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Original Article

Integral method of quantitative estimation of load capacity in power fitness depending on the conditions of muscular activity and level of training

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Abstract:

The paper presents the results of study dedicated to the search for effective methods of quantitative evaluation of power loads that allow developing and introducing into the fitness training process safer and simultaneously more effective modes of muscular activity for achieving maximum adaptive reactions in the body of people with different levels of training and functional abilities. To conduct the research we formed a group of 40 trained males aged 20-21 engaged in power fitness for the last three years. The obtained results show that changing at least one index that influence on the conditions of muscular activity in fitness significantly affects not only the choice of the projectile working mass, but also the entire load regime orientation and the training process on the whole.

It was found out that while performing partial amplitude exercises (90% of the total), despite the projectile working mass that the athlete can lift will be 5-7% more from the full amplitude of motion mass, which is more characteristic of classical power sports (weightlifting, power lifting). It should be noted that other load regime indicators are identical with the conventional ones. At the same time, when performing a partial amplitude training exercises, the number of repetitions in the set decreases because of appearing the premature muscle fatigue and lack of a fixation phase at the peak point during boom lifting. An empirically developed integral method for estimating the load in power fitness is one of the most important methodological elements necessary to optimize the training activities management process. The use of this method allowed us to clearly define the volumes of exercise used in power fitness in the appropriate quantitative units. Thanks to the development of this method of assessing the power loads, it became possible to avoid sufficiently subjective gradations (small, medium, large) that were previously used by researchers and practitioners in the field of sports physiology, sports theory and practice, and sports medicine. The quantitative values of the indicators provided an opportunity to control the design of the training process in details, depending on the load regime characteristics and the level of person's physical fitness.

Key words: integral method of load value estimation, power fitness, projectile mass, load factor, maximum muscular strength, training load index.

Introduction

The search for effective methods of power loads quantitative evaluation, which allow developing and introducing more safe and simultaneously effective modes of muscular activity to achieve maximum adaptive reactions in people with different fitness levels and functional abilities, is one of the priority tasks not only for professional trainers, but also for specialists in the field of sports physiology [1, 4, 5, 6].

The rapid popularization of fitness and its varieties has led to the fact that not only professional athletes began to use this type of sporting activity for maximum muscle mass growth, but also people of different age, sex, level of physical fitness and health to combat hypodynamia, obesity and other [7, 9, 12]. That is why the problem of determining safe and effective load regimes in the conditions of power fitness employment for this category of people and the development of a system for monitoring and controlling the training process, depending on its direction, is quite acute [2, 5, 6, 10]. It should also be taken into account that in fitness, unlike weight lifting and power lifting, the load indicators (technique and speed of performing strength exercises, the number of repetitions and sets, the duration of interval work and rest, the maximum and working projectile weight), depending on the level of training and the tasks of the training process can have a significant variation in application and, due to this, a completely different load regime [4, 7, 8, 11].

In order to determine the load indicators depending on the mode of motor activity and the level of participants' fitness, as well as the development of an empirical integral method for quantifying the load in power fitness, a series of studies was performed. A key condition for the effectiveness of such studies is their compliance with a certain algorithm: the determination of the maximum projectile mass in conditions of the generally accepted fitness regime loads, the determination of the working projectile mass, depending on the

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peculiarities of the prescribed training regimes, determining the effect of changing the load indices on the working projectile mass, the load on the basis of the obtained results.

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Method

To conduct the research, we formed a group of 40 trained males aged 20-21 who have been engaged in power fitness for the last three years.

The planned studies, in accordance with the set tasks, required, first of all, the determination of the maximum projectile mass, which an athlete can lift during the control exercises only once due to muscular efforts, in conditions of the standard power fitness technique.

The next step in our research was to establish the maximum number of repetitions that an athlete can perform in a separate set using the projectile mass, which is 60, 70, 80 and 90% of the maximum (1 PM). The obtained results will allow determining the maximum possible duration of muscular activity in a separate set and making assumptions regarding the system of its energy supply. This information will allow us to assess the direction of the training process: a) to develop strength through increased intramuscular or intermuscular coordination; b) the growth of body muscle mass mainly due to hypertrophy of rapidly shrinking muscle fibers; c) increase of the organism's endurance. At the same time, it should be noted that the conditions for performing power exercises did not differ from those generally accepted in fitness.

We performed a series of studies to determine the projectile mass which a person can train with before complete muscle fatigue with a corresponding number of repetitions under certain conditions of muscular activity (technique and speed of exercise, duration of repetitions and sets, full or partial amplitude).

