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INTRODUCTION

The human locomotor System has two main functions: moving and sensor (proprioreceptor). Both are necessary for muscle activity regulation. Knowledge about muscle morphometric characteristics (length and force arm) during motion allows analysis of: 1) regimes of muscle contraction; 2) the most effective zones of force suppling; 3) data about muscle speed ability.

There are many methods of determining muscle morphometric characteristics. They may be divided into two groups; direct measure methods and simulating. Each of these methods have positive and negative aspects. However, simulating allows more meaningful information to be obtained about the changes in muscle morphometric characteristics during movement (Kozlov et al, 1988). Therefore, it is necessary to have data about joint angles and parameters of distance between a joint centre of rotation and points of muscle attachment to bones. Determination of Joint angle data may be performed with a variety of well know methods (cinematography, ciclo or video). Despite changes in joint angles during movement, parameters which characterize distance between centres of rotation and points of muscle attachment don't change. These parameters are constant and depend on the individuals characteristics. In the literature describing skeletal and muscle anatomy there are only qualitative descriptions of muscle attachment characteristics (Ivanizkij, 1938; Sinelnikov, 1972). There is not enough data about these constant parameters, and some of literature has drawbacks: 1) sexual differences have not been taken into account; 2) subject numbers are low; 3) no examination of the relationship between anthropological characteristics of the human locomotor system and the constant parameters has been made (Kozlov and Zvenigorodskaja, 1981).

The task of this research was to quantify the numerical constants which characterize distance between centre of joint rotation and point of muscle attachment to bone and to determine the relationship between these parameters and the anthropological characteristics of the human locomotor system.

METHOD

For calculation of length and force production on human leg muscles is necessary to have data of 17 constants (figure 1).

