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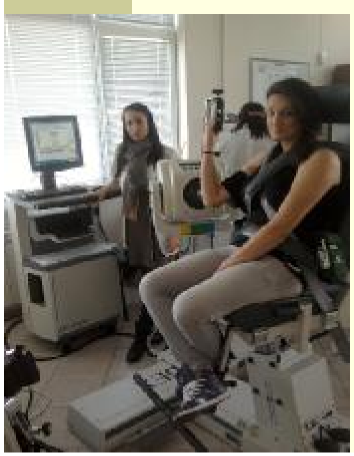
TORQUE – ANGLE RELATIONSHIPS OF THE ELBOW FLEXORS AND EXTENSORS IN HEALTHY FEMALES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Introduction

It is known that altering joint position or muscle length, has a significant impact on the maximum force, that a muscle can produce.

In some studies on the elbow, have been reported different data about the angular position in which the flexors or extensors generate peak torque. Moreover, most of these experiments were performed in a mixed group of men and women.

It is also unclear how the relationship between sEMG and muscle strength, changes from elbow joint angle.

AIMS

The aims of this study are:

1. To obtain knowledge of the isometric torque-angle relationship of the elbow flexors and extensors in healthy untrained females;
2. To explore the impact of the elbow angle on the neuromuscular activity of the biceps brachii – long head (BB-LH) and triceps brachii – long head (TB-LH); and
3. To evaluate the correlations between the isometric flexor or extensor torque and RMS of the muscles tested.

Participants

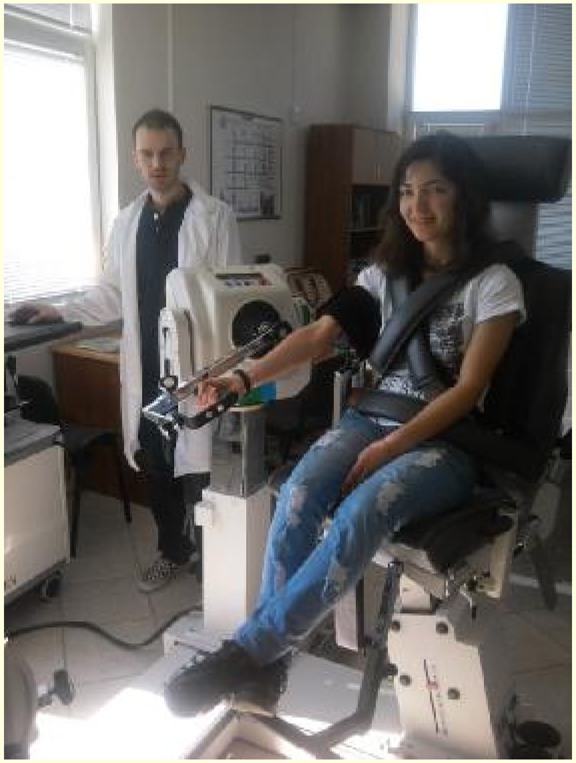
Ten healthy, right-handed, female volunteers.

Subjects had a mean age of 21 years (range 20-24 years), high of 160±10 cm and weight of 57.3±9.1 kg, BMI - 21.6 ± 2.6 kg/m^2; LBM – 43.0±5.0kg.

Nobody of participants, student of SW University, Blagoevgrad, did not involved in training or exercise with their elbow muscles for at least half an year.

All volunteers signed an informed consent form.

Experimental set-up and dynamometric measurements of maximal isometric voluntary torque



Subjects were seated in the dynamometer and strapped tightly to the chair with safety belts to prevent trunk rotation.

The right arm was measured. Arm was fixed and further stabilized by placing the shoulder in 30º flexion and with forearm supinated.

Subjects were familiarized with the testing apparatus on a separate occasion before testing was conducted. In that time they were also trained to exert maximal voluntary contraction (MVC) with the maximal speed of contraction and relaxation.

Joint torque at the elbow was measured with a Biodex System 4Pro (Biodex Medical Systems, Inc., New York, USA)

