

THEORETICAL-METHODOLOGICAL STUDY OF DEVELOPMENT OF POWER-SPEED IN CLIMBING

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Annotation. *Purpose:* of the work was to develop theoretical and methodological foundations of power-speed in climbing. *Material:* 19 analyzed the literature on the problem of the relationship of the various components of speed-strength training. *Results:* the concept of speed-strength training climbers, which in its general form can be used at any stage of training. It was revealed that the components of the speed- force readiness (strength, speed and speed-strength endurance) are in an inverse relationship to each other. These dependences are hyperbolic. The relationships between strength, speed and the time limit for execution of work are summarized in the form of a hyperboloid. It is shown that the inverse relationship between the components of speed-strength readiness is a difficulty in the construction of the training process, as required in climbing all three aspects of speed strength training. The solution to this problem is the interchange of the funds allocated for the development of contradictory qualities. *Conclusion:* it is shown that there are particular manifestations of the various components of speed strength training of elite climbers, specializing in climbing to the complexity, speed, and mountain climbers.

Keywords: rock climbing, mountain climbing, speed, strength, endurance, concept, relationship, physical quality, complexity.

Introduction

Development of kinds of sports, which are based on human interaction with natural objects, relief, including just being in natural conditions, is especially essential to-day. Interaction with nature fills a person with energy, opens concealed abilities, facilitates harmonious physical and spiritual progressing. One of such kinds of sports is rock climbing. Rock climbers say (<http://www.spiritclimbing.com/ru/944>), that being in mountains, in rocks, in nature, active movements, control of breathing, loads on all muscles and organism's systems promote health improvement of people. Besides, rock climbing promotes production of endorphins – "hormones of happiness" – as far as complexly influences on muscles, causing, as I.P. Pavlov said, "muscular pleasure" [7], which is amplified by understanding of difficulties' overcoming and uniting with nature.

Rock climbing takes place in natural conditions (excluding trainings on simulators, in winter) and is a nature of a human being as far as it activates basic skills. Rock climbers think that during climbing they imitate cats, monkeys, lizards; in the process of climbing they are in constant touch with rock – its structure, its logic and its secret (<http://www.spiritclimbing.com/ru/944>). Life in rocks, direct contact with mountains, wind and sun unite a person with surrounding world, whose integral part he is. This feeling is very seldom and extremely required in technocratic epoch.

Ancient Chinese tractates describe ability to rock-climbing as one of the most complex and effective means of harmonization of life and health (<http://www.spiritclimbing.com/ru/944>).

In the process of climbing rock climber assimilates anchor, who left everything for mountain and practices active meditation, in which extreme tension is replaced by relaxation, finishing vanity of everyday life and starting spiritual development. Changing fresher's status into experienced rock-climber a person passes an amazing way of transformation both physical and mental that is a necessary condition of physical and spiritual improvement.

It is natural that training process in rock climbing has its own laws of construction, which, at present, are in the process of development [1, 3, 12, 13, 14, 17]. Training process in rock climbing is based on development of speed-power abilities, which should be manifested in non-standard, natural conditions [18, 19].

In this connection there appeared a demand in development of theoretical-methodological principles of speed-power qualities' development in rock climbing.

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Purpose, tasks of the work, material and methods

The purpose of the work is to create a concept of speed-power qualities' development in rock climbing.

The methods of the research: theoretical analysis and generalization of literature sources, methods of induction and deduction, pedagogic, physiological, psycho-physiological methods of research [4, 8, 10, 11], mathematical-statistic methods.

In research 26 sportsmen took part; 10 of them were international masters of sports, specializing in climbing for speed, 10 of them were international masters of sports, specializing in climbing for complexity and 6 mountaineers of international class. Age of sportsmen was 19-22 years.

Results of the research

For development of general principles of building of programs for speed-power qualities' training in rock climbing we created a concept of rock-climbers' speed-power training, which, in general, can be used at any stage of training.

The central idea of this concept is development of sportsmen's speed-power abilities [2, 5, 6, 15].

