds for each complete cycle of movement (four seconds for the concentric phase and four seconds for the eccentric), was ritemaited with the help of a metronome which supplied to the performer a hearing sign. For each one of these exercises, were created two variations that were based on the final angle between Theraband and the performer's forearm. Were chosen two final angles that represent a situation of minimal torque possible and another of maximal torque possible. This way, in one of the situations, the final angle between Theraband and the forearm should be the closest of 90° and in the other in the smallest possible angle. The determination of the smallest angle was followed in agreement with the movement width verified for each individual, respecting their anatomical and joint characteristics. Therefore, four situations were accomplished:

(a) Shoulder's ER with smallest final angle possible (ER < 90°);
(b) Shoulder's ER with final angle close to 90° (ER 90°);
(c) Shoulder's IR with smallest final angle possible (IR < 90°);
(d) Shoulder's IR with final angle close to 90° (IR 90°).

The sequence for execution of the exercises was randomized by draw. For each one of the created situations, five repetitions of external rotation (ER) and internal rotation (IR) were accomplished on the shoulder. That way each participant completed a total of 20 repetitions.

Goniometry: With the purpose of registering the joint's position articular of the segment an electrogoniometer (Biometrics, model XM110) was used. The electrogoniometer was positioned with adhesive tape in the proximal and posterior portion of the arm close to the shoulder (considered a fix shaft) and in the more distal portion of the arm, close to the olecranon (mobile shaft). The electrogoniometer was connected to a microcomputer Pentium III 650 MHz through an analogical-digital converter (16 bits) of 16 channels. The signal's acquisition rate was of 2000 Hz. A manual goniometer was used to check the final angle between Theraband and the individual's forearm.

Electromyography: The muscular activity was monitored through surface electromyography, with disposable electrodes Meditrace (Ag/AgCl), in bipolar configuration, positioned in the most prominent belly of the muscle, parallel to the orientation of the muscular fibers, with a distance of 2.5 cm between the center of the electrodes. The reference electrode was positioned on the clavicle of each individual. All the procedures related to acquisition and treatment of the electromyographic signal suggested by Ávila et al. (2002) were respected. A six-channel electromygogram was used in differential configuration, with a pre-amplifier close to the electrodes, built at the School of Engineering of UFRGS, with the following technical characteristics: total gain of 1000 times, 10 Gohms of input impedance, CMRR=120 dB (60 Hz), frequency answer of 10 Hz - 1000 Hz. The electricalmyogram was connected to the same analogical-digital converter as the electrogoniometer, and the of acquisition frequency of the sign was of 2000 Hz per channel. The electromyographic signals were normalized from maximum voluntary contractions (MVC), accomplished isometrically. Two MVCs were accomplished, both with the elbow...
close to the body and in 90° flexion, radii-ulnae joint in neutral position. Immobilized in this position, each individual was oriented to repeat three external rotation and three internal rotation attempts with a 2 seconds approximate duration. The highest activation obtained for each one of the monitored muscles was considered for normalization purposes.

Procedures: The acquisition process the EMG signal began with the individual maintaining the arm relaxed along the body, and as follow, the individual was guided to accomplish an elbow's flexion of 90°, trying to find, with the help of the electrogoniometer, the point of neutral rotation. Found the point, the individuals were instructed to hold the catcher in the Theraband and to accomplish the execution of an exercise of ER and IR. At the end of each repetition, the individual returned the forearm to the neutral position. Concluded the five repetitions, the participants were guided to maintain the elbow in flexion for few seconds and, afterwards, to relax, returning the arm along the body. The sequence of the exercises was randomized by draw.

Data treatment: The acquisition and analysis of the data was accomplished through the use of a specific software developed at the School of Engineering of UFRGS (SAD32 - System of Acquisition of Data). The EMG signal was normalized by MVC of each muscle, and later softened by move window RMS, with a window of 0.5 seconds. The total activity of each muscle was expressed by the mean of all five executions for ER and IR considering the concentric and eccentric contractions. Wasn't made a separate analysis from the concentric and eccentric contractions, during the shoulder's ER and IR movement. Considering that, in a rehabilitation program it is very common to realize an exercise without separation of the concentric and eccentric phases, the quantification by the total mean represents all the electric activity that happened during the concentric and eccentric phases.