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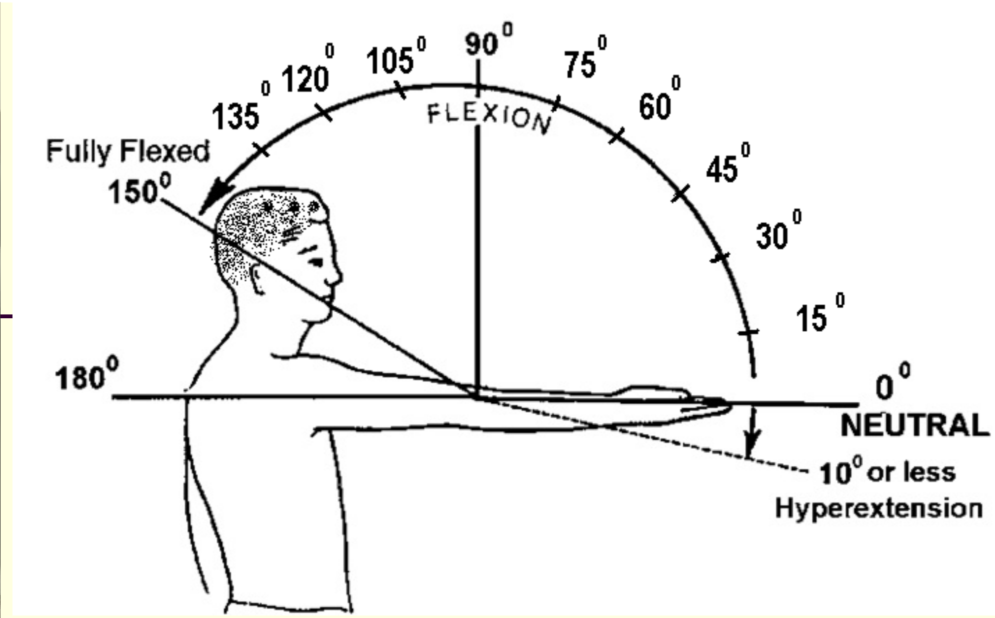
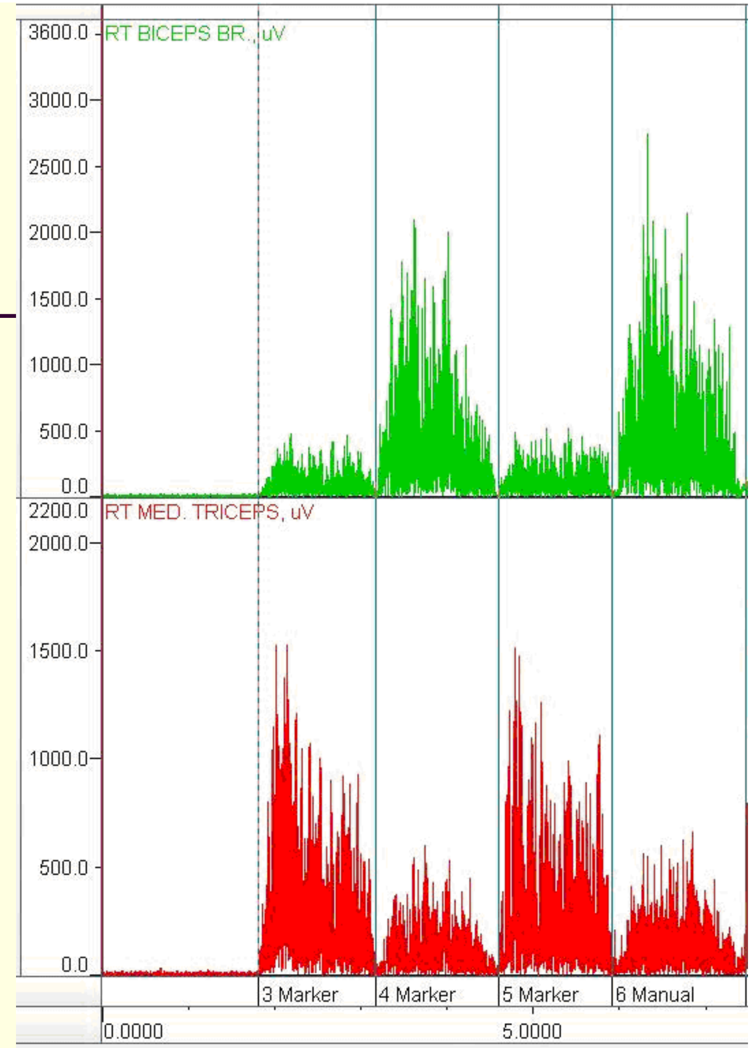


Maximal isometric contractions were performed at the 10 different angles in the range between 5^{o} and 150^{o}: 15^{o}, 30^{o}, 45^{o}, 60^{o}, 75^{o}, 90^{o}, 105^{o}, 120^{o}, 135^{o} and 150^{o}. Participants were instructed to build up either an extension or a flexion torque to maximum within a 3-s period. For each elbow angle, two pairs of contractions were performed, separated by a 10-s relaxation period. The relaxation between angular positions was 60 sec. Elbow angles were presented in random order.