Results

The obtained results show that changing at least one index, influencing the conditions of muscular activity in fitness, significantly affects not only the choice of the projectile working mass, but also the entire load regime orientation and the training process on the whole. It has been established that exercise speed decrease is almost double in comparison with the "standard" one. This leads to a similar decrease in the number of repetitions in the set, but the projectile working mass can be increased by 8-10%. At the same time, the optimal working time in a separate set for power fitness is about 24-36 seconds before complete muscle fatigue, so when modeling the load regime, it is necessary to take into account these time parameters.

It was found out that while performing partial amplitude exercises (90% of the total), despite the projectile working mass that the athlete can lift will be 5-7% more from the full amplitude of motion mass, which is more characteristic of classical power sports (weightlifting, power lifting). It should be noted that other load regime indicators are identical with the conventional ones. At the same time, when performing a partial amplitude training exercises, the number of repetitions in the set decreases because of appearing the premature muscle fatigue and lack of a fixation phase at the peak point during boom lifting.

Thus, the obtained results indicate a wide variety of load regimes in power fitness and their cardinal changes depending on the minimal fluctuation of values of any indicator. Moreover, it becomes clear that it is irrational to use standard methods of estimating the power loads amount. These methods are used for decades in weightlifting and power lifting due to the performing techniques identity in both training and competitive exercises of these sports.

Discussion

Based on the results of experimental studies, we developed an integral method for estimating the magnitude of the load in power fitness [3]. This empirical method clearly defines the indices necessary for the control and management of the training process:

- the regime of power load, depending on the characteristics of the motor activity conditions and the level of persons physical training level;
- the projectile working mass, which an athlete can lift in the given conditions of the training regime;
- the index of training load, the value of which reflects the adequacy of the load regimes and their safety for the human body in the process of long-term employment in power fitness.

The load factor in force fitness is determined by the formula [8]:

$$R_a = R_{max} - (n \cdot Q \cdot t \cdot f_o),$$

where: R_a – load factor, the indicator reflecting the features of the load regime, used by athletes in power fitness, depending on the training process direction and the prescribed conditions of motor activity;

R_{max} – the maximum load factor, which has the following value $R_{max}=1$;

n – a number of repetitions in a separate set. Taking into account the tasks of the training process in power fitness, the level of person's physical fitness and the projectile working mass, the quantitative values of this indicator are in the range of $1 \le n \le 12$;

Q – is the conditional amplitude factor. In power fitness, depending on the training process direction, physical exercises are performed with full or partial amplitude. One of the important elements of the technique of performing exercises is fixing the rod in the maximum phase or lack of fixation. The quantitative values of this indicator are in the range of $0.8 \leq Q \leq 1$. The corresponding dependence was obtained experimentally, proceeding from the fact that it would be easier to perform force exercises with full amplitude and fixation in the maximum phase than at the time of execution with incomplete amplitude (partial);

n - $1 \leq n \leq 12$;

t is the duration of one repetition during the exercise (s). Depending on the training process tasks, the quantitative values of this indicator are in the range of $3 \leq t \leq 9$. The essence of the repetition duration reflects the completed cycle of a one-time motor action (exercise), but the latter includes two phases: concentric (lifting of the bar - $t_п$) and eccentric (lowering the bar - t_o). Thus, $t = t_п + t_o$; $t_o = 2\ t_п$. The overwhelming majority of experts [3, 9, 12, 13, 14] in power sports consider that the most optimal condition for the strength growth in athletes due to the improvement of neuroregulatory mechanisms (intramuscular and intermuscular coordination), increasing the capacity and power of the alaktat mechanism of energy supply when performing physical exercises, is when the duration of one repetition is not more than 3 seconds. At the same time, if the main purpose of exercising power fitness is the growth of muscle mass, then one repetition’s duration should be about 6 seconds. The muscle mass growth is obtained due to hypertrophy of predominantly short-shrinking muscle fibers.

f_o is the empirical coefficient obtained by means of multiple regression analysis, under conditions when the value of the independent variables (n, t, Q, m) is experimentally found, the value f_o= 0,0098 1/s.

The projectile working mass, which an athlete can lift in the given conditions of the training regime, was determined by the formula:

$$m = R_a m_{max},$$

where: m – the projectile working mass (kg) that an athlete can lift in each repetition, the number of which will depend on the load regime characteristics in the process of being engaged in power fitness;

R_a – load coefficient, an indicator reflecting the load regime features that athletes use in power fitness, depending on the orientation of the training process and the prescribed conditions of motor activity;

m_{max}– the maximum projectile mass (kg) that an athlete can lift during physical exercises only 1 time (1 PM), due to muscular efforts, in conditions of the standard techniques for power fitness.