Statistical analysis: For accomplishment of the statistical analysis was used the statistical package SPSS, version 10.0, through the t test for paired samples in the comparisons between the means of the variables in the different analyzed situations (ER < 90, ER 90, IR < 90 and IR 90). The level of assumed significance was p < 0.05.

Results
Through a general analysis on the activity of the agonists muscles in the 20 executions, during the exercises of shoulder's IR, it can be verified that the more activated muscle was the major pectoralis, in 15 of the 20 executions. YI-WEN et al (2000), aiming to evaluate the force of the internal rotators muscles of the shoulder, found similar results, pointing the major pectoralis and the subscapular as the main internal rotators. HINTERMEISTER et al (1998) quantifying the EMG activity of the internal rotators subscapular, anterior deltoid, major pectoralis, in 7 rehabilitation exercises using elastic resistance, showed a larger activity in the subscapular muscle. For the exercises of ER, the more activated muscle was the infraspinatus, in 19 of the 20 executions. These results coincide with the data of HINTERMEISTER et al (1998) in similar exercises also using elastic bands. In a similar study, BALLANTYNE et al (1993) they demonstrated that the muscle more activated during the ER exercise was the infra-spinal and teres minor. In this study, the subscapular and teres minor muscles were not evaluated, due to the difficulty of monitoring deep muscular groups with surface electrodes. The appropriate method of monitoring would be the use of depth electrodes. According to CORREIA et al (1993), besides being an invasive method, this type of electromyographical registration evaluates a tiny portion of the total muscle, limiting the conclusions when they are about comparative kinesiological analyses.

Comparing the EMG activity between the two variations in the final angles, it can be verified that during the external rotation movement, the muscle infraspinatus had the largest mean EMG activity in the two situations, independently of the torque's magnitude. The other external rotators analyzed (supraspinal and posterior deltoid) alternate as the second muscle more activated depending on the angle chosen for the Theraband. For the internal rotation movement, there is difference in the activation level between the angles, close to 90° and smaller than 90°. In the angle smaller than 90°, the more activated muscle, in 100% of the executions, it was the major pectoralis. When the final angle between Theraband and the segment was close to 90°, there was no prevalence of any of the activated muscles. The major pectoralis was the more activated muscle in 50% of the cases, while in the other 50%, the teres major was the muscle with higher mean activity.

In general, the activation of all muscles reduced when the angle between Theraband and the segment was smaller than 90°, except for the anterior deltoid, muscle presented an increase in its activity in the angle smaller than 90°. Through an statistical analysis, it was possible to prove that there was significant difference in the activation of the infra-spinal, supraspinal, posterior deltoid and teres major muscles, during the external and internal rotation exercises of the shoulder, in the angles close to 90° and smaller than 90°. Just the major pectoralis and anterior deltoid didn't present significant difference. The reduction in activity can be confirmed through the Table 1, that demonstrates the mean activation of the muscles in the external and internal rotation exercises of the shoulder.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Angle &lt; 90°</th>
<th>Angle ≥ 90°</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infra-spinal</td>
<td>13.75 ± 6,65</td>
<td>19.85 ± 6,49</td>
<td>p = 0,022</td>
</tr>
<tr>
<td>Supra-spinal</td>
<td>7.67 ± 4,45</td>
<td>12.19 ± 4,07</td>
<td>p = 0001</td>
</tr>
<tr>
<td>Posterior</td>
<td>4.66 ± 2,91</td>
<td>10.47 ± 4,99</td>
<td>p = 0001</td>
</tr>
<tr>
<td>Deltoid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pectoralis</td>
<td>14.87 ± 8,56</td>
<td>14.96 ± 8,17</td>
<td>NS (p=0.960)</td>
</tr>
<tr>
<td>Major redondo</td>
<td>3.89 ± 2,31</td>
<td>14.33 ± 9,54</td>
<td>p = 0004</td>
</tr>
<tr>
<td>Anterior</td>
<td>2.81 ± 2,11</td>
<td>1.9 ± 1,10</td>
<td>NS (p=0.961)</td>
</tr>
</tbody>
</table>

* NS: statistically non-significative difference

The understanding on the interrelation of the angle with the level of muscular activity can help the prescription of exercises in the rehabilitation programs. The reduction in the myoelectrical activity, observed in this study, can be explained by the reduction in torque to each exercise. The results allow us to infer the importance of observing the angle of Theraband during the exercises' prescription, besides the factors traditionally observed (color, length, initial tension, use double or simple, etc). The data here presented show, clearly, a smaller demand of the musculature, depending on the positioning of Theraband. A first application would be to use the Theraband's angle as a form of gradation of the demand of the exercise. In final angles
smaller than 90°, the demand is inferior that the one needed used in final angles close to 90°.