Surface EMG

Noraxon USA Inc., Telemyo 2400R G2.

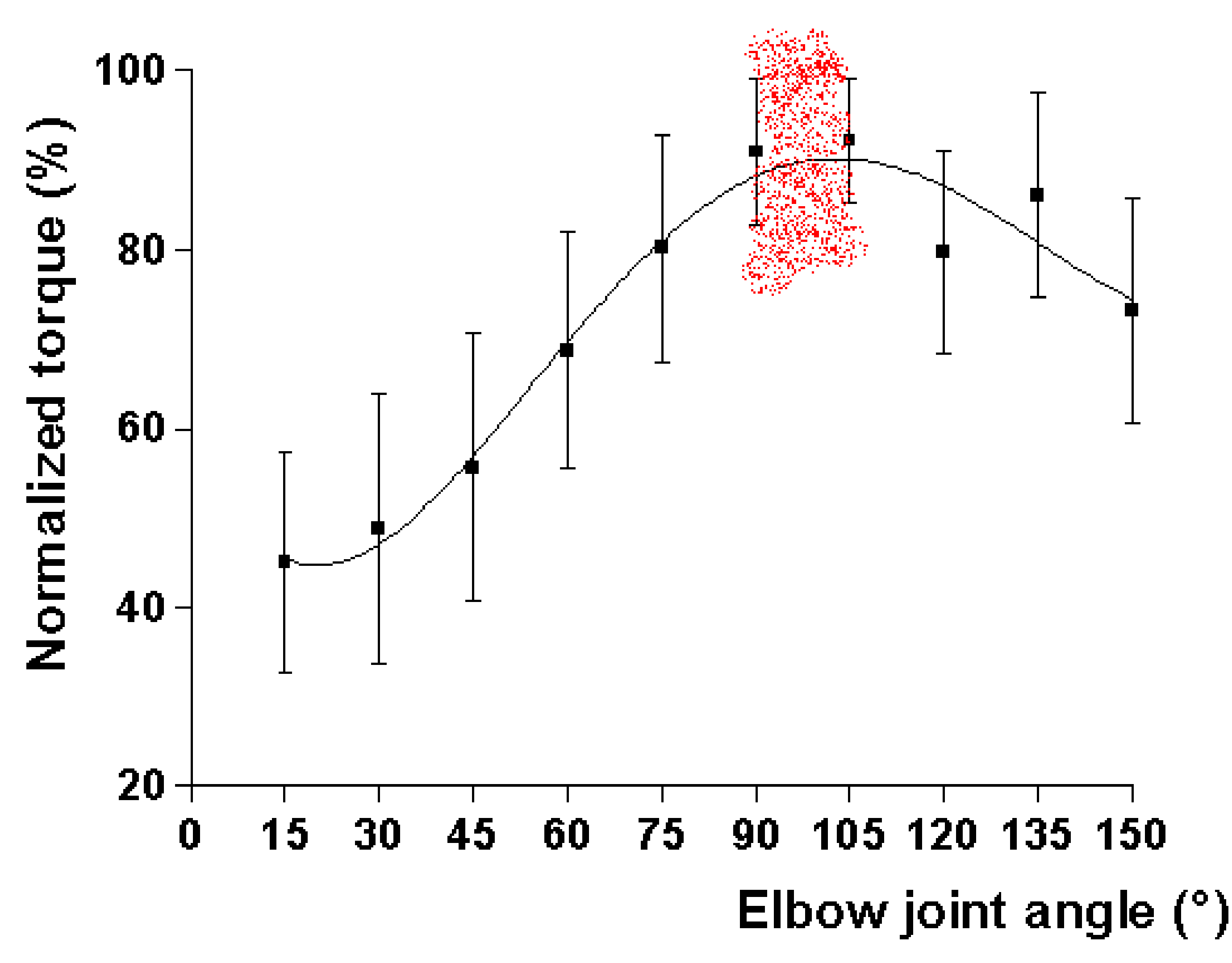


sEMG was recorded using Noraxon USA Inc., Telemyo 2400R G2. Two pairs of surface electrodes were placed, one pair on **biceps brachii (long head**) and one pair on the **triceps brachii (l head)** as described on the website of the SENIAM project, at a center-to-center inter-electrode distance of 2 cm.

The root mean square (RMS) of the MVC EMG data was calculated using 0.5-s of data, centered on the MVC force point. Antagonist activity for both muscles (coactivation) as RMS value, was also calculated.

