DETERMINING THE FUNCTIONS UPON WHICH FORCE GENERATION VELOCITY AND ITS DIMENSIONS ARE CHANGED IN LEG EXTENSORS

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INTRODUCTION: The outcome of a judo combat depends on force generation velocity and the levels of its dimensions that vary throughout the combat according to the requirements arising from a specific situation. In such situations the World and Olympic champions (3) generate a leg extensor force of 1402.5 N at the time of 50-70 ms. In order to program force generation velocity change and the dimensions that it depends on in an individual, specially designed models are used to determine the principles according to which the followed values behave, in the interval between the beginning of generation and the achievement of maximum force. This was done in the present paper.

METHODS AND PROCEDURES: *Subject sample:* Functions upon which force generation velocity and its dimensions change in time in leg extensors were defined in a subject (Dano Pantic), top judoist and winner of gold and silver medals in Balkan, European and world competitions, aged 25, with body height BH = 1.91 m and body mass BM = 97.8 kg, using a special hardware-software designed at Police Academy in Belgrade.
Hardware-software system: The hardware-software system consisted of the equipment for fixating the body positions, the instruments for measuring the distances between measuring points, the computer and software for data acquisition, input, analysis and representation.

Subject's body position at measurement: During the measurement (1,2), the subject was seated in an adjustable chair, with his knee joints in the semi-flexional position at an angle of 115°, while his feet were on an immovable support at an angle of 60-70° to the horizontal. His pelvis was fixed by a wide inelastic band that was fixed to an immovable support by a tensiometric probe. The band and the centers of hip and upper ankle were at the same horizontal plane. The center of gravity of the upper part of the body is located approximately above the axis joining the centers of hip joints, while the subject's arms were fixed at his chest.

Method of measurement: At a specified signal, the subject, positioned as described above with relaxed musculature, tried to reach maximal extension force in the knee joints in the shortest time possible. Force sampling was performed at each millisecond (ms).

Processing the measurement results: In our research we took data about force (Ft) and time (t) at every 1% of maximum force (Fmax). These data were used to calculate force generation velocity (FGV) expressed in Ns, for every % from 1 to 100. Its dimensions, such as muscle involvement velocity (C) expressed in absolute measures; and force generation velocity change (FGVS1) expressed in N/s, were also calculated for every % from 1 to 100. Force generation velocity change (FGVS2) expressed in N/s was calculated at an interval of 1%. Muscle involvement velocity was calculated from the obtained time-force data for each Ft according to: C = - (1/t) *ln((1 – Ft/Fmax)), where Ft is the level of 1%, 2%,…, 99% of maximal force expressed in N; Fmax is maximal force generated by leg extensors expressed in N; C is a constant characterizing motor units involvement velocity; t is time needed to reach the appropriate maximal force level expressed in milliseconds (ms)

Modeling: Fitting, by the least squares method, was used to determine the function forms affecting the followed values.

RESULTS AND DISCUSSION: In the experiment, the subject achieved Fmax of 6719.6 N at the time of 2.461 s. Fitting obtained the following functions that enabled determining the behavior of force generation velocity and its components in the whole scope of force generation:

$FGV=1543.1Ln(t)+5604.5;$
$C(t<0.2)=-220.04t^2+58.732t+0.2286;$
$C(t>0.2)=-0.0978t^3+1.0727t^2-2.5403t+3.423;$
$FGVS1(t<0.2)= -1E + 07t^3 +2E+06t^2-1721.4t-256.13;$
$FGVS1(t>0.2)=1131.6t^4-6607.5t^3+13370t^2-11042t+3344.3$
$FGVS2(t<0.2)=-179437t^2+44792t-428.64;$
$FGVS2(t>0.2) = 254.52t^4-1555.2t^3+3484t^2-3655.4t+2045.4;$

