Determination of Certain Human Muscles Morphometric Characteristics in Sport Movements (Biomechanical Factor in Muscles Moments Formation)

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The main mechanical cause of man's joints movements are torques or muscles' moments. Their formation depends as upon peripherical factors (length and arm tractive force of the muscle) as upon central physiological ones (periods of muscles' physiological activity in the locomotor cycle). The objective of research is to define a combination of morphological and physiological factors of muscles' moments formation in the locomotor cycle of some sport movements.

METHODS

The object of research were the topclass runners and cyclists. Kinematic and electrophysiological motor characteristics of 8 women-runners and 18 men-cyclists were registered. Successive points' positions on the body (the joints correspond to hip, knee and ancle' axes) were fixed on a film with the frequency of 60-100 hertz. Electrical activity of seven leg muscles (m.gluteus maximus, m.tensor fasciae latae, m.rectus femoris, m.vastus lateralis, m.biceps femoris, m.tibialis anterior and m.gastrocnemius) was registered by an oscillograph in different combination (4 muscles in each experiment). Each moment of points' exposure on a film was recorded on oscillograph tape where muscles' electrical activity

(EMG) was also registered. Mathematical models of Morrison (I.B. Morrison, 1970), Stepanov (V.V. Stepanov, 1977), Pedotti (A. Pedotti, 1977), Frigo and Pedotti (C. Frigo, A. Pedotti, 1978), Kozlov and Zvenigorodskaya (I.M. Kozlov, A.V. Zvenigorodskaya, 1982) were used to calculate muscles' morphological characteristics (length and tractive force arm).

RESULTS

The moment developed by a muscle is directly proportional to its force and traction arm and the muscle force depends upon its extension degree. Thus, the muscle length and its traction arm are the morphometric characteristics which cause formation of joints' torques.

Diagrams show typical combination of muscle length and its arm traction force in the running cycle for: m.gastrocnemius (A), m.tibialis anterior (B), m.rectus femoris (C) and m.biceps femoris (D). Figure I represents the plots of muscle traction arm (h) and muscle length (L) vs. time (t). Dotted area limits the support phase. The continuous line corresponds to the active periods (EMG) and the stroke line —to the passive period of muscle morphometric characteristics' change.

Comparison of integrated electrical activity, length and muscle tractive force arm allows to reveal four versions of muscle moments formation.

For m.gastrocnemius (Fig. I-A) which provides the interaction with outer forces in the ancle joints both factors change in the same manner in the running cycle, i.e. a muscle length change is accompanied by an analogous change in the traction arm. The muscle excitation period coincides with the muscle length and traction force maximum values in a locomotor cycle and, conversely, the passive change period coincides with their minimum values. The active period begins before support and stops before it is over. The muscle length variation is 12.3 percent and the variation to relation of the ancle joint is 12.5 percent (individual data).

M.tibialis anterior in the running cycle is characterized by a relative constancy of morphometric indices (Fig. I-B). It is active in the transfer phase as well as the support phase.

The third type of morphometric characteristics combination is peculiar for m. gluteus maximus, m.vastus lateralis, m. rectus femoris at the locomotions. In this case a maximum value of one characteristic corresponds to a minimum one of the other, i.e. their intercompensation of the contribution in the muscle moment formation occurs in the

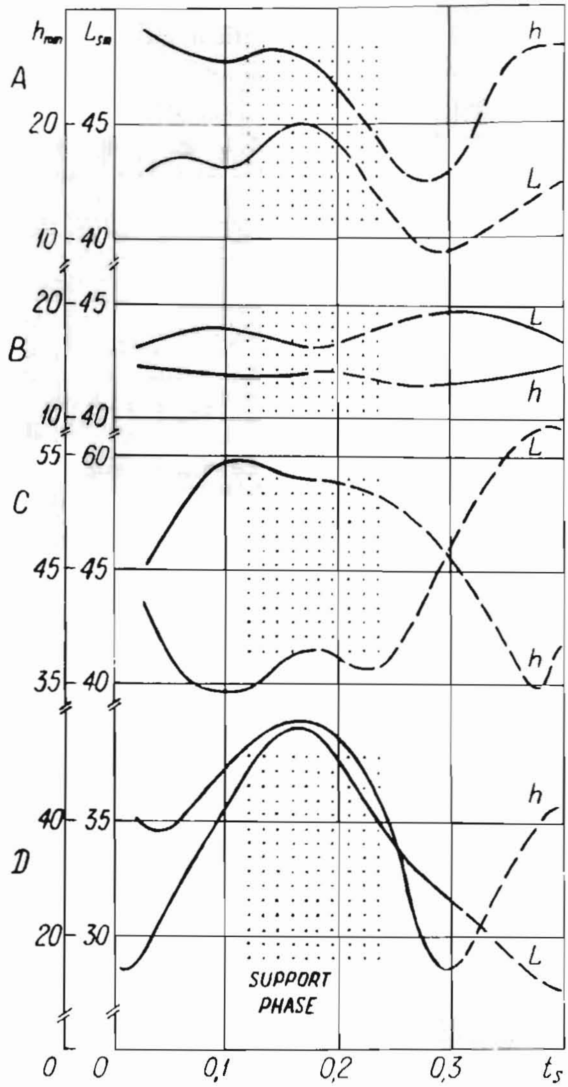

Fig. 1: Combination of muscle length and its arm traction force in the running cycle.