RESULTS

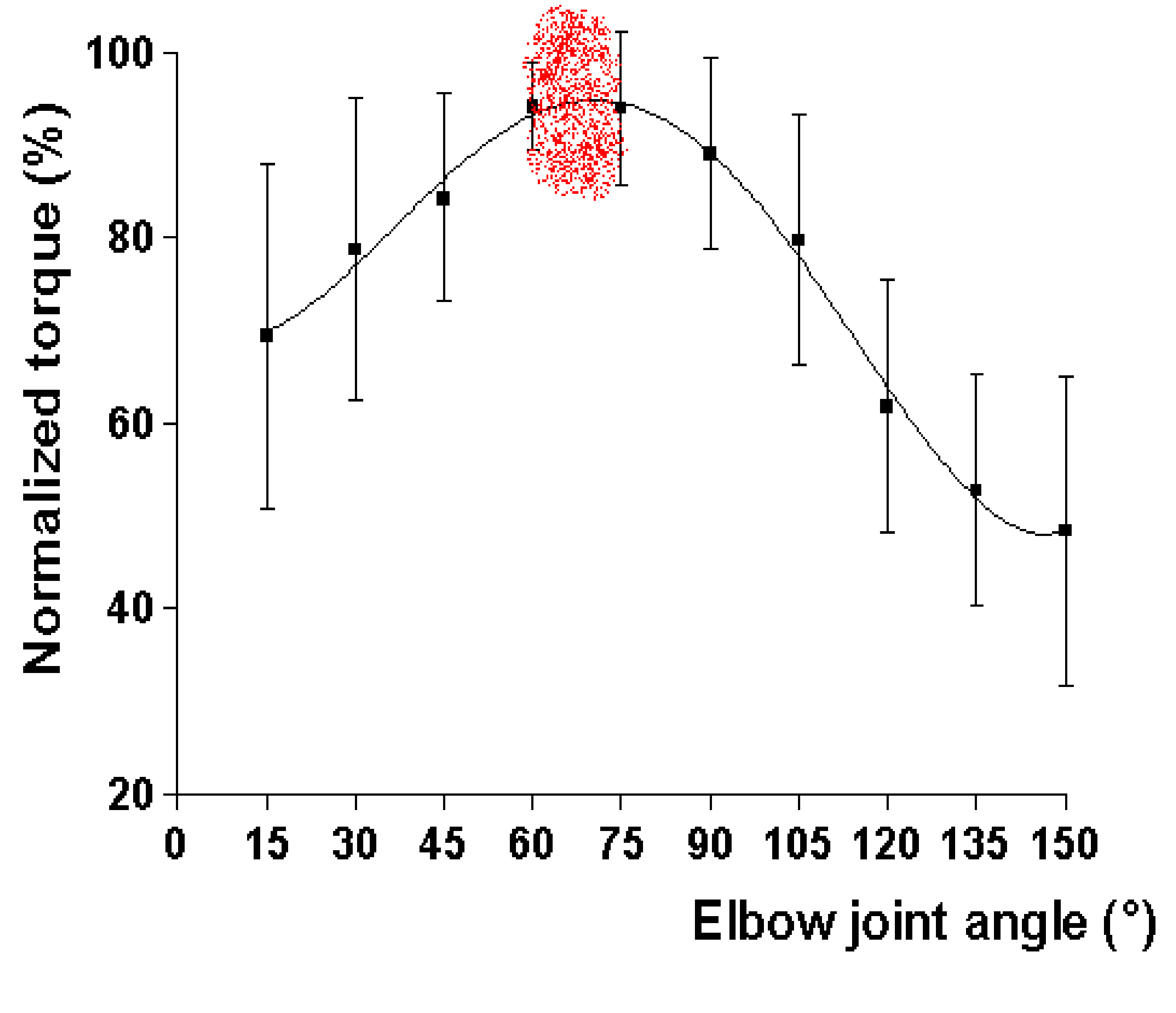
ELBOW FLEXORS: Torque-angle curves



The mean torque-angle curves were modeled with a 4th order polynomial function (Akaike Information Criterion).

The curve had a maximum at 105^0, but no statistically significant differences with the data for peak torque at 90^0, (Mann Whitney test, $p<0.05$). The values of the peak torque in this area are between 27.9±5.4 and 28.0±7.5 Nm, so practically are equal.