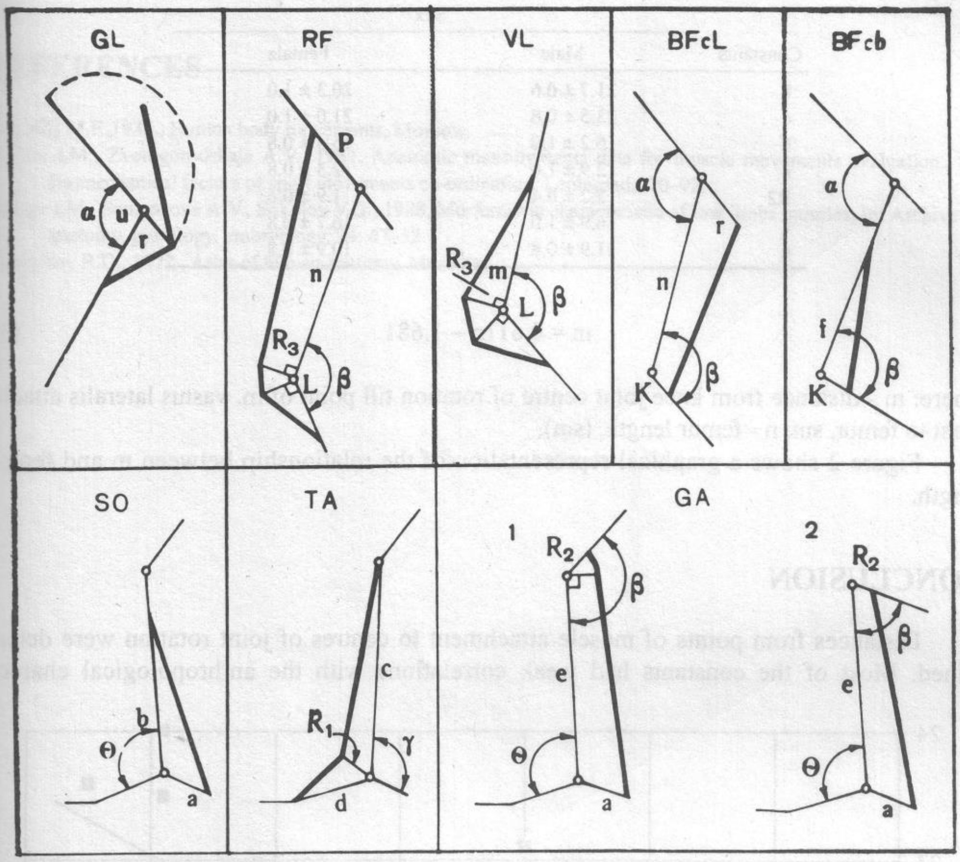

Figure 1. Models of human leg's muscles. Where: GL - m. gluteus maximus; RF - m. rectus femoris; VL - m. vastus lateralis; BFcL - m. biceps femoris caput longum; BFcb - m. biceps femoris caput breve; SO - m. soleus; TA - m. tibialis anterior; GA - m. gastrocnemius. (Designation see at the text). a - distance between the talocrural articulation centre of rotation and the point of the triceps surae attachment to the calcaneal tuber; b - distance between the talocrural articulation centre of rotation and the point of m.soleus attachment to the tibia; c - distance between the talocrural articulation centre of rotation and the point of m. tibialis anterior attachment to the tibia; d - distance between the talocrural articulation centre of rotation and the point of m. tibialis anterior attachment to the foot; e - crus length (distance from the talocrural articulation centre of rotation till the knee joint centre of rotation); f - distance from the knee joint centre of rotation till the point of m.biceps femoris caput breve attachment to the femur bone; k - distance from the knee joint centre of rotation till the point of m. biceps femoris attachment to the fibula bone; l - distance from the knee joint centre of rotation till the point of m. quadriceps femoris to the fibula bone; m - distance from the knee joint centre of rotation till the point of m. vastus lateralis to the femur bone; n - femur length (distance from the knee joint centre of rotation till the hip joint centre of rotation); p - distance from the hip joint centre of rotation till the point of m. rectus femoris attachment to the iliac bone; r - distance from the hip joint centre of rotation till the point of m. biceps femoris caput longum attachment to the tuber of the ischium; R1 - distance from the talocrural articulation centre of rotation till the superior retinaculum of the extensor muscles of the foot; R2 - distance from the knee joint centre of rotation till the point of m. gastrocnemius attachment to the femur bone; R3 - distance from the knee joint centre of rotation till the kneecap front surface. t - distance from the point of attachment to the iliac bone till the tuber of the ischium; u - distance from the hip joint centre of rotation till the point of m. gluteus maximus attachment to the femur bone.

All the constants may be divided in two parts. The first group constants: a, d, e, k, l, n, p, R1, R3 may be measured just on the subject's body or the photo (N=8). The second group constants: b, c, f, m, r, R2, u, and t may be measured on cadavers. For the determination of second group constants male (N=23) and female (N=20) cadavers were measured with an age range of 25- to 45 years. The centre of joint rotation and point of a muscle attachment were marked. For the distance from points of muscle attachment and the centre of joint rotation measurements were made using Martin's anthropometer (error of measurement was 0.05 sm). If the place of muscle attachment was not precisely defined, such as with m. tibialis anterior on the tibia, the most distant point (D) and proximal point (P) of muscle attachment were determinated. Numerical constants b,c,f,m, were calculated by the following formula.

$$Const=(X1-X2)/2 + X1 \quad (1),$$

where X1 – distance from the joint's centre rotation to the point P, X2 - distance from the joint's centre rotation to the point D.

RESULTS

To examine the numeral means of the constants and anthropological characteristics of the human locomotor system a correlation analysis was used (r-Brave-Pearson correlation coefficient) there was a weak correlation between the numerical means of the constants b, c, f, u and R2, and the anthropological characteristics of the human locomotor system but there was a strong positive correlation between the means of constant m and femur length (n), Table 1.

Table 1. Correlation coefficients between characteristics of the human locomotor system and measured constants

Characteristics of the human locomotor system	Sex	Constants					
		b	c	f	m	R2	u
Crus length (e)	M	0.482	0.703	–	–	–	–
	F	0.606	0.404	–	–	–	–
Femur length (n)	M	–	–	0.546	0.817	0.185	0.368
	F	–	–	0.514	0.827	0.188	0.108

For constants b,c,f, t, u, and R2 that have weak correlations with anthropological characteristics a statistical value was calculated (Table 2).

