THE ORGANIZATION, STRUCTURATION AND QUANTIFICATION OF STRENGTH TRAINING IN ATHLETICS - JUMPING

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Abstract
Strength development training is one of the base components of general and specific physical training of athletes. According to the demands of each movement skill, the objectives of strength related training sessions will mainly be targeted at increasing strength and explosive power. An individual quantification of training starts from knowing the maximum output, known by taking a direct or indirect test. Procedures shown are specific models to each type of strength which can be applied individually with a condition that load intensity is a percentage of the initial maximum output, already established at the beginning of each individual training program. The principle which must govern organization, structuration and quantification of training for jumping strength development is "power without high muscle mass", its achievement being possible only in the situation in which the maximum force is obtained by synchronizing and fine-tuning of motor components (limbs and breathing). Strength training is a high-effort high-energy requirement type of training and it also posts a high risk of injury reason why, both general and specific warm-ups as well as taking breaks between exercises must be as important as the exercising itself.

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JEL classification: *I10, I20*

1. Introduction

A fundamental physical quality, strength in physical training activities will always appear in connection with two other basic movement skills, stamina or speed. Out of these combinations a series of complex skills emerge, called maximum strength, stamina force, explosive force and reactive strength. If we take in consideration the definition which Zatiorski offers to us: "strength is the ability of a muscle or a group of muscles to overcome an exterior force and to withstand a force which presses on it or them by muscular activity", we will see that an essential part in organizing and structuring strength training sessions is identifying and defining types of muscular tension needed for optimizing specific strength. Muscle contraction regimes can be classified as following:

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- Isometric contraction regime (static). This regime represents a type of muscle contraction which doesn't lead to a lengthening in muscle fibers and in a dynamic light, hasn't as consequence a structured movement. Basically, in isometric effort, resistance is greater than the applied force.
- Un-isometric contraction regime (dynamic). This manifests itself in the following ways:
  - **Dynamic-concentric contraction** which is achieved through shortening of the muscle fibers by closing in the muscle's insertion points. Viewed as a mechanical process, this contraction regime means strength is greater than resistance. (the most often used in sports training). In general, working in this regime means overcoming any weight (from lying down pushing in which arms lift a dumbbell from the chest)
  - **Eccentric-dynamic contraction** which is achieved by lengthening involved muscle fibers, the insertion points being forced apart. Mechanically, the muscle acts with resistance towards an exterior force, that exterior force's value being sensibly lower than that muscle's actual resistant capacity. A classic example used in training is pushing by lying down of a dumbbell with increased weight where pushing away the rod from the chest is the concentric part of movement and returning the rod to chest level is the eccentric one.
  - **Plyometric muscle workout** is a rapid succession of dynamic concentric and eccentric contractions used in training for developing explosive strength. Successive jumping and high surface jumping make good examples for this kind of workout.

During sports training, according to which discipline or trial characteristics, the methodical approach will focus on four main types of force:

- **Maximum force** is defined by the degree of intensity muscles can put out during a voluntary movement. In direct link with contraction regimes, we are talking about a static maximum force, a dynamic maximum force both concentric and eccentric. Under physiological view, there are 2 ways of developing maximum strength, by either synchronization of motor units or by developing the cross-section of the muscle. Starting from the hypothesis that during sports a main objective of strength training is to become more powerful and not bigger in size, the first option becomes obvious to use (synchronizing motor units)
- **Speed based force** is also known as **power** and its **characterized** by the capacity of neuron-muscular system to overcome certain external resistance with the highest contraction speed. During this kind of strength training, an athlete is forced to produce very fast actions while using the highest amount of force. According to the required tasks by every discipline, speed based force can have 2 sides:

Strength-force, as the indispensible type of power used in a series of contact sports (rugby, judo, wrestling, etc.) in which a constant need for countering the opponents moves is present. A second form of power manifestation is **power-speed** which means creating a high-as-possible velocity against a very weak resistance (sprint start or javelin throws)

- **Strength-stamina** is the capacity of an individual to maintain a certain percentage of his maximum strength during an isometric exercise or the capacity to repeat a certain percentage throughout an exercise over a determined period of time (dynamic exercise)
- **Explosive force** is the capacity of a subject of suddenly changing his / her movement quantity or that of a pressed upon object. Mechanically speaking, explosiveness can be defined as the possibility of the neuron-muscular system of increasing its force capacity (Weineck, 1986)

Moving away from pure theoretical aspects of strength to the practical one, we must highlight the fact that no matter what the training type or methods used, a central element will always be at the base of any construction – maximum strength. No matter the objective is maximum strength, strength-based speed or stamina-strength, quantifying training sessions will start from an athlete starting maximum force. Knowing maximum force value ensures strict strength training in accordance to the requirements of the practiced event.