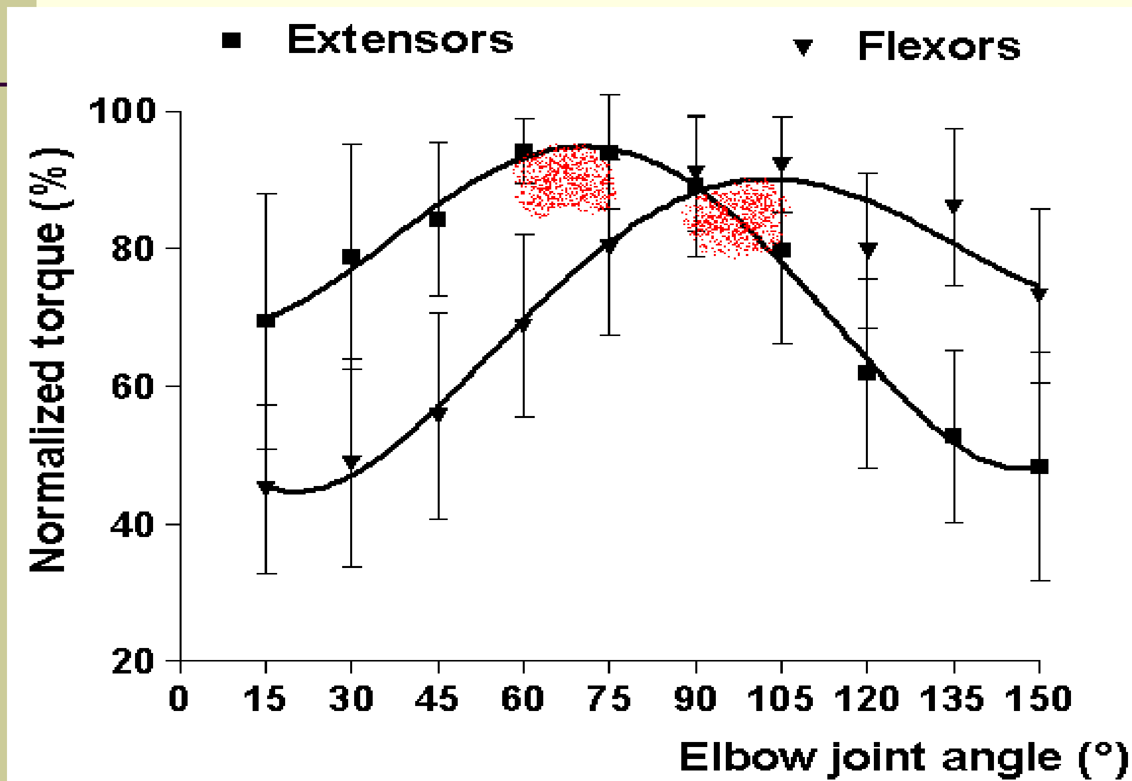
ELBOW EXTENSORS: Torque-angle curves

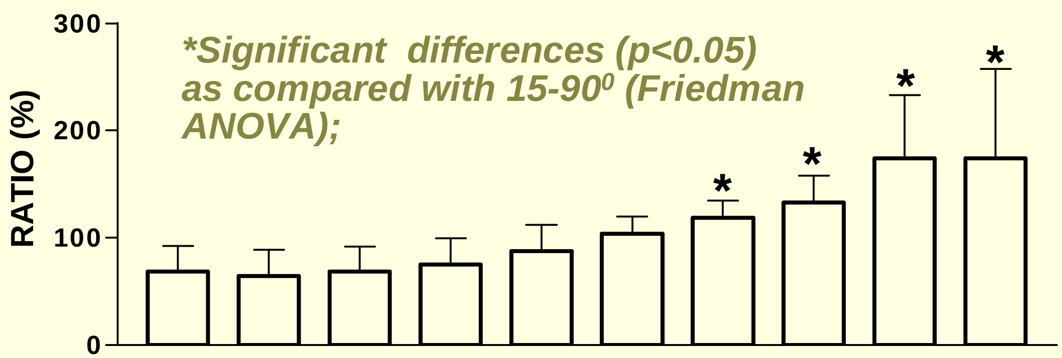


The same modeling with a 4th order polynomial function (Akaike Information Criterion) was applied.

The curve had a maximum at 75^0, with mean value for the torque - 28.9±6.7 Nm, and without statistically significant diffe-rences with values in 60^0 (28.7±5.8 Nm). So, the area of maximum strength of the elbow extensors in healthy, untrained women was between 60 and 75 degrees.

