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Kinematical and neuromuscular assessment of the rowing exercise in the upright position with barbell to improve muscle strength and muscle endurance in group fitness classes

INTRODUCTION

Physical fitness is dependent from several major components including cardiovascular fitness, flexibility, body composition, muscle strength and muscle endurance.

Since long, muscle strength and muscular endurance training was done in individual sessions, where subjects after a preliminary assessment of their fitness level have a training program designed with specific volume, intensity, density, using weight machines, barbells, rubber bands, bodyweight exercises, etc.

In the last couple of decades emerged new muscle strength and muscle endurance training programs that are not done individually but in group fitness classes. Most of these programs adopt as main equipment the barbell to improve the muscle strength and muscle endurance. There are a given number of exercise routines done in each class sessions to train a specific muscle group (e.g., 10 muscle groups per session). Each exercise routine should be done following the cadence metrics of the music's track being played. Subjects can choose subjectively if they what to use 5, 10 or 20 [kg] as external load inserted in the barbell. Added to that, instructors are able to cue exercise repetitions based in the music cadence. E.g., perform one full exercise cycle within one, two or four musical beats. So, music cadence is a strategy used on regular basis to achieve a given intensity of exertion.

It seems to exist little research done about the kinematical and neuromuscular activity performing basic muscle strength exercises as done in group fitness classes.

The aim of this paper was to assess the interaction between kinematics and neuromuscular responses of subjects performing the rowing exercise, with barbell in the upright position, in group fitness classes, with different external loads and cadences. It was hypothesized that kinematical behavior and neuromuscular activation will be affected by the external load and the cadence imposed.

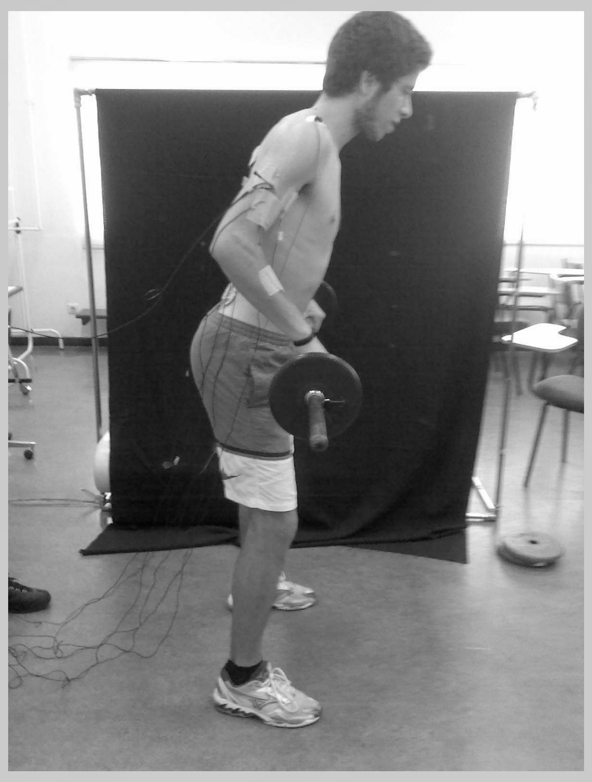

Figure 1. The rowing exercise with a subject instrumented.

METHODS

Fifteen male subjects (25.6 ± 3.8 years-old; 1.8 ± 0.1 [m] of body height; 75.7 ± 7.4 [kg] of body mass; 24,4 ± 2,0 [kg.m^{-2}] of body mass index; 334.5 ± 119.3 [min.week^{-1}] of physical activity) composed the sample group. All subjects were familiarized and/or participated on regular basis in strength group fitness classes. All procedures were in accordance to the Helsinki Declaration regarding experiments with Human subjects.

Each subject performed nine sets of nine repetitions of the rowing exercise with weight bar in the upright position (fig. 1). On regular sessions instructors state they use this exercise to develop the back muscles of the trunk. Subjects grab a weight bar with the hands, trunk slightly flexed forward, both feet apart at the shoulders within distance. The exercise consisted in the forearm's flexion with concomitant arm hyperextension until the bar achieves the trunk. Thereafter the forearms do an extension and the arm's a flexion reaching the initial and neutral position. Sets were composed by a pair wise combination of different external loads (5, 10 and 20 [kg]) and cadences (1, 2 and 4 musical beats) in a randomized order. Cadence was controlled with an electronic metronome (Korg, MA-30, Tokyo, Japan) connected to a sound system at 134 [b.min^{-1}]. Whenever necessary, the evaluators gave verbal and/or visual cues for subjects follow the appropriate exercise cadence and accomplish the number of repetitions asked.

Kinematical and neuromuscular data were collected at the same time and both biosignals were synchronized throughout the protocol. The first two and the last two repetitions of each set were eliminated and not considered for further analysis. Kinematical data was collected with an electrogoniometer (Biometrics, XM180, Gwent, UK) fixed in the arm and forearm to assess angular kinematics from the elbow joint at a sampling rate of 1k [Hz]. It was assessed the: (i) exercise period (i.e., absolute duration of each exercise repetition); (ii) minimum acute relative angle between the arm and forearm during the flexion action.