For more specific analysis of speed-power training we determined its components: power, quickness and speed-power endurance. These components were analyzed for their interconnection, basing on data, provided by literature both in theoretical and practical aspects. It was found that speed-power components were in reverse interconnections. For example, speed and power are in reverse interconnection; their connection is depicted as hyperbolic curve. In the same way strength and time of muscular contraction are connected as well as speed and time of muscular contraction. This fact creates certain difficulty in building of speed-power training process as far as rock climbing requires all three aspects of speed-power fitness.

The created by us concept of speed-power qualities' training is based on methodological principles, which, besides general-scientific, methodological principles, include biological foundations of speed-power qualities, in particular, interconnection of speed-power components: strength, quickness and time of muscular contraction. Besides, analysis of speed-power abilities' manifestation in rock climbing in comparison with other speed-power kind of sports is a methodological basis. For this purpose we analyzed speed-power fitness of advanced rock-climbers from the point of view of different speed-power components' manifestation.

Interrelations of levels of development of different speed-power components in rock-climbing.

According to data of leading specialists in theory and practice of sports [7, 15], mathematical models, based on fundamental laws of physics and mathematics, i.e. borrowed from fundamental sciences are the most purposeful and universal.

In this connection creation of universal mathematical models for determination of sportsmen's individual characteristics seems to be rather urgent.

The conducted analysis of interconnection physical characteristics' individual peculiarities resulted in determination of the most universal model of manifestation of speed-power qualities' manifestation, on the base of which it is possible to determine individual features of sportsmen.

According to equation of Hill, the work, produced by a muscle, corresponds to the following formula:

$$A = Pvt = bPt(P_0 - P)/(P + a)$$

where:

v – speed of contraction;

P – force (load);

P₀ – maximal isometric tension, which a muscle can manifest;

b – constant, which has dimension of speed;

a – constant, which has dimension of force.

If load is precisely equals to full isometric tension, which muscle is capable to develop, there will be no external contraction. With other maximal value of load – zero- speed of contraction shall be maximal.

Experimental data are quite completely described by hyperbolic equation of Hill:

$$v = b(P_0 - P)/(P + a), \quad P = \frac{(P_0 + a)}{\frac{v}{b} + 1} - a,$$

where:

v – speed of contraction;

P – force (load);

P₀ – maximal isometric tension, which a muscle can manifest;

b – constant, which has dimension of speed;

a – constant, which has dimension of force.

V.M. Zatsiorskiy [5, 6], Я.М. Kots [16], in their theoretical and experimental data point that with analysis of interconnections between physical qualities it is necessary to consider two dependences: “speed-power” and “speed-duration” of muscular contraction.

In connection with dependence “speed-power” (see fig.1) with dynamic contraction the displayed force is in reverse relation to muscular contraction (speed of travelled link of body): the higher external load is, the less if displayed force. The other formulation of this dependence: the higher external load is (resistance, weight), the lower speed of contraction is (movement) and the more displayed force is; and on the contrary: the less external load is, the

higher is speed of movement and the less is displayed muscular force. Product of force and speed of muscular contraction determines its capacity.

Dependence “power-duration” of muscular contractions is expressed in the fact that the more power (or capacity) of muscular contractions is the shorter is their maximal duration. It is correct both for local and for regional static and dynamic work and for global work [7].

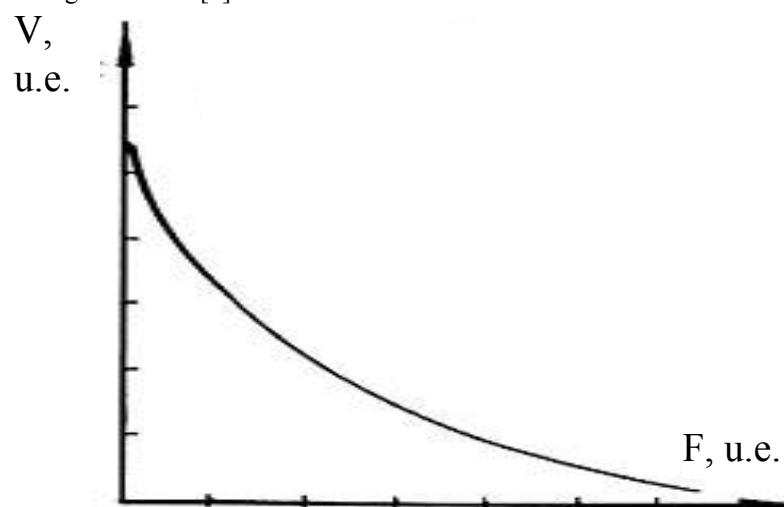


Fig. 1. Diagram “Power-speed” by Kh. Ralstone (1949), A. Hill and K. Ober (1950) [7, 16]