Comparative presentation of elbow flexors and extensors: Torque-angle curves

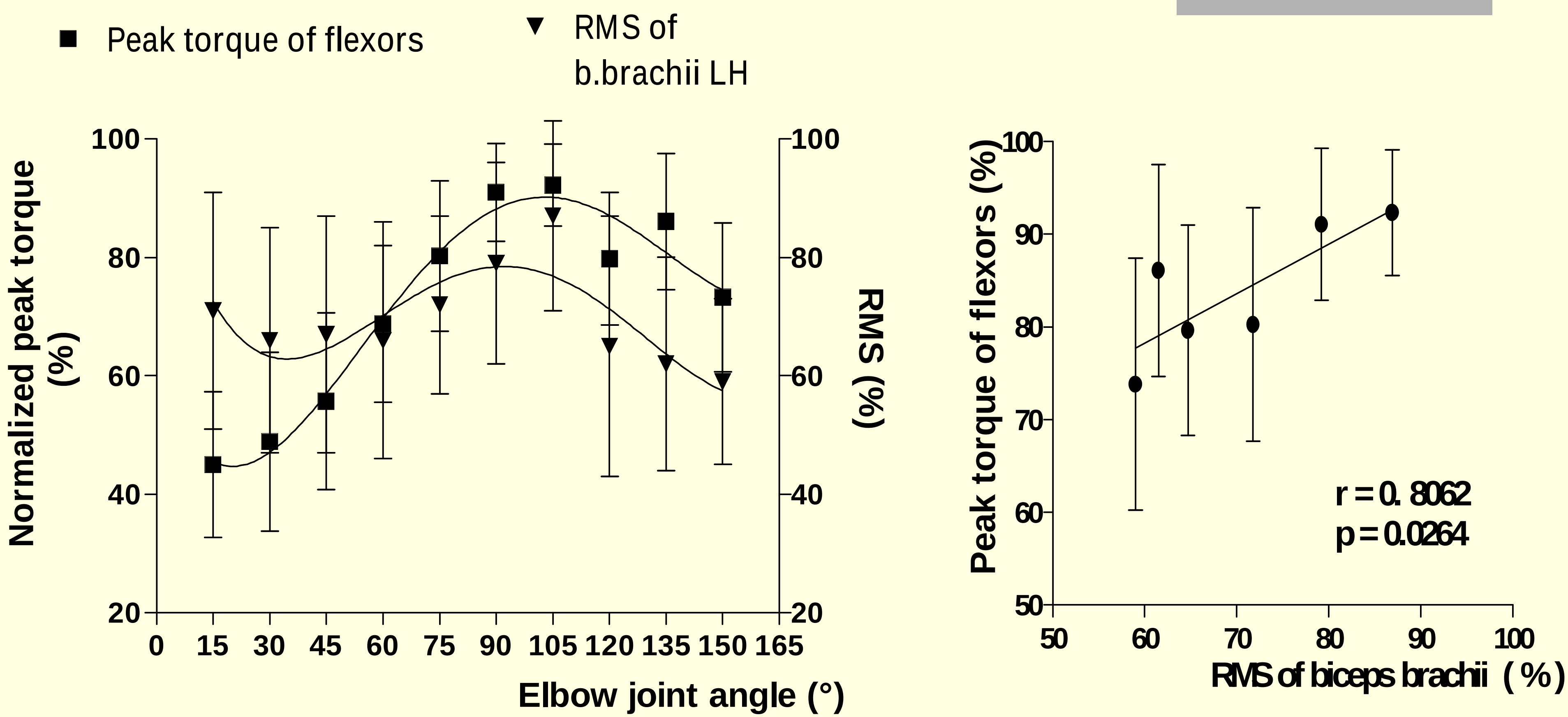




- Both muscle groups are equally strong at 90º and show greater strength than that of 90 º
- Peak values of the strength of extensors occur in moderate extension, and those of the flexors - in moderate flexion, which is appropriate for the activities of daily living
- The values of ratio flexors toward extensors torque in all joint angles tested, demonstrate this force distribution, which suggests that in the area of maximal and submaximal extension, balance, coordination and smoothness of arm movement is probably provided by a greater strength of the extensors, while in submaximal and maximal flexion by that of the flexors.
- For the most part the observed variation in normalized torque with elbow angle can be attributed to force-length and to the moment arm – angle relationships.

