146 - EVALUATION OF SHOULDER INTERNAL AND EXTERNAL ROTATION EXERCISES USING THERABAND: EXTERNAL MECHANICAL EVALUATION

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Introduction
In the rehabilitation programs used in the physiotherapy, Theraband is a device of elastic resistance commonly used to increase the muscular force. HINTERMEISTER (1998) mentions in his study that among the several modalities available for muscular conditioning, the use of devices of elastic resistance has been suggested by several authors as an option for rehabilitation of the shoulder. According to this author, the use of elastic resistance propitiates for patients the execution of the exercises, in a slow and controlled way, with a low muscular load in concentric and eccentric conditions. HUGHES (1999) mentions some reasons for the use of Theraband as low cost, simplicity, versatility, portability and no dependence of the gravity. According to ANDREWS (2000) the therapeutic exercises for the shoulder should emphasize force, endurance and dynamic stability, and a wide range of techniques can be used to reach those objectives. The elastic tube is a versatile instrument that can be used to strengthen the muscles in diagonal patterns, differently of the exercises using free weights or even specific machines for this purpose.

However, in spite of several representative colors of different resistance levels exist, the form of use of this device is usually made in an empiric way, where the evaluation of the resistance offered by this accessory during the execution of the exercise is subjectively evaluated. HUGHES (1999) tells that the training with elastic resistance seems to belong to a different category from the traditional exercises, due to the fact of these depend on the properties of tension of the elastic material and the degree of stretching of the device. The author also tells, that in spite of having documented improvement in the force with this type of training, few studies have been detailing the true resistance provided by the elastic bands, therefore hindering, the standardization of the subject's effort, disabling the comparison of training with elastic resistance with other forms of exercises. That way, the present study had as objective measures the load in exercises of internal and external rotation of the shoulder accomplished with the use 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 patient'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 rituated 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 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 articular characteristics. Therefore, four situations were accomplished:

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.

Resistance of Theraband: In the exercises proposed in this study exist basically two forces acting in the segment of interest in the transverse plane: the force of Theraband and the muscular force. The forces exercised by ligaments and other components of the articular structures were considered as symmetrically acting around the joint, in a way that its rotacional effect is annulled. The weight of the segment acts in a different plane (perpendicular to the transverse) generating an extension force in the elbow, counterbalanced by the torque isometric of the elbow's flexors. This way the effect of the Theraband's force, here designated as "resistance torque", is counterbalanced by the effect of the muscular force, that can be called "potency torque". For situations of static balance (isometric) or dynamic balance (movement with constant velocity) the potency torque is equal to the resistance torque. In other words, measuring the resistance torque we can get to the potency torque. This way, the force of antagonistic muscular groups, that could be concomitantly contracted, either to stabilize the movement or even for shortening of the musculature, will be not considered. The resistance torque produced by Theraband was quantified by the equation (1):

\[ F = \text{d. sen} \]
\[ \text{torque produced by Theraband's force} \]
\[ F \text{' Theraband's force} \]

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distance between the point of applied force and the rotational axis
smaller angle between the force direction and the segment in which it applied

According to the equation (1), for the determination of the resistance torque (load offered by Theraband) it is necessary to know its force, the distance of the point of force application to the rotation axis, and the angle between the direction of this force and the segment where it is applied. The resistance force of Theraband was determined through a calibration procedure, as described in full details by LOSS et al 2002. With the obtained data, was plotted a graphical of force by length and was interpolated a curve that best represented the area of the points. The distance between the point of force application and the rotation axis was measured with a measuring tape, and it was admitted constant during the whole range of movement. Through the equation (1) it is possible to notice that as smaller the angle, smaller will be its sine, and consequently smaller the torque of the respective force. On the other hand, the angle that propititates the largest possible torque is 90 degrees, correspondent larger possible value for the sine of an angle (\(\sin 90^\circ = 1\)). As the angle between Theraband and the segment varied along the whole movement range, indicating a variation in the resistance torque, we choose to characterize each execution just for the torque at the end of the concentric phase of the exercise. This way, the angle between Theraband and the segment was only measured in the end of each execution, with aid of a manual goniometer.

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 and discussion
All individuals, without exception, related that there was higher difficulty in the execution of the exercise when the Theraband angle was final close to the 90°. A t test paired was made to prove that there was statistically significant differences in the torques for ER and IR in the angles close to 90 and smaller than 90°, according to Table 1.

<table>
<thead>
<tr>
<th>Exercise evaluated</th>
<th>Statistical significance</th>
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<tr>
<td>ER &lt; 90° x ER ≥ 90°</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>IR &lt; 90° x IR ≥ 90°</td>
<td>p &lt; 0.001</td>
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The initial length of Theraband was of 0.30 m to all the participants and in all of the exercises. However the final length, fundamental element for the determination of the resistance force, varied depending on the position of Theraband's fixation. This can be explained and visualized in the Figure 1, which shows that although the TH begins with the same length (0.30 m) depending on the fixation point in relation to the individual, its final length is altered. The closer of the rotation axis its fixated, minor will be the final length reached by Theraband.