Table 2. Mean values of constants which characterize distance from axes of rotation to points of muscle attachment, (sm)

Constants	Sex	
	Male	Female
b	21.7±0.6	20.3±1.0
c	23.5±0.8	21.0±1.0
f	16.2±1.0	15.5±0.8
r	2.9±1.0	2.3±0.8
R2	2.2±0.4	1.9±0.6
t	16.9±1.0	16.7±0.8
u	11.9±0.8	10.9±0.8

For constant m which has a strong positive correlation with femur length a regression equation was evaluated. A linear regression equation was calculated between the mean of m constant and femur length. Formulas which describe the relationship between mean value of m constant for men (2) and women (3) were obtained.

$$m = 0.560n + 0.654 \qquad (2)$$

$$m = 0.611n - 1.681 \qquad (3),$$

Where m – distance from knee joint center of rotation till point of m. vastus lateralis attachment to femur, sm; n – femur length, sm.

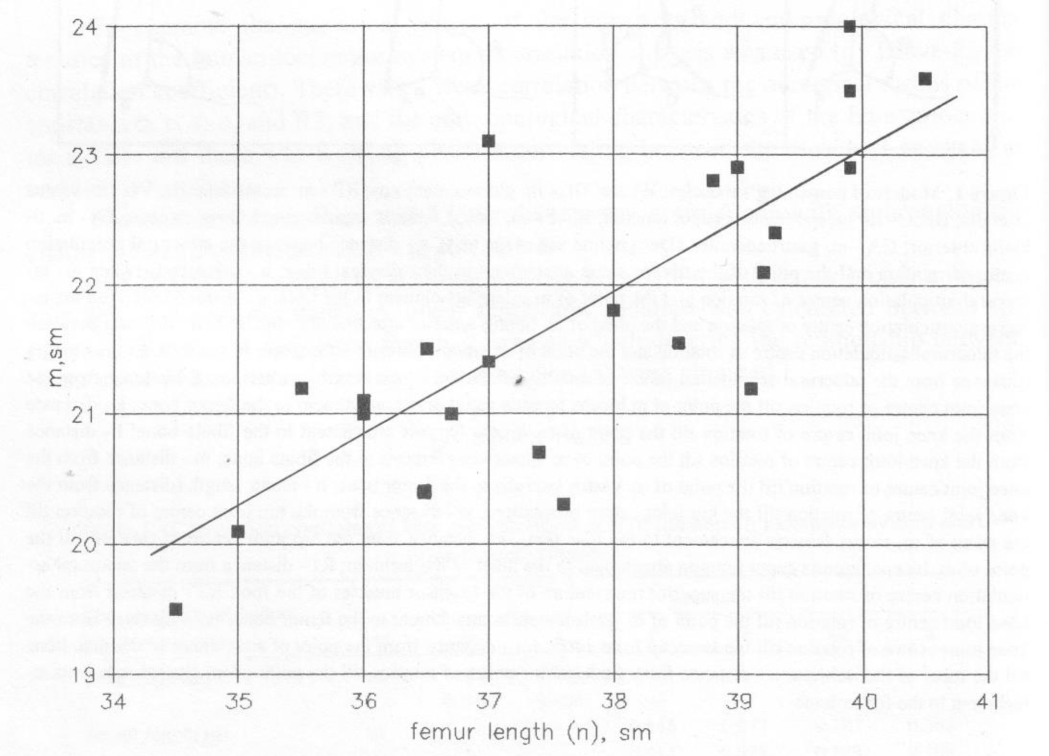

Figure 2 shows a graphical representation of the relationship between m and femur length.

CONCLUSION

Distances from points of muscle to centers of joint rotation were determined. Most of the constants had weak correlations with the anthropological characteristics of the human locomotor system. A regression equation was calculated to allow modeling of morphometric muscle characteristics during sport movements.

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