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VARIABILITY OF MUSCLE CONTRIBUTIONS TO LEG EXTENSIONS PERFORMED ON THE REFORMER APPARATUS

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SUMMARY

Performing leg extensions on a Reformer apparatus has been thought to strengthen hip and/or knee extensor muscles. In order to gain insight into the exercise, this study was aimed at analyzing leg extensions on a Reformer apparatus. Hip and knee inverse dynamics analysis were performed for the exercise. Subjects tended to use one of two conceptual strategies, performing the movement (i) either by using simultaneous hip and knee extension moments, (ii) or by using simultaneous hip flexion and knee extension moments. Neglecting inertial effects, these two strategies are achieved by directing the line of action of the resultant force from the foot rest between knee and hip joint for strategy (i), and below the hip for strategy (ii). Theoretically, it would also be possible to direct the resultant force from the foot rest above the knee (resulting in a simultaneous knee flexor and hip extensor strategy), but this strategy was not used in this study. Therefore, leg extensions on the Reformer apparatus primarily strengthen the knee extensor muscles, and secondarily strengthen the hip extensors (strategy (i)), or the hip flexors (strategy (ii)).

INTRODUCTION

Pilates exercising has become an accepted exercise method for the general public, with a rapidly growing number of participants [1,2]. Pilates as a rehabilitation tool has been treated cautiously with calls for research evaluating its effects on the body [3,4,5]. However, there has been controversy as to whether leg extensions on the Reformer primarily strengthen the hip extensor or the knee extensor muscles. In order to gain insight into this controversy, we calculated the resultant hip and knee moments using an inverse dynamics approach.

METHODS

Eight Pilates trained females (56.7 ± 6.7 kg and 1.60 ± 0.04 m) between 20 and 42 years old, with no history of lower limbs or trunk injury consented to participate. Kinematics and kinetics were obtained while subjects performed ten repetitions of the leg extension exercises on a Reformer apparatus of the Pilates Method against spring resistance. Sagittal plane forces were measured using an instrumented foot bar. Movements were measured at the sagittal plane using a video system (JVC GR-DVL 9800; 25Hz) and reflective markers placed at the base of the fifth metatarsus, lateral malleolus, lateral condyle, greater trochanter, acromion process, and the mobile cart. A complete exercise cycle consisted of extension and flexion of the leg.

Force data was processed with 3rd order low-pass recursive Butterworth filter, 5 Hz cut-off frequency calculated using residual analysis criterion [6]. Leg angles and positions were input for differentiation used for calculating joint velocities and accelerations from the displacement-time data with respect to time. Resultant net joint moments at knee and hip were calculated using an inverse dynamics approach [7] with inertial data from regression equations by Clauser [8].

RESULTS AND DISCUSSION

Resultant net moments at the hip and knee presented two distinct patterns between groups of subjects (Figure 1): those with knee and hip moments essentially extensor for most of the movement (subjects d to h) and those who have a substantial phase of flexor hip moments (subjects a to c). This is related to the foot's reaction force line of action.

Theoretically there are three possible ways for performing this exercise, depending on how the line of action of the resultant foot reaction force is directed: (i) above the knee, creating knee flexor and hip extensor moments; (ii) between knee and hip, creating knee and hip extensor moments; or (iii) below the hip, creating knee extensor and hip flexor moments (Figure 2).

While performing the exercise the subject pushes the reformer apparatus bar, generating a reaction force on the subject's foot. This reaction force will be the main responsible for the moments that will be generated in the hip and knee joints. Depending on the direction of the force the subjects pushes the bar, the reaction force may assume basically three directions (a) upward, (b) approximately horizontal and (c) downward. The direction is determinant for the characteristics of the joint moments. Although possible, the strategy with the line of action above the knee joint was not used by the subjects in this study. The line of action was kept mostly under the hip by three subjects, while the other five presented a line of action closer to the horizontal, maintaining it between the knee and hip joints.