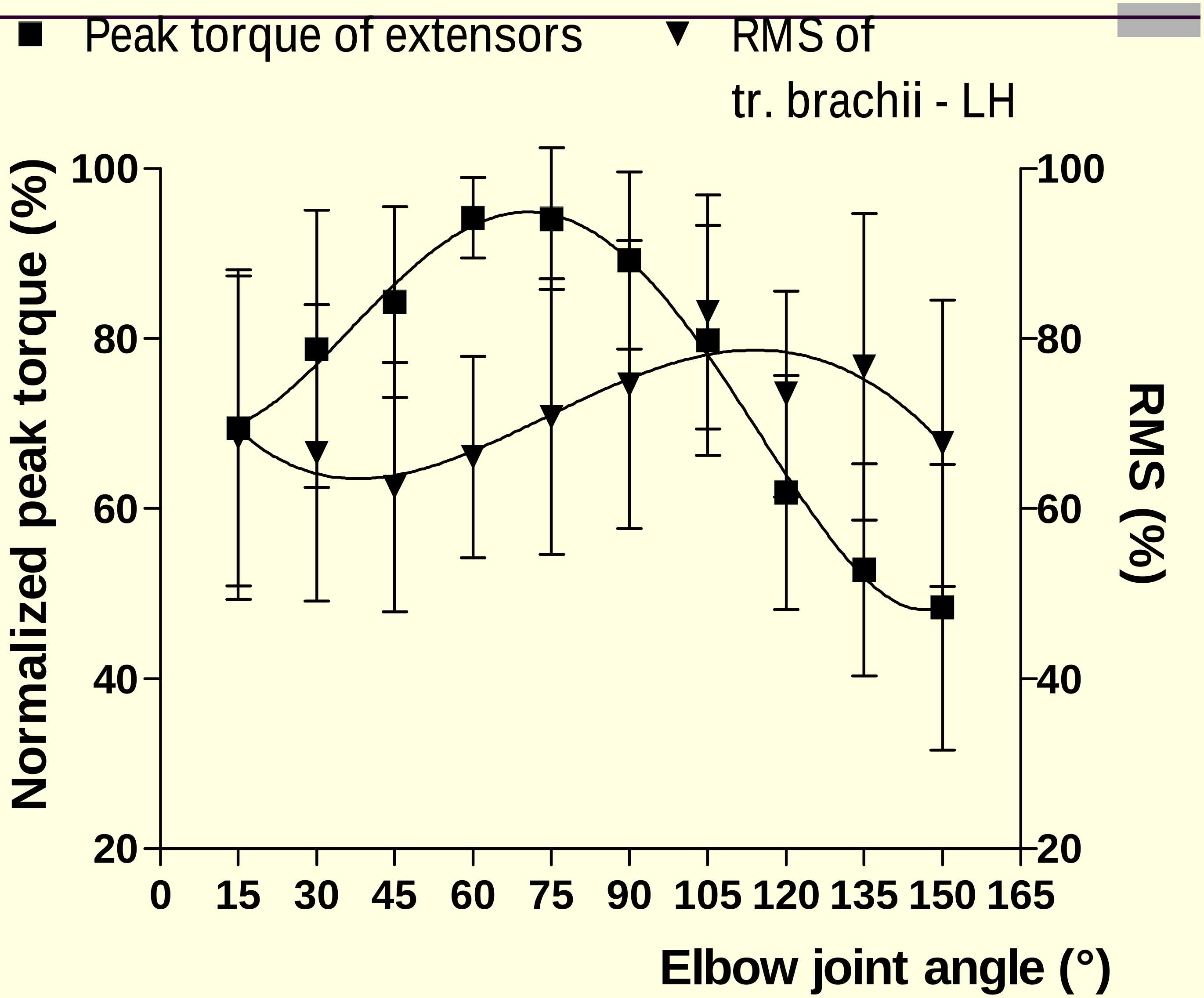
Parallel plot of peak torque-angle curve of elbow FLEXORS and RMS-angle curve of b.brachii

Correlation: torque of flexors and RMS of b.brachii - angular range 75-150º.



RMS-angle curve of BB-LH, plotted in parallel with the torque-angle curve of flexors, shows that there is a correlation between the values of RMS and net torque of flexors only in the range of 15-150 º (Pearson correlation coefficient).

Parallel plot of peak torque-angle curve of elbow EXTENSORS and RMS-angle curve of tr.brachii - LH



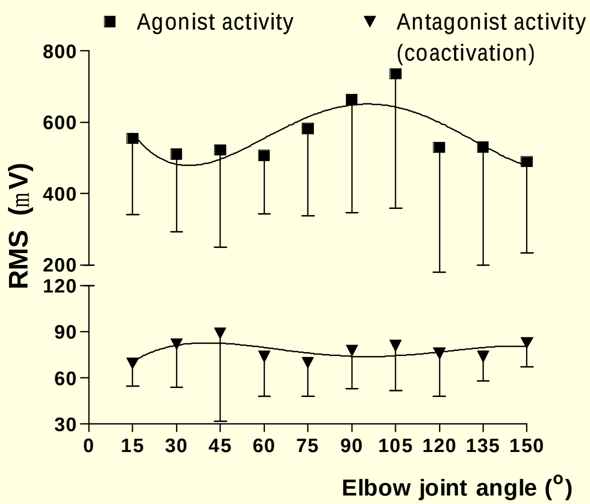
The values of RMS of triceps brachii-LH do not correlate with extensor's net torque (Pearson corr. coefficient). So, the variations in neuronal input of this extensor do not contribute to the shape of the torque-angle curve.