By displayed power and capacity of muscular contractions and by connected with them maximal time of work all physical exercises can be divided into three groups: power, speed-power (for capacity) and exercises for endurance.

Power exercises are exercises with maximal or close to maximal tension of main muscles, which they display in static or dynamic mode at slow speed of movement (under great external resistance, weight). In fig.1, left side of curve “power-speed” corresponds to power exercises. Maximal duration of exercises with maximal manifestation of strength is several seconds. Force is main motion characteristic, which determines success of power exercises.

There is power and speed, with which capacity of muscular contraction is maximal. This mode takes place, when both power and speed are approximately 30% from maximal possible values.

Dynamic exercises, in which leading muscles simultaneously display relatively big force and speed of contraction, i.e. big capacity are speed-power exercises. Maximal power of muscular contraction is achieved in conditions of maximal muscular activation at speed of contraction about 30% from maximal for unloaded muscle. At curve “power-speed” speed-power exercises take central position – up to 50-60% from maximal speed (see fig.1). Maximal capacity is displayed by muscles under external resistance (weight) of 30-50% from their maximal (static) strength. Maximal duration of exercise with higher capacity of muscular contractions is within the range from 3-5 sec to 1-2 minutes – in reverse dependence from capacity of muscular contractions (load). Capacity plays the most important role in speed-power exercises.

Exercises, in which leading muscles display not very high by force and speed of contractions but are capable to repeat these movements during long time (from several minutes to many hours, in reverse dependence from power or strength of muscular contractions) are exercises for endurance [7, 15]. Endurance is a leading characteristic for exercises of this group.

Endurance with static work is determined by time, during which constant force of pressure is maintained or some load is kept in permanent position [7, 9].

Maximal time of static work is in reverse dependence from force, displayed by muscles (see fig.2). When require force is less than 20% from maximal value, static work can be fulfilled during very long period of time. In literature [7, 9] there are data that in the range of load’s pressure 20 - 80% from maximal strength maximal time of fulfilled static work reduces with increasing of pressure force (load) as per the following dependence:

$$t_{\text{lim}} = \frac{K}{F / F_{\text{max}}}$$

where: t_{lim} – maximal time of static work;

K- constant;

F – force of pressure (load);

F_{max} – maximal force;

From this formula we can see that even very little decreasing of static contraction’s force results in significant increasing of time period – during which this contraction can be maintained.

The same regularity is characteristic for dependence of maximal timer of work on speed of movement (see fig.3).

Thus, in sport physiology and bio-mechanics there is proved dependence between displaying of different physical qualities: strength and quickness are in reverse dependence in relation to each other; endurance, determined by maximal time of work with such force and speed of muscular contraction is in reverse dependence on speed, power or capacity of muscular contractions. These dependences are hyperbolic.