A – m.gastrocnemius

B – m.tibialis anterior

C – m.rectus femoris

D – m.biceps femoris

h – arm traction force, L – muscle length

t – time

Dotted area limit a support phase, continuous line corresponds to an active period and stroke line to a passive period of muscle morphometric characteristics' change.

locomotor cycle. Thus the moment of force developed by the muscles is created more uniformly at the locomotions of the corresponding joint. The peculiar feature of m.gluteus maximus is that it functions only in concentric regime when running. Muscle length variation is 43.3% and force arm variation is 36.4%. The length variation of m.vastus lateralis is 26.6%, m.rectus femoris is 13.5%.

Correlation of m.biceps femoris morphometric characteristics (Fig. I-D) is of intermediate character: during one part of a locomotion cycle the traction arm (in relation to the knee joint) and muscle length change in similar manner, but during the other part —in the opposite way (the 4th type). Muscle length variation is 25.5% and force arm variation is 23.2%.

Combinations of tractive force arm and muscle length at locomotions are various: they either change in the same direction, or in the opposite direction, or they do not change at all. Recuperation of energy in a running cycle when muscles contraction regimes change occurs like that: at the eccentric regime the muscle traction arm decreases and at the concentric one it increases.

Comparison of muscles activity periods in a locomotion cycle when pedalling bicycle in a voluntary and maximum rate shows that at the maximum rate the muscles activity periods are shorter, however relative activity time is longer (Fig. 2). Thus combinations of activity periods and muscles morphometric characteristics in a locomotor cycle is a factor of movements' rate regulation.

The moment when locomotor muscle activity starts and when it stops in locomotor pedalling cycle are shown in the table.

Time Characteristics of Muscle Activity when Pedalling in a Maximum Rate (ms)

Muscles	n	Muscles Electrical Activity					
		Point of Begning			Point of Stopping		
		X	G	V%	X	G	V%
Tensor fasciae latae	30	9.0	1.5	16.7	41.9	1.8	4.3
Gluteus maxim.	30	47.4	1.8	3.8	82.3	0.9	1.1
Rectus femoris	25	27.0	0.9	3.3	80.2	0.9	1.1
Biceps femoris	25	24.3	1.8	7.4	37.5	0.9	2.4
Gastrocnemius	19	16.2	0.9	5.5	23.4	0.7	2.9

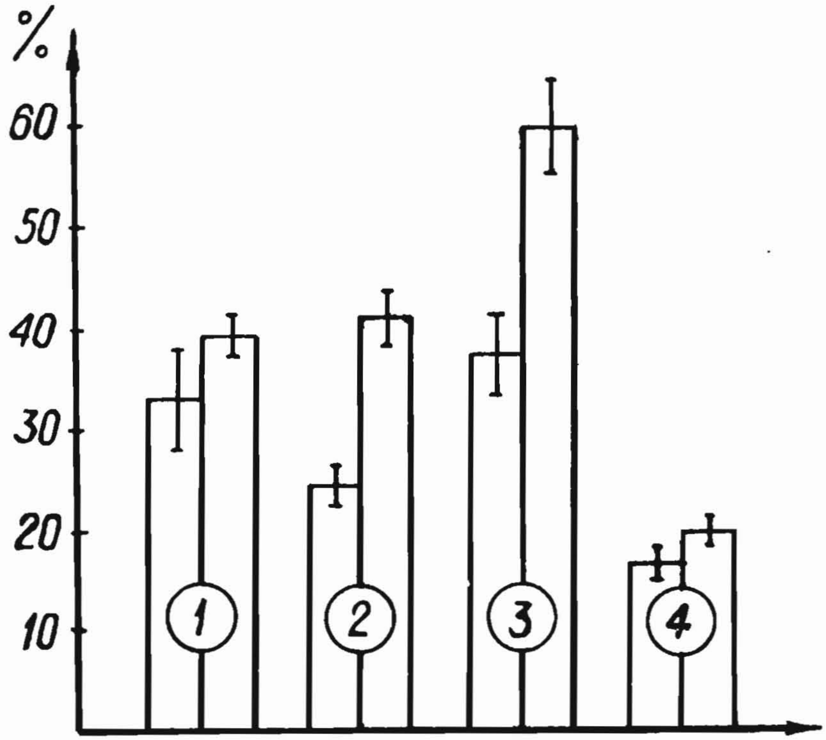

Fig. 2: Periods of muscles activity in a motor cycle when pedalling a bicycle in a voluntary and maximum rate.

1 – m.tensor fasciae latae
2 – m.gluteus maximus
3 – m.rectus femoris
4 – m.biceps femoris

Pedalling occurs in stereotype conditions of kinematic and dynamic change in successive movement cycle (constant and stipulated trajectory of leg links' movements and rate uniformity). This allows to reveal the differences between central (motor programme) and reflectory movement organization. Central motor programme is of much variability. Higher coefficients of muscles' entering moments variations in a locomotor cycle in comparison with the moments of their activity testify to that. This difference is particularly significant for multi-joint muscle (m.tensor fasciae latae).

CONCLUSIONS

Formation of muscles' moments in the movement process occurs as a result of different combinations of muscle length and tractive force arm. However, in most cases these indices change in phase opposition which leads to a more uniform formation of muscles' moments.

Though the multi-joint length is greater, than that of a single-joint one, the degree of their contraction is less than that of a single-joint one.

As a rule, eccentric contraction is accompanied by decrease of tractive force arm and concentric contraction —by its increase.

Movements rate increase is achieved as a result of muscles activity duration relative to a locomotion cycle. The starting moment is provided by the central commands (motor programme) and the moment of stopping —in a reflectory way.

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