ISOTONIC MEASUREMENT OF 3D MUSCLE ACTIVATION SURFACE TORQUE/POWER BY ANGULAR POSITION BY ANGULAR VELOCITY

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For measuring biomechanical characteristics of $M = M(\alpha, \omega)$ and $P = P(\alpha, \omega)$ (where M,P -respectively are torque, power developed by maximally excited muscle groups driving a joint, -joint angle, -angular velocity) nowadays the isokinetic method is used (Fuglevand 1987, Kume and Ishii 1981, Marshall et al. 1989). A disadvantageous point of this method is the measurement range is restricted to about 1/3 of the maximum angular velocity. Moreover our experiments have proved that isokinetic motion is felt by the subject as an unnatural one. Therefore in our research we have employed the isotonic measurement method.

METHOD

Isotonic dependencies $\omega = \omega(\alpha)$ for maximal knee extension trials at various constant torques were collected for four volunteer subjects using a dynamometer which is an improved version of the instrument described elsewhere [Kedzior et al. 1987]. Adaptive system of computer control of the dynamometer allowed for isotonic measurement conditions [constant torque resisting the motion in the investigated joint] within the range $0 < \omega < 15$ rad s^{-1}. For a given subject a whole series of isotonic measurement were done increasing the imposed constant torque by 5 N or so from minimum up to maximum. Between the measurements the subject took a rest.

When the isotonic measurements was done on the same stand and with the same positioning of the subject.

RESULTS

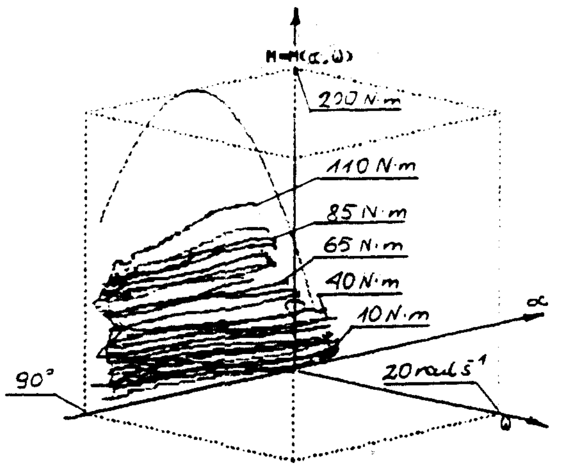

Figure 1: Rough results of isotonic and isometric measurements of the knee joint extensor muscle group (subject D.D)

Figure 1 gives an example of results collected for one subject - a set of curves of the $\omega = \omega(\alpha)$ type obtained for different loads M = const and supplemented with static characteristic $M(\alpha)$ for $\omega = 0$. The coordinate system begins in point M = 0Nm, $\alpha = 180^0$, ω =0rad/s. Angle $\alpha = 180^0$ means that the limb is fully stretched.

This set of data was approximated (least square method) using a 3D surface formula similar to the 2D A.V.Hill equation

$$M(\alpha, \omega) = \frac{[\,M_0 + a(\alpha)\,] \quad b(\alpha)}{\omega + b(\alpha)} - a(\alpha) \qquad (1)$$

where: a, b - square functions of angle α, M_0 - maximal static torque.

Figure 2 presents the 3D biomechanical characteristic M(,) obtained on the basis of rough results shown in Fig. 1. Using contour lines makes it easier to detect the course of the surface. The program processing and presenting the results of measurements determines also 3D dependence

$$P(\alpha, \omega) = M(\alpha, \omega) \cdot \omega \qquad (2)$$

Fig.3 shows such characteristics obtained on the basis of results presented in Fig.2

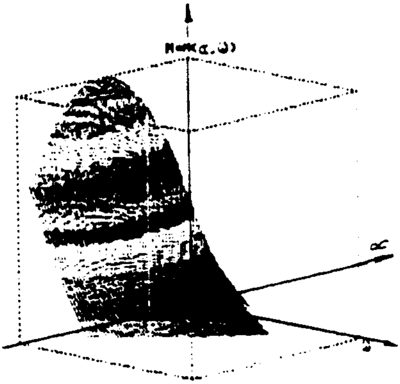

Figure 2: Biomechanical characteristic $M = M(\alpha, \omega)$ of the knee joint extensor muscle group (subject D.D).

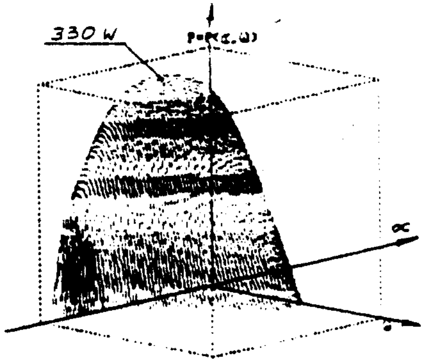

Figure 3: Biomechanical characteristic $P = P(\alpha, \omega)$ of the knee joint extensor muscle group (subject D.D)

The program allows one to read the values of M or P for required α and ω and to project any cross-section of a surface.

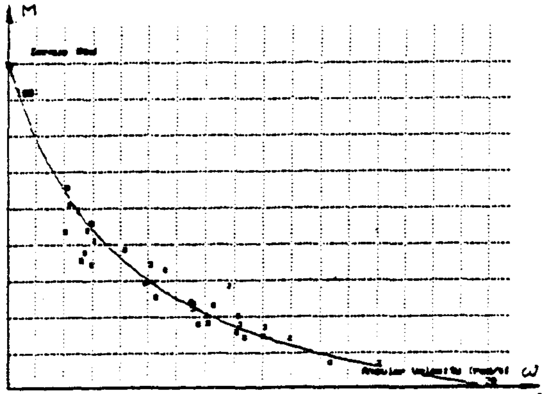

Figure 4: Velocity characteristics of the knee joint extensor muscle group for $\alpha = 150^0$

Fig.4. shows a projection of the cross-section of a surface $M(\alpha, \omega)$ shown in Fig.2 with the plane parallel to plane M, ω for $\alpha=150^0$. It is a characteristic of torque- angular velocity type . This example allows one to evaluate the discrepancies between the theoretical characteristics and the actual measurmed data.

CONCLUSIONS

The problem of investigating 3D characteristics of muscle groups of $M(\alpha, \omega)$ and $P(\alpha, \omega)$ is relatively new. There are no, so far, commonly accepted or tried procedures of measuring and interpreting experimental results of such investigations. The purpose of our study was to present a method which consist of conducting a series of measurements of isotonic and isometric characteristics. For small load, not exeeding 10 Nm, high angular velocities of motion in joint can be attained. Therefore it is possible to determine the course of characteristics in the range up 15 rad s^{-1} and over. That range of velocity of motion in joints, very important in some disciplines of sports, has been so far hardly investigated.

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