Figure 1

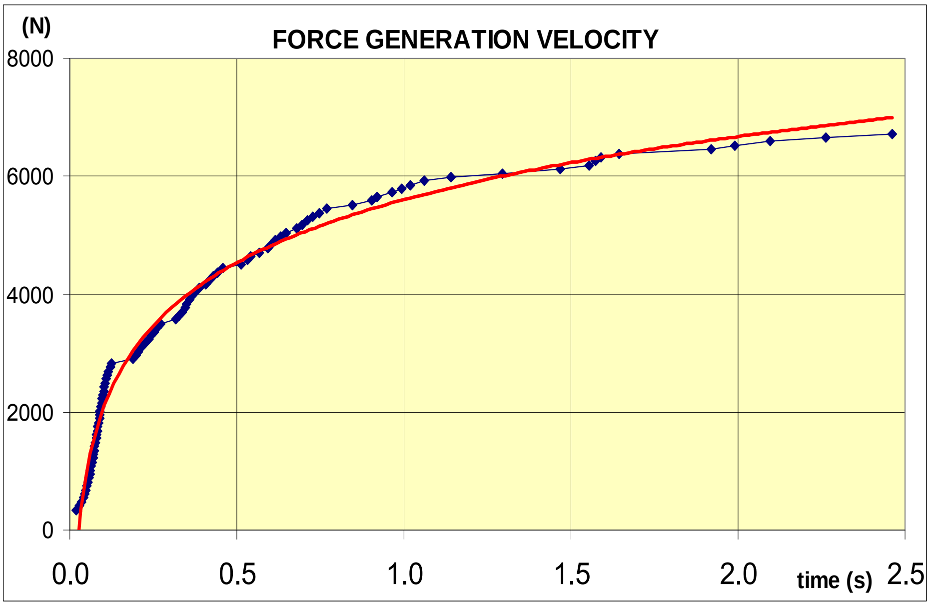


Figure 2. MUSCLE INVOLVEMENT VELOCITY

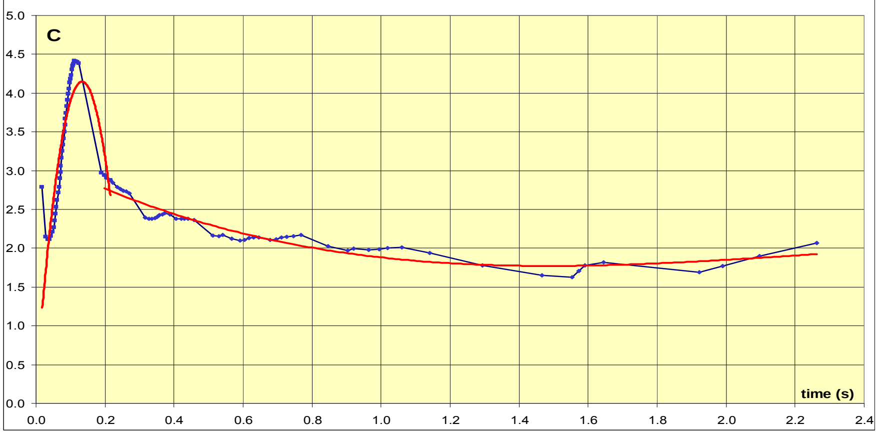


Figure 3. FORCE GENERATION VELOCITY CHANGE – FGVS1

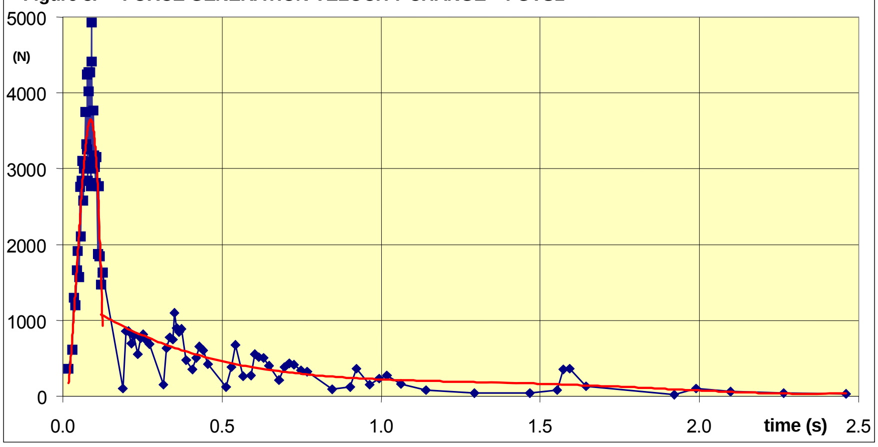
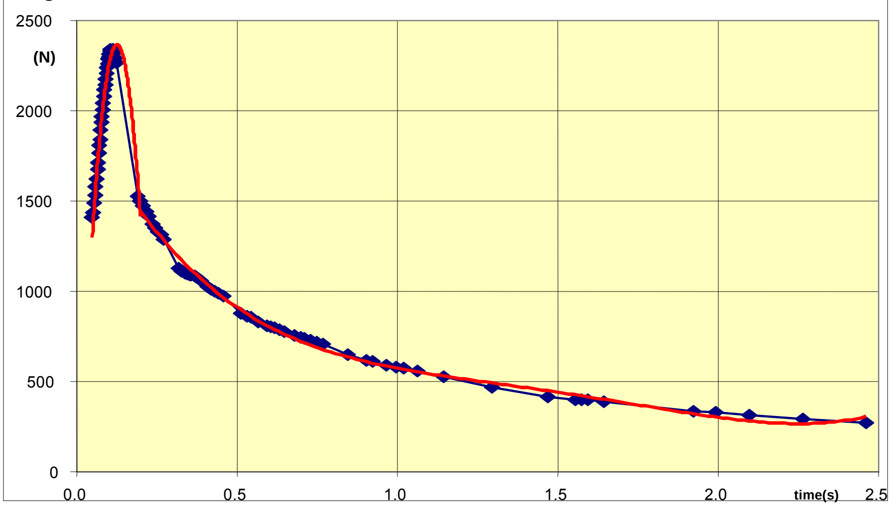


Figure 4. FORCE GENERATION VELOCITY - FGVS2



If the results of our subject are compared to the results of world champions (3), it is observed that our subject generates a lower level of force at the critical time. Maximal values of the observed dimensions that affect force generation velocity are reached in a time longer than is required in combat. The knowledge of the shape of functions that describe the observed values in our subject, and of combat requirements, together with findings in research work (3,4,5,6), help decide upon the choice and composition of adequate methodology that would change the observed dimensions in a specified time as required in combat, so that a contestant could be brought to winning gold medals in world championships.

CONCLUSIONS: The obtained functions define the principles according to which force generation velocity and its dimensions behaved in the whole scope of generation in the individual subject. The functions are used to simulate the changes in the observed variables according to combat requirements, to design the training methods and to control the effects of the training.

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