A reduction in the mean activity of some muscles, statistically proven, also reflects the necessary care for the appropriate prescription of the exercise, considering the type of lesion, the recovery stage, and the objectives to be reached. It can be interesting to work the specific reinforcement of a certain musculature, while others don’t suffer a substantial increase in its load. In a rehabilitation program, with the objective of recovering the internal rotation movement, for instance, it can begin the work with a TheraBand positioning in a final angle much smaller than 90° and, to proceed, pass for a final angle close to the 90°. This procedure would maintain the activity in the anterior deltoid and teres major muscles, however it would increase the demand on the teres major. This procedure would allow, this way, a practically isolated work of a specific musculature, in the case, the teres major.

CONCLUSIONS

Based on the results presented it is possible to affirm that in of a rehabilitation program, the TheraBand’s angle with the segment can be used as a resource to work isolated muscular groups.

REFERENCES


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EVALUATION OF SHOULDER INTERNAL AND EXTERNAL ROTATION EXERCISES USING THERABAND: ELECTROMYOGRAPHY ANALYSIS

Abstract

The prescription of exercises for functional rehabilitation of post muscle lesions, post surgical and fractures emphasize the use of exercises of passive and active mobility, followed by exercises with lower levels of strength during the initial recuperation phase. The exercises during this process have the purpose of increasing the muscle capacity for stress generation, flexibility and resistance, restoring the kinematics of the movement and this way allowing the return of the patient or his daily and sportive activities. TheraBand is an approach of elastic resistance commonly used to increase muscle strength. The aim of the present study is to evaluate the electromyography activity of muscle groups of the shoulder during the execution of exercises performed with TheraBand. Ten individuals executed two exercises: shoulder internal rotation (RI) and external rotation (RE). For each exercise it was made two variations on the fixation place of the TheraBand. The load of the TheraBand was evaluated through the resistance moment offered by it. It was collected the superficial electromyography signals from the muscles infraspinatus, supraspinatus, deltoideus anterior and posterior, teres major and pectoralis major. During the RI exercises, the most activated muscle was pectoralis major. For RE exercises, the most activated muscle was infraspinatus. In general, the activation of all muscles was higher when the angle between the TheraBand and the segment ended close to 90°. Based on the results it is possible to say that in a rehabilitation program, the angle between the TheraBand and the segment can be used as a way to work with isolated muscle groups.

Key-words: TheraBand, shoulder, electromyography

ÉVALUATION D’ÉPAULE INTERNE ET D’EXERCICES DE ROTATION D’EXTERNAL EN UTILISANT THERABAND: ANALYSE D’ELECTROMYOGRAPHIE

Résumé

La prescription des exercices pour la réadaptation fonctionnelle des loisirs de muscle de poteau, signalent chirurgical et les ruptures soulignent l’utilisation des exercices de la mobilité passive et active, suivis des exercices avec des niveaux plus bas de force pendant la phase initiale de récupération. Les exercices pendant ce processus ont le but d’augmenter la capacité de muscle pour la génération, la flexibilité et la résistance d’effort, reconstituer la cinématique du mouvement et de cette façon permettant le retour du patient ou de ses activités quotidiennes et folâtres, TheraBand est une approche de la résistance élastique généralement employée pour augmenter la force de muscle. Le but de la présente étude est d’évaluer l’activité d’electromyographie des groupes de muscle de l’épaule pendant l’exécution des exercices exécutés avec TheraBand. Dix individus ont exécuté deux exercices: rotation interne d’épaule (RI) et rotation externe (RE). Pour chaque exercice c’a été fait à deux variations sur l’endroit de fixation du TheraBand. La charge du TheraBand a été évaluée par le
moment de résistance offert par elle. C’a été rassemblé les signaux superficiels d’électromyographie de l’infra-spinatus, du supra-spinatus, du deltoïde antérieur et postérieur, des teres commandant et du grand pectoral de muscles. Pendant les exercices de RI, le muscle le plus activé était grand pectoral. Pour des exercices RE, le muscle le plus activé était infra-spinatus. En général, l’activation de tous les muscles était plus haute quand l’angle entre le Theraband et le segment a fini près de 90°. Basé sur les résultats il est possible de dire que dans un programme de réadaptation, l’angle entre le Theraband et le segment peut être employé comme manière de travailler avec les groupes d’isolement de muscle.