Figure 1 Schematical drawing of Theraband's positioning in the beginning (CI) and in the final (CF) of each exercise. (a) ER<90°; (b) ER90°; (c) IR<90°; (d) IR 90°
Theraband fixation point does not affects just the value of the resistance force by changing the final length, but also the torque is modified, through the change of the angle between Theraband and the segment. The implications of this difference are evident in a program of functional recovery. Consecutive rehabilitation sessions can be interpreted by the performer as an improvement or worsening of the muscle's functional capacity, while the variation could be really happening in the load (or resistance torque) of the executed exercise. On the other hand, knowing the implications of torque in the exercise characteristic we can take advantage of this aspect in a rehabilitation program. We can, for instance, begin the rehabilitation work with an exercise that presents a small final torque (angle between Theraband and the segment closest to zero), and as the progress is accomplished can slowing increase the final angle of Theraband with the segment up to 90°, without altering the color or the length of Theraband. This procedure can also be explored in function of the muscle's physiologic characteristic "force x length".

According to KISNER (1998), the progressive resistance of Theraband could be a limiting factor for the execution of the exercise. The fact that elastic bands have progressive resistance would be one of the great disadvantages of its use, because the muscles present a smaller length in the final ranges of movement, and, therefore, less capable of force production. However the resistance force offered by Theraband is not the only relevant aspect in the execution of the exercise. A progressive increase of the resistance force can be counterbalanced by an appropriate force angle, so that the resistance torque remains the same or even decreases. Using this fact appropriately, a weakened muscular group, in a recovery phase, can be worked in a more appropriate way, as for the external load applied on it, as for its physiological capacity. This aspect is not exclusive of the external and internal rotation exercises here presented. All of the exercises involving the rotation of segments against an external load not just depends on the magnitude of the resistance force, but also on the direction of this force's application.

Conclusions
Based on the presented results is possible to affirm that:
- The Theraband's angle affects the resistance torque and, consequently, the employed effort in the external and internal rotation exercises;
The Theraband’s fixation close to the rotation axis makes the angle between Theraband and the segment, in the end of the exercise, approach to zero, reflecting a smaller resistance torque, compared to the fixation far away from the rotation axis;

In a rehabilitation program, besides the factors traditionally observed in exercises involving the use of Theraband (color, length, initial tension, use double or simple), the angle that it does with the segment should be also observed;

In a rehabilitation program, the Theraband’s angle with the segment can be used as a form of graduation of the exercise’s demand. In final angles close to 0° the demand is inferior to that needed in final angles close to 90°.

Bibliography

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EVALUATION OF SHOULDER INTERNAL AND EXTERNAL ROTATION EXERCISES USING THERABAND:
EXTERNAL MECHANICAL EVALUATION

Abstract
Among the rehabilitation programs used in physical therapy, Theraband is an approach of elastic resistance commonly used to increase muscle strength. Even existing a variety of colors which represent different levels of resistance, the way of usage of this approach is usually empirical, where the evaluation of the resistance offered during the execution of the exercise is evaluated subjectively. The aim of the present study was to measure the load of shoulder internal and external rotation exercises using Theraband. It was executed two exercises, shoulder internal and external rotation. For each exercise, it was made two variations on the place where the Theraband was fixed, which implied in variation of the exercise load. The exercise load was evaluated through the measurement of the resistance moment offered by the Theraband. The results allow to conclude that: (a) the Theraband angle affects the resistance moment offered and, consequently, the effort applied on the exercises; (b) the fixation of the Theraband close to the axis of rotation makes the angle between the Theraband and the segment in the end of the exercise equals nearly zero, implying in a lower resistance moment, compared with the fixation far from the axis of rotation; (c) in a rehabilitation program besides the common parameters observed in exercises involving Theraband (color, length, initial stress, double or simple usage) the angle that the Theraband makes with the segment should be also observed; (d) in a rehabilitation program, the angle that the Theraband makes with the segment could also be used as a way for the graduation of the effort of the exercise. In final angles close to 0°, the effort was lower than in angles close to 90°.

Key-words: Theraband, shoulder, load exercise

ÉVALUATION D’ÉPAULE INTERNE ET D’EXERCICES DE Rotation D’EXTERNAL EN UTILISANT THERABAND: ÉVALUATION MÉCANIQUE D’EXTERNAL

