MEASURING MUSCLE FATIGUE AND GENDER DIFFERENCES WITH ISOKINETIC CONTRACTIONS

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INTRODUCTION

Muscle fatigue has been defined as “any reduction in the force generating capacity of the total neuromuscular system regardless of the force required in any given situation” (Bigland-Ritchie and Woods, 1984). A reliable muscle fatigue measure has subtly emerged during maximal effort isokinetic contractions that has been able to highlight gender differences in quadriceps and hamstring torque generating ability. The objectives of this presentation are to: I) discuss and contrast different methods of documenting muscle fatigue during isokinetic contractions (Pincivero et al, 2001), II) demonstrate the relationship between isokinetic peak torque generating ability and muscle fatigue (Pincivero et al, 2000a), and III) examine gender differences in quadriceps and hamstring torque and muscle fatigue (Pincivero et al, 2000b).

METHODS

I) 16 healthy male (n=8) and female (n=8) volunteers participated. Each subject performed 30 maximal, concentric repetitions (Biodex System II) at a pre-set angular velocity of 180 deg•sec⁻¹ for both dominant and non-dominant legs. Quadriceps work was evaluated between a range of 10 and 60 deg flexion, for each repetition. Quadriceps muscle fatigue was calculated through an index (work performed last 5 repetitions / work performed first 5 repetitions x 100%) and the slope (β) across the 30 repetitions. The subjects participated in 2 test sessions separated by 1-2 weeks. Intraclass correlation coefficients (ICC) and standard errors of measurements (SEM) were calculated for each fatigue measure on both legs.

II) 16 healthy male and 16 healthy female volunteers participated. Subjects performed 30 reciprocal, concentric maximal knee extension and flexion contractions at a pre-set angular velocity of 180 deg•sec⁻¹. Values for quadriceps work (N•m) were calculated for each repetition between a windowed range of motion of 10 degrees and 60 degrees of flexion. Values for quadriceps work were then normalized to body mass (N•m•kg⁻¹). The rate of quadriceps fatigue was calculated as the decline in work output by the slope (β) across the 30 repetitions. The relationship between peak quadriceps work and the associated slope was examined by regression analysis for males and females, separately, and differences in these relationships were calculated using Fisher’s Z-transformation.

III) 20 healthy female and 17 healthy male volunteers participated. Subjects performed 4 sets of 30 reciprocal maximal effort isokinetic contractions for the dominant leg
at 180 deg•s\(^{-1}\). Subjects were randomly assigned to a short (1 min) or long (5 min) inter-set rest interval. Quadriceps and hamstring peak torque (PT), total work (TW), and average power (AP) were calculated for each set.

**RESULTS AND DISCUSSION**

I) The findings demonstrated moderate to high ICC’s for the non-dominant leg (0.78 – 0.92) and high ICC’s for the slope and y-intercept for the dominant leg (0.82 and 0.89, respectively). The fatigue index for the dominant leg was found to be low (0.26).

II) The results demonstrated that peak quadriceps work, normalized to body mass, was significantly higher \(t_{30} = 4.82, p<0.05\) in males \(1.35 \pm 0.17 \text{ N•m•kg}^{-1}\) than females \(1.10 \pm 0.11 \text{ N•m•kg}^{-1}\). Males also showed a significantly greater reduction in work output over 30 repetitions than females \(t_{30} = -5.45, p<0.05\), as demonstrated by the \(\beta\) values (males: \(\beta = -1.70 \pm 0.47\); females: \(\beta = -0.92 \pm 0.32\)). The relationship between peak quadriceps work and the rate of work decline \(\beta\) was found to be statistically significant in both males \(r = 0.86, p<0.05\) and females \(r = 0.69, p<0.05\), and was higher in males \(r^2 95\% \text{ C.I.: } 0.57 – 0.95\) than females \(r^2 95\% \text{ C.I.: } 0.30 – 0.89\).

III) Males displayed a significantly greater reduction for quadriceps PT, TW and AP across sets 1-2 with a 1 min rest interval, as compared to the other groups (Figure 1). Males in both groups displayed a significantly greater reduction in hamstring PT, TW, and AP than the females across sets 1-3 (Figure 2).

**SUMMARY**

These studies demonstrate that muscle fatigue can be reliably documented by the slope, and suggest that males possess greater susceptibility to muscle fatigue than females. It is speculated that this greater rate of fatigue in males may be explained by the significantly greater relationship to normalized peak torque generating capacity.

**REFERENCES**