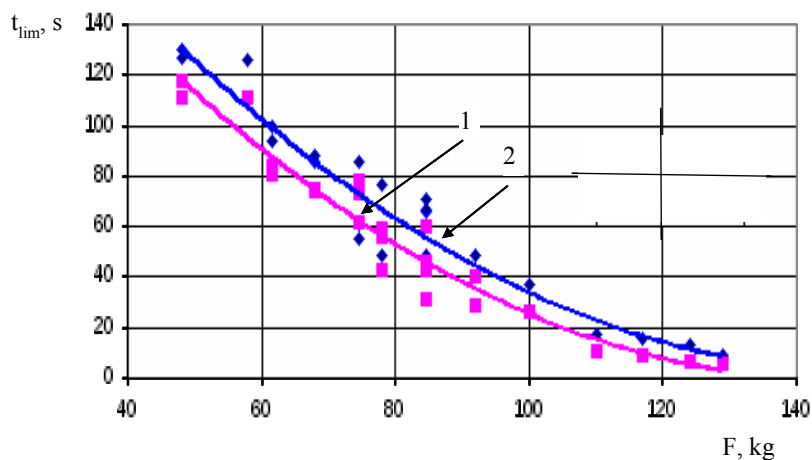
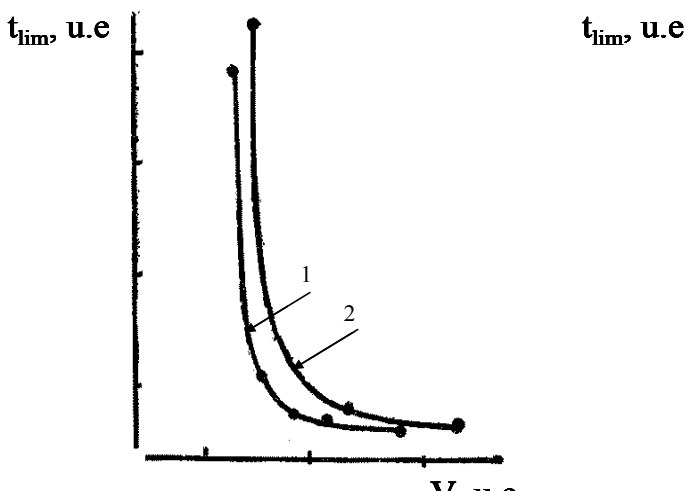


Fig.2. Dependence of maximal time of hanging on bar (t_{lim}) on body mass (F) [9]:
1 – left hand
2 – right hand



Puc. 3. Dependence of maximal time of work (t_{lim}) on speed (frequency) V of movements [9]:
1 – left hand
2 – right hand

If to plot dependences between force and maximal time of fulfillment of work in generalized form and in form of space diagram, 3-d diagram of these dependences will be depicted as hyperboloid, to be more exact as upper part of two-cavity hyperboloid (fig. 4).

Let us apply the described regularities to the tasks of sport training. With equal possibilities to fulfill external work and total quantity of energy resources work can be executed, mainly, owing to increasing of force (F) with reducing of speed (V) and total time of work (t). In this case sportsman will be bent to work of power character. Work can also be fulfilled owing to increasing of speed (V) with reducing of other parameters. In this case sportsman will be characterized by expressed speed abilities. Work can also be ensured by prevailing increasing of force and speed product ($F \cdot V$), i.e. by increasing of load power and reducing of work fulfillment's time (t). In this case sportsman will be characterized by expressed speed-power abilities with approximately equal display of speed and power components.

Physical work can be also fulfilled owing to increasing of total time, required for its execution (t) with decreasing of its ($F \cdot V$). In this case sportsman will have expressed special endurance.

Besides, physical work can be fulfilled owing to equal display of all indicators and optimal regulation of these indicators' manifestation in the required quantity and in the required moment of time. In this case sportsman will have expressed coordination abilities.

It is natural that with increasing of fitness level there happens total increasing of energy potential and, accordingly, increasing of potentially possible scope of the fulfilled external work. However, individual bents to manifestation and development of different abilities are preserved with any level of energy potential.

In this connection we should like to note that according to data, obtained by us, as well as in compliance with described above interconnections between different components of speed-power qualities, there are characteristic features of display of speed-power qualities' components; there are peculiarities of manifestation of different speed-power fitness's components of elite rock-climbers, specializing in complex and speed rock climbing and mountaineers. For example, rock climbers, who specialize in complex climbing, have prevailing power component of speed-power qualities and power endurance at short periods of time (5-10 minutes). Rock climbers, specializing in speed climbing, have prevailing speed components of speed-power qualities and speed endurance. Mountaineers have prevalence of power endurance at long periods of time.

In fig.4 there are marked different sectors of hyperboloid, which correspond to manifestation of different physical qualities. For example, sector 1 corresponds to higher expressiveness of speed component in speed-power qualities – in our research it corresponds to rock climbers physical fitness (speed climbing); sector 2 corresponds to higher expressiveness of power aspect in speed-power qualities (in our research it corresponds to physical fitness of complex climbers); sector 3 corresponds to higher expressiveness of power endurance (in our research it corresponds to mountaineers' physical fitness); sector 4 corresponds to expressiveness of speed endurance (in our research it corresponds speed rock climbers physical fitness).