Evaluating maximum force

The current paper aims at synthesizing ways of training and strength development, in general for athletics and specially for specialized athletes in jumping events, reason for which maximum dynamic force testing is done. As static strength is not used in athletic jumping, we considered presenting the ways of evaluating static maximum force not essential. Gauging dynamic maximum force has the objective of determining an operational value which represents the maximum potential of a muscle group at a certain time as well as the stamina of that muscle or group of muscles. Particular to maximum force is the value of the maximum load which can be lifted more than once called 1RM (1 being the additional maximum repeat). Strength endurance corresponds to the number of repeats which can be achieved with sub-maximum load on a long as possible period of time, usually until fatigue.

Applying the test for determining the maximum dynamic strength shows the number of repeats is reverse proportional with the value of the payload. This linear side of strength-payload relation is constant for a number of 1-10 repeats as beyond 10 both vectors start showing declines.

- **The method of direct evaluation of maximum dynamic force.** It is the most common method for determining maximum force. In order to correctly gauge the ongoing test, using this method means a good

knowledge of a subject's strength capacity. The following protocol applies (for any strength exercise): after a 10-15 minutes of general warm-up, a specific dumbbell warm-up, 5 to 8 repeats with 40-60% maximum coach anticipated load, a 2-3 minutes break, 3-5 repeats with 60-80% of the maximum load lifts. Once on this level, the payload will gradually increase with the athlete having to does only one repeat for each try. It is recommended that reaching maximum value is done through 3 to 5 previous tries. The value of the last load the athlete manages to fully lift and lower is the dynamic maximum force (1-RM). In the next example, the subject tested on lying down exercising managed to lift 100 kg, the test starting at 5-8 x 40 – 60 kg, then 4-5x60 – 80kg, and then the proposed test in which he lifts 1x95 kg, 1x 100 kg, 1x 105 kg, 1x110 kg and if he cannot lift the maximum weight of 110 kg, 105 kg is set as his maximum dynamic strength. This direct method of evaluation of the maximum force is a reliable solution only if an athlete is not on his first time in training, has perfect knowledge of the exercise and sticks to planned warm-up sessions as well as to breaks as they were initially planned in order to avoid accidents and injuries.

- **The indirect method of evaluating dynamic force.** In principle, this way of testing maximum strength rests in determining maximum strength by starting from a sub-maximum test. Reminding previous statements regarding the connection between the direct link of maximum force and stamina, when strength increases, the number of repeats tends to drop in linear manner. At the same time, we must highlight this relation is only present between maximum force and number of repeats within the 3 to 12 margin. This way of measuring maximum force represents its advantage when testing both beginners and performance athletes who have been interrupting their strength training sessions for a longer period of time. Factors which can distort the results of this method of evaluating maximum strength are rhythm of execution (a 2-4 minutes rhythm allows lifting higher loads than that of 1-2 minutes) and the endurance ability of an athlete (the ratio between 1st degree and 2nd degree muscle fibers). The procedure of accomplishing this test requires the subject, after the general and specific warm-ups to lift a high as possible weight. Determining a payload on a rod must be done so the athlete can lift it successfully more than 10 times (the operator, which is also a trainer sees that these tasks are correctly completed and the rhythm kept as it should). For example: a subject in lying down push test lifts 5-RM a weight of 50 kg and by looking at the table below we observe 5 repeats correspond to 89,8% of 1-RM (Maximum strength) of the subject. In order to find a training operational value, 89,8 is divided to 50 so that **1-RM = 55,7 kg**

Number	1	2	3	4	5	6	7	8	9	10

of repeats										
% din 1-RM	100	97,4	94,9	92,4	89,8	87,6	85,5	83,3	81,1	78,9

Under these conditions, it is obvious the fact that indirect maximum strength testing rules out any risk of injury and knowing the maximum strength level of a beginner becomes much easier.

