

AGING, REGULARITY AND VARIABILITY IN MAXIMUM ISOMETRIC MOMENTS

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INTRODUCTION

In old age there are various changes in the properties of human muscle, for example muscle cross-sectional area is reduced (e.g., Kent-Braun & Ng, 1999), and fiber type distribution changes (e.g., Lexell, 1995). These changes have implications for the ways in which movements are executed. There is also evidence that in older age there is a reduction in the number of motor units comprising a muscle (e.g., Sica et al., 1976).

Given a reduced number of motor units to coordinate it may be that in the development of maximum isometric force there is reduced variability, or increased regularity, in the force profile for older subjects compared with the young. This study examined the variability and regularity of maximum isometric moment production of the plantar flexors in the young and elderly.

METHOD

Two groups of subjects, one young and the other elderly, gave informed consent to participate in this study. Subject details and group sample sizes are presented in table 1.

Table 1: The means (standard deviations) of the subject characteristics for the three groups.

Group (n)	Age (years)	Mass (kg)	Height (cm)
I (10)	23.8 (2.8)	82.1 (11.5)	178 (5)
II (12)	73.7 (3.2)	76.2 (10.8)	172 (5)

After appropriate warm-up the subjects performed three maximum isometric plantar flexions using a Biodex dynamometer. Subjects were tested with an ankle angle of 90 degrees, and a knee angle of 180 degrees (fully extended). The dynamometer position was manipulated so the axis of rotation of the ankle joint was aligned with the axis of rotation of the dynamometer. For each trial data collection lasted 10 seconds, with two minutes rest between trials.

For each subject the trial producing the maximum moment under each condition was selected for additional analysis. From these trials only the plateau regions of the curves were analyzed.

The time-moment curves were assessed using the approximate entropy (*ApEn*) algorithm described by Pincus (1991). *ApEn* is a measure of the regularity of a data set. It takes sequences of m data points and determines the logarithmic likelihood that this sequence is similar to other sequences of data points. If the data set is regular then *ApEn* has a small value; conversely *ApEn* increases in value with increasing irregularity of the data set. A parameter r is used to determine the closeness of data sequences, which effectively filters out sequences which are not close. For the comparisons made in this study m was set to 2, and r was set at the measurement precision of the Biodex dynamometer.

Comparisons were made of the peak

moment, signal coefficient of variation (Coef. Var.), and *ApEn* for the two subject groups using analysis of variance. Bartlett's test was used to confirm homogeneity of variance before all analyses. A 0.05 significance level was used.

RESULTS

The young subjects produced a statistically greater peak moment than the elderly subjects (table 2). This pattern persisted when these data were normalized with respect to subject mass. The coefficient of variation was not statistically different between the two subject groups indicating similar variability. In contrast there was a statistically significant difference between the two groups in *ApEn*, that is the older group demonstrated greater regularity.

ApEn does not distinguish between signal components due to the subject (deterministic), and that due to random noise in the measurement process. Therefore a surrogate data test was used, which confirmed that the results were reflecting the properties of subject signal not measurement system noise (Theiler et al., 1992).

DISCUSSION

As would be expected with increasing age the subjects demonstrated reduced plantar flexion strength, such decrements have previously been reported in the literature (e.g. Overend et al., 1992). Variability in the time-moment curves was the same for the two groups, but there was a difference in signal regularity. Surrogate analysis confirmed this result was due to signal properties not measurement noise.

With increasing age many physiological processes have been described as having

Table 2: The means (standard deviations) of the analysis of the plateau of the time-moment curves.

Group	Peak Moment (N.m)	Coef. Var. (%)	<i>ApEn</i>
I	111.5 (33.5)	5.7 (1.4)	0.253 (0.075)
II	78.1 (29.6)	5.8 (1.4)	0.352 (0.072)

reduced complexity (Lipsitz, 2002). While *ApEn* tests for regularity not complexity, the two are related (Gell-Mann, 1995); these results lend support to the hypothesis of reduced complexity with aging. The increased regularity in older age can be explained by the anticipated reduction in the number of motor units comprising the muscles used to produce the maximum moments. This reduction in the number of motor units means fewer units need to be coordinated to produce the moments.

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