Mots clés : Theraband, épaule, électromyographie

EVALUACIÓN DE EJERCICIOS DE ROTACIÓN EXTERNA E INTERNA DEL HOMBRO CON EL USO DE THERABAND: ANÁLISIS ELECTROMIOGRÁFICA

Resumen
La prescripción de ejercicios para la recuperación funcional después de lesiones musculares, post operatorias y fracturas enfatizan ejercicios de movilidad pasiva y activa, seguidos de ejercicios con bajo nivel de fortalecimiento durante la fase inicial de recuperación. Los ejercicios, durante ese proceso, son direccionados para aumentar la capacidad del músculo de generar tensión, flexibilidad y resistencia, restaurando la cinemática del movimiento, posibilitando así, el retorno del paciente para sus actividades diarias y deportivas. El Theraband es un dispositivo de resistencia elástica comúnmente utilizado para incrementar la fuerza muscular. El presente estudio tuvo como objetivo evaluar la actividad electromiográfica de grupos musculares de la región del hombro durante la ejecución de ejercicios realizados con el auxilio del Theraband. La muestra consistió de diez individuos que ejecutaron dos ejercicios, rotación interna (RI) y externa (RE) del hombro. Para cada ejercicio fueron hechas dos variaciones en el local de fijación del Theraband. La carga del Theraband fue evaluada a través del torque de resistencia por él ofrecido. Fueron colectadas las señales electromiográficas de superficie de los músculos infraespinoso, supraespinoso, deltoide anterior y posterior, redondo mayor y pectoral mayor. Durante los ejercicios de RI del hombro, el músculo más activado fue el pectoral mayor. Para los ejercicios de RE, el músculo más activado fue el infraespinoso. De un modo general, la activación de todos los músculos era mayor cuando el ángulo entre el Theraband y el segmento terminaba próximo a los 90°. A partir de los resultados encontrados es posible afirmar que dentro de un programa de rehabilitación, la angulación del Theraband con el segmento puede ser utilizado como recurso para trabajar grupos musculares aislados.

Palabras claves: Theraband, hombro, electromiografía

AVALIACIÓN DE EXERÇÍCIOS DE ROTAÇÃO EXTERNA E INTERNA DO OMBRO COM O USO DE THERABAND: ANÁLISE ELETROMIOGRÁFICA

Resumo
A prescripción de exercícios para recuperação funcional após lesões musculares, pós-operatórios e fraturas enfatizam exercícios de mobilidade passiva e ativa, seguidos de exercícios com baixo nível de fortalecimento durante a fase inicial de recuperação. Os exercícios, durante este processo, são direcionados para aumentar a capacidade do músculo de gerar tensão, flexibilidade e resistência, restaurando a cinemática do movimento possibilitando assim, o retorno do paciente para suas atividades diárias e esportivas. A Theraband é um dispositivo de resistência elástica comumente utilizado para incrementar a força muscular. O presente estudo teve como objetivo avaliar a atividade eletromiográfica de grupos musculares da região do ombro durante a execução de exercícios realizados com o auxílio de Theraband. A amostra consistiu de dez indivíduos que executaram dois exercícios, rotação interna (RI) e externa (RE) do ombro. Para cada exercício foram feitas duas variações no local de fixação da Theraband. A carga da Theraband foi avaliada através do torque de resistência por ela oferecido. Foram coletados os sinais eletromiográficos de superfície dos músculos infra-espinhoso, supra-espinhoso, deltoide anterior e posterior, redondo maior e peitoral maior. Durante os exercícios de RI do ombro, o músculo mais ativado foi o peitoral maior. Para os exercícios de RE, o músculo mais ativado foi infra-espinhoso. De um modo geral, a ativação de todos os músculos era maior quando o ângulo entre a Theraband e o segmento terminava próximo aos 90°. A partir dos resultados encontrados é possível afirmar que dentro de um programa de reabilitação, a angulação da Theraband com o segmento pode ser utilizada como recurso para se trabalhar grupos musculares isolados.

Palavras-chave: Theraband, ombro, eletromiografia