Ways of structuring strength training according to a required strength type

Strength development training, as any other performance sport training must be individual, to represent a solution for one athlete and not for a group of athletes. Therefore, in the following presented protocols, several parameters of strength training are taken in consideration; parameters which correctly applied can lead to an improvement in the desired type of strength. It is of the essence that time between exercises is individually allocated for increasing recovery time for athletes recovering from a longer period of inactivity or whenever an important muscle group is being worked.

Developing maximum strength. The whole action methodology is based in this case on Zatiorski's theory who proposes creating maximum tension in muscles by 3 methods: maximum load with maximum effort, maximum effort with sub-maximum load with repeats until exhaustion and maximum dynamic effort (mobilizing a sub-maximum load on a maximum speed)

1. Maximum load with maximum effort

PARAMETERS	Values
Load intensity	90 – 100% of 1-RM
Repeats per series	3 – 1rep.
Recovery time between series	2 - 3´ and in special cases 4 - 5´
Execution speed	Maximum, even with a high load
Number of repeats / muscle group / training session	24 rep.
Form of structuring training sessions	Levels. pyramid, ascending or descending array
Identical exercise recovery time	24 - 48 h

PARAMETERS	Values
Load intensity	60 – 75% of 1-RM
Repeats per series	6 – 12 rep. or 15 - 20″ effort time

Recovery time between series	2′30″ - 4′
Execution speed	Maximum
Number of repeats / muscle group / training session	60
Form of structuring training sessions	Pyramid, levels, descending array
Identical exercise recovery time	24 – 48 h

2. Maximum effort with sub-maximum load

3. Maximum dynamic effort protocol

PARAMETERS	Values
Load intensity	50 – 70% of 1-RM
Repeats per series	7 - 10″ effort
Recovery time between series	2′30″ - 3′
Execution speed	Maximum
Number of repeats / muscle group / training session	60
Form of structuring training sessions	Levels or descending array
Identical exercise recovery time	24 – 48 h

4. Maximum eccentric strength protocol

PARAMETERS	Values
Load intensity	80 – 130% din 1-RM
Repeats per series	2 – 4 rep
Recovery time between series	2′30″ - 3′
Eccentric phase duration	5 - 7″
Execution speed	Maximă in faza excentrică
Number of repeats / muscle group / training session	20 în excentric
Form of structuring training sessions	Pe paliere sau gamă descendentă
Identical exercise recovery time	72 h

NOTE: This protocol is difficult to complete in the situation we don't possess a specialized instalation which can change loads according to a type of action (concentric or eccentric). The commercial name for this installation is BERENICE.

- **Developing maximum power**

1. Developing strength – force proctocol

PARAMETERS	Values
Load intensity	50 – 70% of 1-RM
Repeats per series	6 – 8 rep.
Recovery time between series	2 - 3′
Execution speed	Maximum
Number of repeats / muscle group / training session	40
Form of structuring training sessions	Levels or descending array
Identical exercise recovery time	24 to 48h

2. Strength-speed protocol

PARAMETERS	Values
Load intensity	30 – 50% of 1-RM
Repeats per series	4 – 6 rep.
Recovery time between series	3 - 4′
Execution speed	Maximum
Number of repeats / muscle group / training session	40 or less if execution speed drops
Form of structuring training sessions	Levels or ascending array
Identical exercise recovery time	24 to 48h

- **Developing explosive force.** This holds the highest percentage in jumping training exercises. The ways of organizing explosive force training are based on action-reaction, a principle which is the base of all athletes jumping optimization.