Résumé
Parmi les programmes de réadaptation utilisés dans la thérapie physique, Theraband est une approche de la résistance élastique généralement employée pour augmenter la force de muscle. Même existant une variété de couleurs qui représentent différents niveaux de résistance, la manière de l’utilisation de cette approche est habituellement empirique, où l’évaluation de la résistance offerte pendant l’exécution de l’exercice est évaluée subjectivement. Le but de la présente étude était de mesurer la charge des exercices internes et externes d’épaule de rotation en utilisant Theraband. C’a été exécuté deux exercices, rotation interne et externe d’épaule. Pour chaque exercice, c’a été fait à deux variations sur l’endroit où le Theraband était fixe, qui a impliqué dans la variation de la charge d’exercice. La charge d’exercice était cuyette évaluée que la mesure du moment de résistance a offert par le Theraband. Les résultats laissent conclure cela : (a) l’angle de Theraband affecte le moment de résistance offert et, par conséquent, l’effort appliqué sur les exercices ; (b) la fixation du Theraband près de l’axe de la rotation fait l’angle entre le Theraband et le segment à la fin de l’exercice égale presque zéro, impliquant dans un moment inférieur de résistance, comparé à la fixation loin de l’axe de la rotation ; on devrait également observer (c) dans un programme de réadaptation sans compter que les paramètres communs observés dans les exercices impliquant Theraband (couleur, longueur, utilisation d’effort, double ou simple initiale) l’angle que le Theraband fait avec le segment ; (d) dans un programme de réadaptation, l’angle que Theraband fait avec le segment pourrait également être employé comme manière pour le repère de l’effort de l’exercice. Dans des angles finals près de 0°, l’effort était inférieur que dans les angles près de 90°.

Mots-clés : Theraband, épaule, exercice de charge

EVALUACIÓN DE EJERCICIOS DE ROTACIÓN EXTERNA E INTERNA DEL HOMBRO CON EL USO DE THERABAND?: ANÁLISIS DE LA RESISTENCIA MECÁNICA EXTERNA

Resumen
Dentro de los programas de rehabilitación utilizados en la fisioterapia, el Theraband2 es un dispositivo de
resistencia elástica comúnmente utilizado para incrementar la fuerza muscular. A pesar de existir varios colores que representan los diferentes niveles de resistencia, la forma de utilización de este dispositivo se hace usualmente de forma empírica, en donde la evaluación de la resistencia ofrecida por este accesorio durante la ejecución del ejercicio es evaluada subjetivamente. El presente estudio tuvo como objetivo mensurar la carga de ejercicios de rotación interna y externa del hombro realizados con el uso Theraband. Fueron ejecutados dos ejercicios, rotación interna y externa del hombro. Para cada ejercicio fueron hechas dos variaciones en el local de fijación del Theraband, que implicaron en variación de la carga del ejercicio. La carga del ejercicio fue evaluada a través del torque de resistencia ofrecido por el Theraband, los resultados permiten concluir que: (a) la angulación del Theraband afecta el torque de resistencia y, consecuentemente, el esfuerzo empleado en los ejercicios de rotación interna y externa; (b) la fijación del Theraband próxima al eje de rotación hace con que el ángulo entre el Theraband y el segmento, al final del ejercicio, se aproxime a cero, reflejando un torque de resistencia menor, comparado a la fijación lejos del eje de rotación; (c) dentro de un programa de rehabilitación, además de los factores tradicionalmente observados en ejercicios envolviendo el uso de Theraband (color, largura, tensión inicial, uso doble o simple), la angulación que ésta hace con el segmento también debe ser observada; (e) dentro de un programa de rehabilitación, la angulación del Theraband con el segmento puede ser utilizada como forma de gradación de la exigencia del ejercicio. En ángulos finales próximos a 0° la exigencia se muestra inferior a aquella utilizada en ángulos finales próximos a 90°.

**Palabras claves:** Theraband, hombro, carga de ejercicios

**AVALIAÇÃO DE EXERCÍCIOS DE ROTAÇÃO EXTERNA E INTERNA DO OMBRO COM O USO DE THERABAND: ANÁLISE DA RESISTÊNCIA MECÂNICA EXTERNA**

**Resumo**

Dentro dos programas de reabilitação utilizados na fisioterapia, a Theraband é um dispositivo de resistência elástica comumente utilizado para incrementar a força muscular. A pesar de existirem várias cores representativas de diferentes níveis de resistência, a forma de utilização deste dispositivo se faz usualmente de forma empírica, onde a avaliação da resistência oferecida por este acessório durante a execução do exercício é avaliada subjetivamente. O presente estudo teve como objetivo mensurar a carga de exercícios de rotação interna e externa do ombro realizados com o uso Theraband. Foram executados dois exercícios, rotação interna e externa do ombro. Para cada exercício foram feitas duas variações no local de fixação da Theraband, que implicaram em variação da carga do exercício. A carga do exercício foi avaliada através do torque de resistência oferecido pela Theraband. Os resultados permitem concluir que: (a) a angulação da Theraband afeta o torque de resistência e, consequentemente, o esforço empregado nos exercícios de rotação interna e externa; (b) a fixação da Theraband próxima ao eixo de rotação faz com que o ângulo entre a Theraband e o segmento, no final do exercício, aproxime-se de zero, refletindo um torque de resistência menor, comparado à fixação longe do eixo de rotação; (c) dentro de um programa de reabilitação, além dos fatores tradicionalmente observados em exercícios envolvendo o uso de Theraband (cor, comprimento, tensão inicial, uso duplo ou simples), a angulação que esta faz com o segmento também deve ser observada; (e) dentro de um programa de reabilitação, a angulação da Theraband com o segmento pode ser utilizada como forma de graduação da exigência do exercício. Em ângulos finais próximos a 0° a exigência mostra-se inferior àquela utilizada em ângulos finais próximos a 90°.

**Palavras-chave:** Theraband, ombro, carga de ejercicios.