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Bases of technique of sprinting

Abstract. ***Purpose:*** *to determine the biomechanical consistent patterns of a movement of a body providing the highest speed of sprinting.* ***Material and Methods:*** *the analysis of scientific and methodical literature on the considered problem, the anthropometrical characteristics of the surveyed contingent of sportsmen, the analysis of high-speed shootings of the leading runners of the world.* ***Results:*** *the biomechanical bases of technique of sprinting make dispersal and movement of the general center of body weight of the sportsman on a parabolic curve in a start phase taking into account the initial height of its stay in a pose of a low start. Its further movement happens on a cycloidal trajectory which is formed due to a pendulum movement of the extremities creating the lifting power which provides flight duration more in a running step, than duration of a basic phase.* ***Conclusions:*** *the received biomechanical regularities of technique of sprinting allow increasing the efficiency of training of sportsmen in sprinting.*

Keywords: *index of activity, technique of run, parabolic and cycloidal trajectories of movement of the general center of a body weight, anthropometrical characteristics.*

Introduction. The question of the movement of a person and animals is connected with the implementation of the step movement. The greatest attention in the research of this motive act is directed on studying of biomechanical characteristics of walking and run. In the theory of sport the main interest is concentrated on the research of sprint for the purpose of the establishment of mechanisms of a movement of a body with the most achievable speed. In bionics this task is connected with the creation of the walking mechanisms in robotics as such movement doesn't demand a smooth paving.

Concerning sprint, it is possible to say that the main objective of physical action is the achievement of maximum speed of a movement which depends on metabolic opportunities of an organism, the executive systems and the biokinematic characteristics of the musculoskeletal system.

Communication of the research with scientific programs, plans, subjects. The research is executed according to the plan of scientific researches of the chair of track and field athletics of KSAPC.

The objective of the research: the representation of the defining biomechanical regularities which are a cornerstone of the implementation of kinematics of a movement in a smooth sprint.

Materials and methods of the research: the analysis of scientific and methodical literature on a case in point, the analysis of high-speed video filming of run of the leading sprinters of the world and anthropometrical characteristics of the structure of their constitution, and also the main regularities of biokinematic characteristics of a movement of a body in basic and its unsupported provisions.

Results of the research and their discussion. In sprint the defining phases of "dispersal" of a body weight are start and starting acceleration. The subsequent efficiency of run is defined by possibility of a preservation of necessary intensity of metabolic processes in ensuring an inquiry of the working components of the dynamic stereotype defining the established cycle of a step of high-speed run [1].

There is a dispersal of the general center of a body weight (GCBW) for the set trajectory in a phase of starting dispersal from the provision of a low start which is defined by an action of two forces which are orthogonal one to each other. One is directed on a rise and a deduction of GCBW at a necessary height over the support plane, and another provides its horizontal movement. The interaction of these forces defines technique of a performance of leaving from starting blocks and kinematics of the first starting steps.

The first starting steps, from the moment of a separation of hands from a support, are connected with the need of a removal of the falling GCBW on an optimum trajectory of its subsequent movement. Coming back to the interacting forces, it is necessary to consider optimum conditions of their ratio and behavior of the biokinematic links of a body providing their emergence. In all cases the initial pose of a sportsman provides the arrangement of GCBW concerning the support plane, and the net force, passing through it, determines a trajectory of movement of GCBW by the vertical and horizontal direction. Such movement can be carried out only on a parabolic trajectory to the following stage of a basic situation on other foot. Thus the vertical component of a net force has to provide a carrying power not less than force of a gravitational attraction on the entire period until the following phase of a support. Then this process repeats. The vertical component arises due to the movement of a swing leg, a back extension in the period of a support of two feet on starting blocks and pendulum swing movements of hands which are carried out in the different direction. Depending on it there is a raising of GCBW on the possible height of a working trajectory of a smooth run. In the subsequent phase of a support a derivation of GCBW proceeds to a height of a working trajectory of its movement. In an actual practice this process occupies three – four first running steps [2].