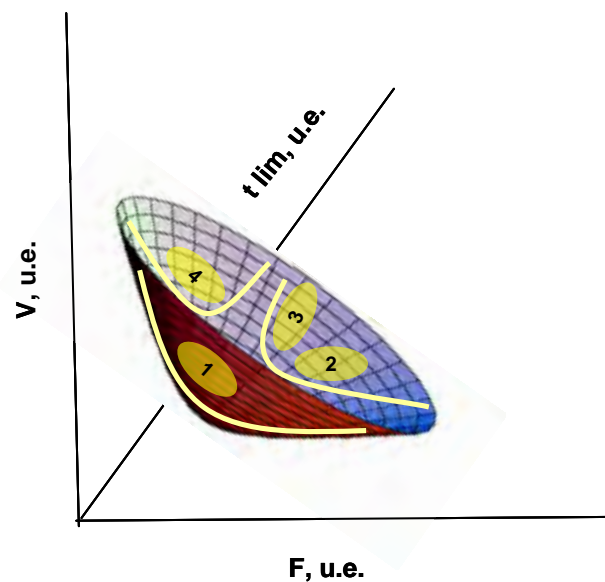


Fig.4. Diagram of interconnection of power, speed and maximal possible time of muscular work in the form of upper part of two-cavity hyperboloid; different sectors of hyperboloid correspond to manifestation of different physical abilities:

1 – speed-power qualities (higher expressiveness of speed aspect); in our research it corresponds to rock climbers physical fitness (speed climbing);

2 – higher expressiveness of power aspect in speed-power qualities (in our research it corresponds to physical fitness of complex climbers);

3 - corresponds to higher expressiveness of power endurance (in our research it corresponds to mountaineers' physical fitness);

4 – expressiveness of speed endurance (in our research it corresponds speed rock climbers physical fitness).

V – speed;

F – power;

t_{lim} – maximal time of work.

As far as components of speed-power fitness, i.e. power, speed, speed-power endurance are in reverse interconnection, it is rather difficult to build training process in rock climbing on development of speed-power qualities. Especially it is essential at initial stage of training of students, who started rock climbing at HEE. It should be noted that at further stages of training this problem remains to be essential even for highly qualified sportsmen. The most difficult is searching of optimal combination of means, oriented on development of strength, quickness, speed-power endurance, as far as intensive application of means, oriented, for example, on development of strength hampers development of

quickness and speed-power endurance. Means, oriented on development of speed, hinder development of power and endurance. Accordingly, development of endurance contradicts to development of quickness and strength.

We see solution of this problem as gradual interchange, directed on development of contradicting each other qualities.

Conclusions:

1. We have developed a concept of speed-power training of rock climbers, which in its general form can be used at any stage of training; however, in our case, main principles of concept were determined for development of speed-power qualities of students at initial stages of rock climbing training.

2. It was found that components of speed-power endurance (strength, quickness and speed-power endurance) are in reverse interconnections between each other. For example strength and quickness are in reverse connection. This interconnection is a hyperbolic curve. In the same way strength and duration of muscular contraction, speed and duration of muscular contraction are interconnected. These dependences are hyperbolic. Dependences of strength, speed and maximal time of work's fulfillment have been presented in generalized form as a space diagram. 3d diagram of these dependences is an upper part of two-cavity hyperboloid.

3. It was noticed that reverse dependence between speed-power fitness's components creates certain difficulty in building of training process as far as rock climbing requires all three components of speed-power fitness. We see solution of this problem as gradual interchange, directed on development of contradicting each other qualities.

4. There are certain peculiarities of manifestation of different speed-power fitness's components by elite rock climbers, specializing in speed, complex climbing and by mountaineers. Complex rock climbers have prevalence of power component of speed-power qualities as well as power endurance at short periods of time (5-10 minutes). Speed rock climbers have prevalence of speed component of speed-power qualities as well as speed endurance. Mountaineers have prevalence of power endurance at long period of time.

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