The lack of correlation can be explained by **lower isometric functional capacity** of the TB-long head, which has shorter moment arm and his length changes are negligible.

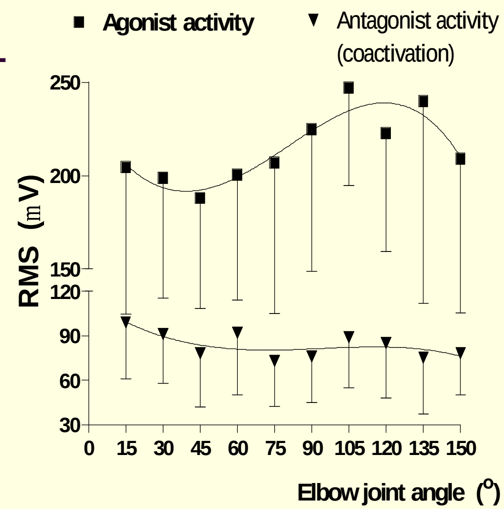
May be the power spectrum and curve with some frequency parameters must also be modelled and analyzed.

Comparison between agonist and antagonist (coactivation) activity of BB_LH and TB-LH; RMS is in µV

Biceps brachii – LH



Triceps brachii – LH



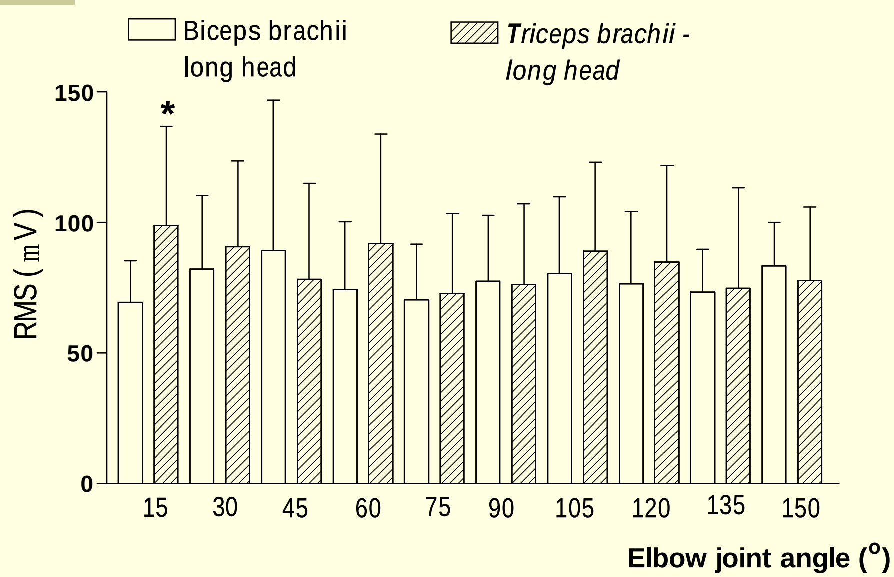
Neuromuscular activity of BB-LH is higher than that of TB_LH in all angular positions, with the exception in 120º and 135º flexion (*Friedman ANOVA)*.

The antagonist activity for both muscles tested,was low, do not result angle-dependant, and were not statistically different between the two muscle in all joint angle, with exception in 15º flexion (*Friedman ANOVA)*.

This coactivation will decrease the net joint torque around the elbow. But it is hard to predict the size of crosstalk and the degree of underestimation.

Coactivation of triceps-brachii - long head during flexion is between 31% and 41% of its activity in extension while coactivation of biceps brachii - long head during extension is between 11.7% and 17.1% of its activity during flexion.

Coactivation



*Significant differences ($p<0.05$) as compared with biceps brachii; *(Friedman ANOVA);*

Conclusions

- The observed variation in normalized extensors or flexors net torque with elbow angle, can be attributed to force-length relationship and the moment arm-angle relationship of the elbow extensors or flexors in healthy untrained females.
- The variations in neuronal input of biceps brachii-long head contribute the shape of flexor torque – angle curve in the range of 75º – 150º flexion.
- The behavior of RMS-angle curve of triceps brachii – long head differs from that of the curve extensor torque-angle.
- It remains to be established whether the power spectrum of the muscle tested is related with the elbow joint angle.

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