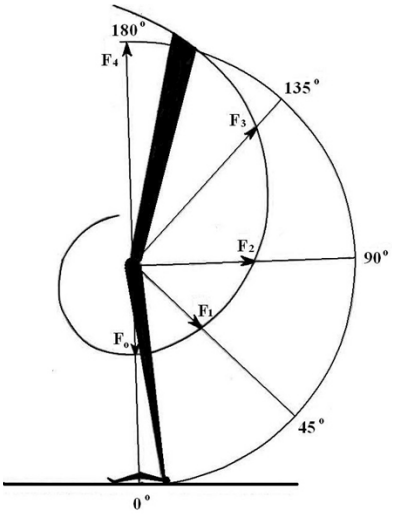
Optimum conditions of a ratio of the movement of the biokinematic links providing the redistribution of driving forces consists that GCBW comes to a parabolic trajectory which provides the maximum flying range. Such trajectory is reached when moving GCBW at an angle 45° concerning the support plane. In almost carried out supervision the angle of movement of GCBW when leaving from starting blocks makes for about 40,8±1,19°. The deviation of this size depends both on the optimum carried out equipment, and on the anthropometrical data of a sportsman. Actually, the specified size reflects the average characteristic, but anyway it remains 45° that makes the most effective angle of a derivation of GCBW to the level of working height of a smooth run.

Such disagreement of supervisions and the theory of ballistics of a movement of a body in an unsupported state is explained by that a runner's GCBW is in a starting situation already over a support at a certain height and a starting point,

at correctly carried out technique of start, lies on an intermediate point of a parabola with a departure angle 45°.

The starting position of GCBW in the provision of a low start depends on individual anthropometrical characteristics of a somatotype of a sportsman and his current physical state. The higher the center of gravity is located, in a bigger measure a redistribution between a vertical and horizontal component of net force towards a horizontal component is possible that provides higher initial speed of starting dispersal of GCBW. This effect is checked by a physical model which reflects a reduction of an angle of a departure for ensuring a faster horizontal movement of a body that is accurately shown at insignificant distances of movement of an object and rather small speeds of its movement. In track and field athletics types this effect is observed in all types of a throwing, shot put, long jumps, in a triple jump.

The efficiency of technique of a performance of a low start completely depends on the correct pose of a sportsman that is defined by a distance of starting blocks and a place of remoteness from the line of start. The noted characteristics carry individual manifestations and first of all depend on the anthropometrical data of a sportsman, but the defining factor is the general regularity connected with an impulse of force which is given by a sportsman by an extension of feet in knee joints. In all cases the main indicator is speed of the development of force and duration of its action. The most characteristic, on what attention is paid in providing an impulse, the speed of the development of force in time or size is which is defined as $\frac{df}{dy}$, but thus such factor remains unaddressed as an initial and final value of the developed force during its action. The initial force as an indicator of the beginning of the development of the process of its growth, is defined by a foot extension angle in a knee joint completely. This process is characterized by a force increment on an angle of an extension of the biokinematic links presented by a shin and a hip. This size is defined as $\frac{df}{dy}$ and its value on each linear change of an angle of the extension proceeding on an arithmetic progression gives a force increment which changes on a geometrical progression. Being presented in polar coordinates, changes of this size are described by a logarithmic curve. This feature of an increment $\frac{df}{dy}$ is presented in the pic. 1 [3].



Pic. 1. The force size increment on a foot extension angle in a knee joint where the corresponding to it the growing effort size is noted to each value of an angle of an extension

The increase in an angle of an extension gives the increase in an initial value of force and its further growth, but thus the process course time is reduced. The optimization of a value of a size of an impulse of force is reduced to a usual variation task. This regularity defines a distance of starting blocks among themselves, and possibility of preservation of a starting pose defines the remoteness of starting blocks from the starting line.