METHODS

Neuromuscular data was collected with superficial electromyography (Biopac Systems, MP100A, Santa Barbara, USA) at a sampling rate of 1k [Hz]. Data was collected from the biceps brachii, triceps brachii (long head), latissimus dorsi, trapezius (middle portion) and erector spinae with bipolar active electrodes (Biopac Systems, 150A, Santa Barbara, USA) with a gain of 350 and a passing band of 12-500 [Hz]. Electrodes were placed: (i) according to literature suggestions [1,3]; (ii) in one side of the body, since the exercise is a symmetrical one [2] (Fig. 2). Skin was prepared, clean and shaved to reduce bio-impedance and artifacts. After being digitally processed (i.e., filtered, fully rectified, smoothed and crated the linear envelope) it was computed the EMG amplitude (aEMG), the EMG room mean square (RMS) and the activation time. The aEMG and RMS data were normalized to the three maximal dynamical values obtained, in each muscle group, during the data collection.

Data normality was verified with Shapiro-Wilk test. It was calculated the descriptive statistics mean and one standard deviation. Each dependent variable (i.e., period, relative angle, aEMG, RMS, activation time) was assessed according to its interaction with the external load (i.e., 1, 5, 10 [kg]) and the cadence (1, 2, 4 [b.min.$^{-1}$]) in the muscle groups selected (i.e., biceps, triceps, trapezius, erector spinae) with Manova test. When Monova test failed, factorial Anova and Mancova tests were computed. Significance level was set at $p \leq 0.05$.

Figure 2. The rowing exercise with a subject instrumented.

RESULTS AND DISCUSSION

Standard deviations of both EMG variables were quite high for all conditions. This can mean that the training load (external load plus cadence) did not take into account the individual fitness level of the subjects. So, probably as happens in individual muscular strength sessions, in the group fitness classes an individual assessment of the training load should be done as well, instead of the subjects selected subjectively the load they want to use in the session.

Taking into account the cadence effect, the period had a significant interaction (Λ=0.064; $F_{(8,108)}$ =53.31; p <0.01). Significant data was observer for biceps brachii ($F_{(2,113)}$ = 770.59; p <0.001), triceps brachii ($F_{(2,113)}$ = 791.47; p <0.001), latissimus dorsi dorsal ($F_{(2,113)}$ = 540.65; p <0.001), Trapezius ($F_{(2,113)}$ = 787.95; p <0.001) and erector spine ($F_{(2,113)}$ = 790.84; p <0.001). Increasing cadence decreased the absolute duration of the exercise cycle. There were no significant interaction between the joint angle and the external load ($F_{(8,108)}$ = 0.516; p = 0.8) nor the cadence ($F_{(2,114)}$ = 0.22; p = 0.8).

The significant interaction in period is related to the fact that subjects strictly followed the music cadence as cued by evaluators. The non-significant interaction in the angular kinematics is explained by the fact that subjects had a high expertise and background participating in this kind of strength training programs and were able to increase the angular velocity to follow the appropriate music cadence. Otherwise, subjects with less expertise and/or in fatigue would decrease the elbow range of motion throughout the protocol.

Regarding the RMS variable, it was verified significant interactions based in the external load and the muscle groups assessed (Λ=0.303; $F_{(8,108)}$ = 3.948; p <0.001). Significant differences were observed in the biceps brachii ($F_{(8,108)}$ = 10.686; p <0.001), triceps brachii($F_{(8,108)}$ = 17.568; p <0.001) and erector spinae ($F_{(8,108)}$ = 10.755; p <0.001). Anova test verified significant effect of the cadence for the biceps brachii ($F_{(2,114)}$ = 4.270; p <0.016). In all these situations, increases in the external load and in the cadence imposed a RMS increase as well.

It was also verified a significant interaction among the aEMG and the external load in four muscle groups (Λ=0.52; $F_{(8,108)}$ = 2.028; p <0.001). Differences were significant for the biceps brachii ($F_{(8,108)}$ = 9.802; p <0.001) and triceps brachii ($F_{(8,108)}$ = 6.385; p <0.001). Non-significant interaction was verified between muscle groups aEMG and cadence.

As reported on regular basis the increase of the external load and /or the increase of the exercise cadence will affect the neuromuscular activity [e.g., 4].

CONCLUSION

Performing the rowing exercise, in the upright position with a barbell, as done on regular basis in muscle strength and muscle endurance group fitness classes, neuromuscular activity increases with the increase of the external load or the cadence or a combination of both. The high data dispersion suggests that external load and cadences should be selected based in individual preliminary assessments of the subject's fitness level, instead of they choose it based in their own subjective perceptions.

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