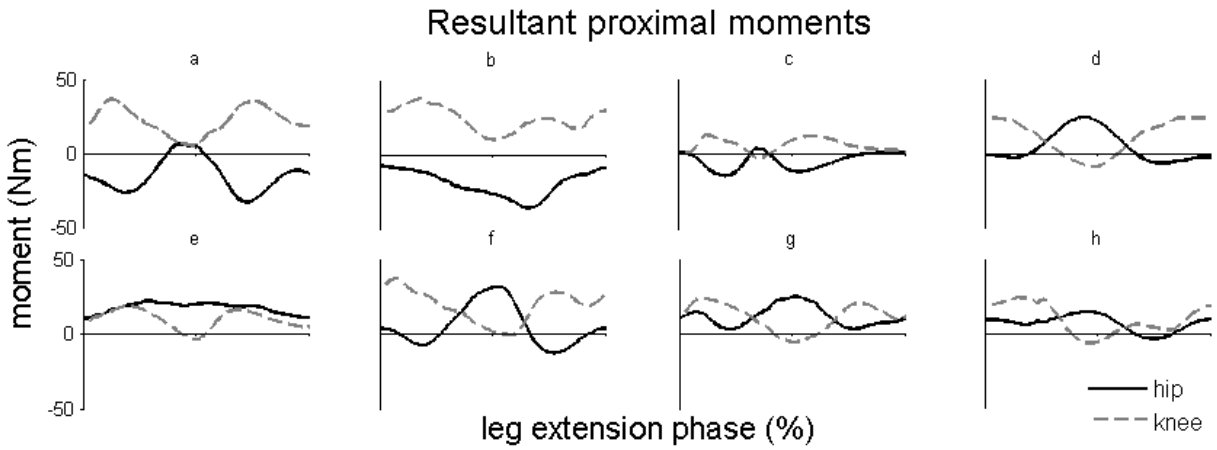

Figure 1: Mean hip (−) and knee (- -) resultant moments normalized to the extension phase of the movement. Positives values correspond to extensor moments and negative values to flexor moments. Each graph represents one subject.

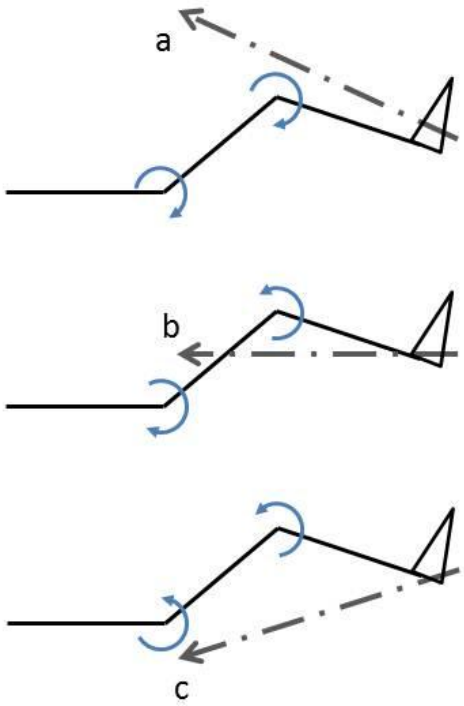

Figure 5: Potential possibilities for the leg extension exercise: (a) reaction force directed above the knee joint, generates knee flexor and hip extensor resultant moments, (b) reaction force directed between the knee and hip joints, generates knee and hip extensor resultant moments, and (c) reaction force directed under the hip joint, generates knee extensor and hip flexor resultant moments.

In movements involving more than one joint, the positions of each segment must be considered in order to control, or learn, the direction of an external force (Jacobs and Schenau, 1992). In such case, the proximal moment not necessarily will correspond to the moment expected from the segments positions, and the direction of the reaction force will depend on the proximal moments (Van Ingen Schenau et al., 1992). It is also true that the direction of the reaction force in a movement will determine each joints resultant moments. Although the differences between squat and leg press exercise and the exercise performed in the reformer apparatus may seem small, in inverse dynamics a small detail may change completely the exercise (Wells, 1981). The reaction force is where the inverse dynamics analysis starts, then it is understandable that changes in the reaction force will have important influence in the internal moments.

CONCLUSIONS

Leg extension exercise on the reformer apparatus is mostly performed with an alternation of moments of the hip and the knee. In the beginning and end of the exercise, knee moment and forces from knee extensor muscle are predominant, while in the middle of the exercise, hip moment and forces from hip extensor muscles are predominant in the majority of the subjects in this study.

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