1. Low-high contrast payload training

PARAMETERS	Values
Load intensity	Series of 80 cu 40%, 90 with 30%, , 90 no load
Repeats per series	2 – 5 with high loads, 6 -10 easy loads
Recovery time between series	3′
Execution speed	Maximum and identical for both types of loads
Number of repeats / muscle group / training session	60
Form of structuring training sessions	Ascending array for heavy loads and descending for low ones
Identical exercise recovery time	48h

2. Static dynamic protocol, Is done by lifting a medium or light weight from a flexed starting position

PARAMETERS	Values

Load intensity	50 – 70% of 1-RM/ for 5-7″
Repeats per series	3 – 6 rep (5-7″ maintained+3 -6 rep. Forms a series)
Recovery time between series	2′30″ - 3′
Execution speed	Explosive after holding
Number of repeats / muscle group / training session	40
Form of structuring training sessions	Levels, pyramid or ascending
Identical exercise recovery time	48h

3. On and off high level surface jumping

PARAMETERS	Values
Load intensity	High surface 20 – 80 cm
Repeats per series	10 – 12 rep.
Recovery time between series	3′- 4′
Execution speed	Explosive on ankle level
Number of repeats / muscle group / training session	60
Form of structuring training sessions	Height and flexing changes
Identical exercise recovery time	48h

Ways of organizing and performing strength development training

The array of development methods for required strength type during sports training is applied by a series of specific forms adapted to each method of strength development.

1. **Levels strength training.** By changing the load and/or the number of repeats as well as the execution rhythm, in this method, a training session can focus upon only one of the three types of strength (maximum, speed or endurance)

- Constant load, constant number of repeats (example: 3x10 rep x 70% or 10rep X 70% + 10 rep X 70%+10 rep X 70%)
- Variable load with constant repeats number (example: 10 rep x 50% + +10 rep x 60% + 10 rep X 70%)
- Constant load with variable repeats (example: 80% x 8 rep + 80% x 6 rep + 80% x 4 rep)

2**. Pyramid training.** This type of training has as its main trait increasing the load starting from the base of the pyramid to its top, followed by a decrease towards the base and, at the same time, a proportional number of repeats to the payload value. Pyramid training offers the possibility that, according to its design, only one type of strength is developed. Therefore, in a situation in which the

number of repeats is low and the payload is close to 1-RM, training will be done on top of the pyramid and will result in developing maximum strength through a better muscle coordination. Should the training will consist of a higher number of repeats (5-8) and the payload 50-70% of 1RM, training favors speed-strength. Finally, should the repeats number is 20-25 with a low payload value (20-40 % of 1RM) endurance will be the type of strength enhanced.

3. Training in a descending array. This form of training organizing imperatively means a global and specific warm-up carefully supervised. The explanation for this requirement is that training starts directly with high loads which can lead to accidents if a superficial warm-up is done. Particular to this method or organization is that as load value drops, the repeats increase. (example: 1 x 3 rep x 90% + 3x5rep X 80% +3x8 rep x 70%). Recovery times depend on each protocol's nature.

4. Ascending array training. The essential difference to the previous method of organizing training is that it starts with relatively easy loads and increases to values close to 1-RM decreasing the number of repeats (example: 1 x 8 repeats x 40% - warm-up, 2x8 x 70% + 1 x 6 rep x 80% +3x3 rep x 90% + 1x1-2 rep x 100%)

5. **Circuit training.** In this type of training "workshops" are established. Circuit training aims at rotating the desired muscle groups in a number of 6-12 workshops. The timeframe for each workshop varies between 20-40 minutes and the pause between them is either equal to the work time, in highly trained athletes or double the time for beginners. This form of training is mostly used for developing endurance or at the beginning of a new competition season.

Conclusions

Strength development training is a base component for athlete training procedures and may bring significant benefits in the general area of training with the sole condition that is well integrated in the general training program.

- Unlike training types which only target specific events, strength training is a major liability to an athlete body integrity if not done correctly or perfectly adapted to real and tested physical traits;
- The idea on which the whole paper is supporting is 1-RM (maximum force) in every stage of training and also for every exercise done. Overworking the athlete is extremely dangerous and can cause injury while working below his / her capacity is unproductive;
- All presented protocols cover the entire array of strength manifestation encountered in athletic jumping and can be applied to any athlete whose maximum strength was established in a previous test;
- Finally, planning, conducting and supporting strength training must have one mandatory principle: athlete strength (no matter its nature) is less

important, the fact which makes a big difference is how much of that accumulated strength is used in specific movement skills.

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