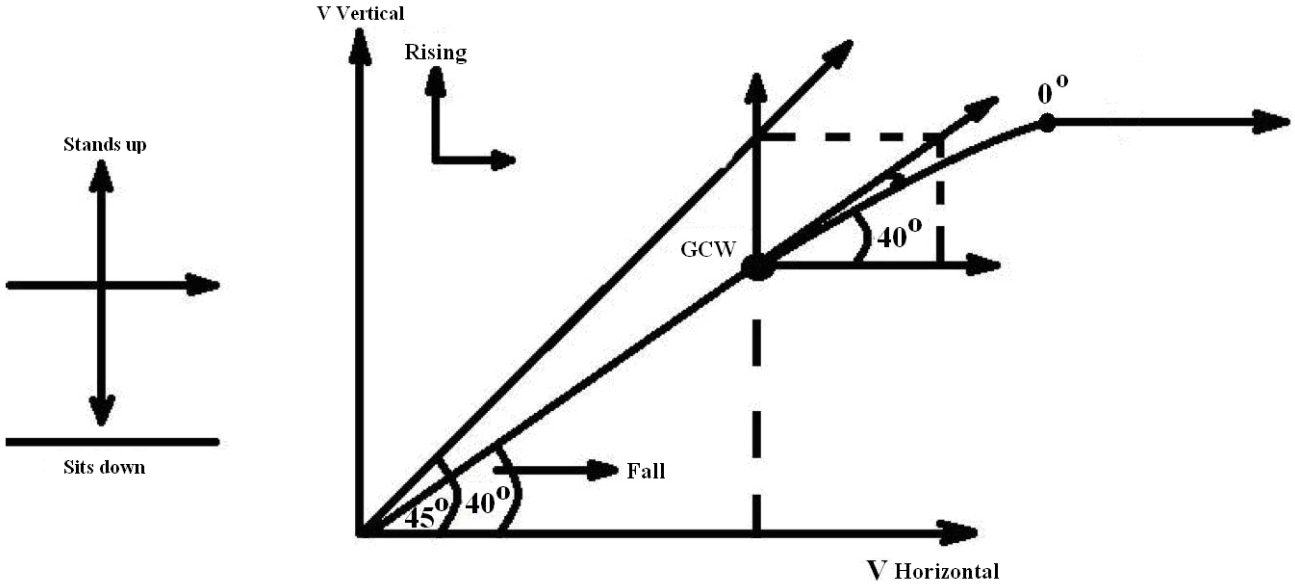
At a dispersal of GCBW the period of a joint leg extention is observed, each of which has the initial angle of an extension. The difference of these angles allows reaching a site of an extension of a take-off foot for a period of a joint extension of a supporting (jog) leg and swing leg on which the increment of effort to a angle of an extension reaches the maximum value and such duration of effort at which the reported impulse of force (Ft) reaches the maximum size. Such distance between starting blocks is the most effective. A shorter distance doesn't provide a sufficient dispersal (a swing leg) and length of the first step is much shorter, than it is necessary. In the return case, at long distance of starting blocks, the first step is very long, but its speed is insignificant.

The general structure of the movement of GCBW when performing a low start is presented in the pic. 2 [4-5].

The schedule of a resolution of forces in starting situation and the speeds of the movement GCBW gathered by them reflecting the reason of its movement at an angle is less 45° where the parabola site which is noted by a fat line corresponds to a real trajectory of the movement of GCBW; the site noted by a dotted line corresponds to the alleged movement of GCBW under a condition if a dispersal began with the line of a support [6-8].

Rising of GCBW to a starting position at smooth run is reached at the qualified sportsmen on the first three steps that are presented in pic. 3. The activity index (the support of the time of a phase relation to the time of a flight phase) on the first 10 steps remains more units, and then there is a stabilization of length and frequency of running steps which is followed by the change of the time of a phase of a support and flights. After a full dispersal of a body the time of a support becomes shorter, and a flight is longer that is followed by the reduction of an index of activity. The equality of an index of activity to

Pic. 3. Performance of the first step of a low start of the ex-world record-holder in run on 100 m of Asafy Powell



Pic. 2. The movement of GCBW when performing a low start

unit testifies to the end of the first phase of acceleration of run and the beginning of the second phase reflecting run with the maximum speed. The efficiency of a starting dispersal is defined by a value of an index of activity equal to unit and reached for the shortest time.

The most effective technique of a smooth run is the minimum indicator of an index of activity. Studying of biokinematic characteristics of steps of a smooth run shows that kinematic characteristics of GCBW of the "waving" extremities represent two-linked pendulums which move on cycloidal trajectories that creates the carrying power which is sufficient for flight of GCBW. In each phase of a support there is a certain decrease in horizontal speed of a movement due to the redistribution of the potential and kinematic energy of a movement. By this period the swing movements of hands begin an active movement which creates the carrying power and an additional depreciation extension of a trunk that provides the necessary carrying power for a flight of a body at activity coefficient of a less unit in the sum. Such technology of a movement remains till 30 steps at sportsmen of the top skills. Then the index increases to unit again and starts surpassing this value.

The index of activity characterizes the intensity of the happening metabolic processes in an organism that influences duration of their course. The general dependence of these relations changes on the exponential regularity that allows defining an optimum index of activity for passing of a distance.

The main reason for the rapid growth of an index of activity by the end of a distance is connected with the exhaustion caused by a change of a ratio of portioned pressure of oxygen and carbon dioxide in blood that is characteristic for the suffocation mechanism. Thus the intensity of the top humeral belt is observed. The cycloidal form of the movement of GCBW, two-linked kinematic pendulums is carried out on forming with a smaller radius, the frequency of steps increases and their length reduces that as a result conducts to the reduction of speed of run.

The improvement of result of run in this case depends on the development of high-speed endurance that is reached by special physical preparation of the haemo-cardio-respiratory interdependent relations. The realization of various approaches in the creation of the structure of the training process of runners on short distances allows their wide variation, but in all cases it demands the accounting of the anthropometrical analysis of a constitution, the nature of course of metabolic processes and optimization of volume and the content of special physical preparation and a share ratio of the general and special preparation.

Conclusions. The sprinting is characterized by phases of its course which concern: the dispersal of GCBW from a low start and its derivation to the working height of a smooth run on a distance that is carried out when performing the first 3–4 steps; the second component of a starting dispersal is characterized by the stabilization of length and frequency of a running step that leads to the change of an index of activity and the achievement of the maximum speed of run due to the reduction of time of a support and the increase in time of a flight; and the third phase consists in the performance of run with the most available speed.

The optimum condition of technique of the performance of a low start consists in ensuring the movement of GCBW on a parabolic trajectory which passes through GCBW point in the accepted sportsman's pose after the order "attention". This parabola makes the line leaving at an angle 45° from the support basis and this corner of the direction of its movement always remains less than 45° in the initial point of the movement of GCBW. The size of this difference depends on the anthropometrical features of a somatotype of a sportsman.

The most effective arrangement of starting blocks relatively each other and their remoteness from the starting line completely depends on feature of the increase in force at an angle of an extension of biokinematic links of the lower extremity and a position of feet at which the highest impulse of force providing a dispersal of GCBW.

The maximum speed of a linear movement on a distance is reached at a ratio in a running step of a higher duration of the time of a flight, than the support time that is characterized by an activity index which reflects the skill level of a sportsman. The necessary ratios arise due to that the centers of weight; two-linked pendulums of extremities carry out the

movements on a cycloidal trajectory and a sufficient carrying power providing a flight phase appears at its certain forming and speeds of its movement.

The duration of a preservation of such mode of run is defined by the level of activity of metabolic processes and the duration of their preservation for ensuring the necessary speed of run. The increase in duration of ensuring metabolic processes with necessary intensity that is characterized by high-speed endurance is reached by the special physical preparation consisting in the increase of efficiency of haemo-cardio-respiratory indicators in their interdependent functioning.

Prospects of further researches. The stated provisions make a basis of biomechanical characteristics of sprinting that allows using a method of mathematical computer modeling for the creation of an optimum technique of run on the basis of the accounting of the individual anthropometrical data of a somatotype of a sportsman and his current physical state. The development of this direction submits the content of further researches in the improvement of training of sportsmen in sprinting.

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