The load volume in power fitness is determined by the formula:

$$Wn = m \cdot N_{max},$$

where: Wn – the load volume in the working set (kg). The total projectile mass that an athlete lifted using the mode with the maximum number of repetitions in the working set to complete muscular fatigue;

m is the projectile working mass (kg), which an athlete can lift in each repetition. The number of repetitions will depend on the load regime characteristics in the process of power fitness engagement.

N_{max} is the maximum number of repetitions in a separate set which a person can perform in a given load mode.

The training load index is determined by the formula:

$$ITNA = \frac{Nmax \cdot \left(Rmax - (n \cdot Q \cdot t \cdot fo)\right) \cdot 3tп}{Tmax \cdot Q}$$

where: ITNA – the index of training load, the indicator reflects the level of physical activity under certain conditions of power muscular activity (ITNA≤1);

N_{max} – the maximum number of repetitions in a separate set that a person can perform in a given load mode;

R_{max}– the maximum load factor, R_{max}=1;

Q – provisional coefficient of amplitude;

t – is the duration of one repetition during the physical exercise (s);

$t_п$ – the duration of lifting the bar when performing physical exercises (s);

f_o=0,0098 1/s;

T_{max}– maximum duration of performing an exercise in one set depending on the set load mode.

The examples of practical implementation of the proposed method in the process of power fitness training are shown in Table 1. The results were obtained with the participation of a group of 40 athletes aged 20-21. We selected 17 young men from the group with almost the same anthropometric body indices and the level of body power capabilities development.

Let us consider the following example. The maximum projectile mass (mmax) was 110 kg. We experimentally found it because each of the examined athletes was able to lift it only once while performing the exercise "bench press on the horizontal bench". The duration of one repetition (t) was 6 s. The exercise was performed with a full amplitude without fixing the rod in the maximum phase (Q = 0.9). 4 repetitions are planned in one set (n = 4).

Table 1

ITNA index results in athletes in different conditions of power load modes, n=17

Indicators	Variants of power load modes depending on the conditions of motor activity				
	1	2	3	4	5
Maximum projectile mass (m_{max}, kg)	110	110	110	110	110
Number of repetitions in a set	4	4	6	4	8
Duration of performing one repetition (t, c)	6	3	9	9	5
Provisional coefficient of amplitude (Q)	0,9	1,0	0,8	0,8	0,9
Maximum duration of performing an exercise in one set (T_{max}, c)	24	15	54	36	40
Projectile working mass (m, kg)	86,9±0,14	96,8±0,76	63,8±0,37	78,1±0,41	70,4±0,21
Load coefficient (R_a)	0,79±0,01	0,88±0,02	0,58±0,02	0,71±0,03	0,64±0,01
Load volume in the working set (Wn, kg)	347,6	387,2	382,8	312,4	563,2
Training load index (ITNA)	0,88±0,01	0,70±0,02	0,73±0,04	0,89±0,02	0,71±0,01

We can find the training load coefficient by the formula:

$R_a = R_{max} - (n \cdot Q \cdot t \cdot f_o) = 1 - (4 \cdot 6 \cdot 0,9 \cdot 0,0098) = 0,79$

We can count the working projectile mass which an athlete can lift in the set conditions of training by the formula:

$m = R_a m_{max} = 0,79 \cdot 110 = 86,9$ кг

We can define the load volume in a working set by the formula:

$Wn = m \cdot N_{max} = 86,9 \cdot 4 = 347,6$ кг

The training load index can be counted using the formula:

$$ITNA = \frac{N_{max} \cdot \left(R_{max} - (n \cdot Q \cdot t \cdot f_o)\right) \cdot 3tn}{T_{max} \cdot Q} = \frac{4 \cdot \left(1 - (4 \cdot 0,9 \cdot 6 \cdot 0,0098)\right) \cdot 6}{24 \cdot 0,9} = 0,88$$

Thus, the obtained results indicate that the magnitude of the power load in the given conditions of muscular activity during the physical exercise "bench press" was adequate to the level of training of the examined athletes. At the same time, the proposed load regime (R = 0.79) can be safely used in exercising power fitness for a long time without the threat of overtraining.

Conclusions

Empirically developed integral method for estimating the magnitude of power load in fitness is one of the important elements of the methodological base necessary to optimize the management process of training activities. The use of this method allowed us to clearly define the exercise volumes that are used in power fitness in the appropriate quantitative units. Thanks to the development of this method of assessing the power loads, it was possible to avoid sufficiently subjective gradations (small, medium, large) that were previously used by researchers and practitioners in the field of sports physiology, sports theory and practice, and sports medicine. The quantitative values of the indicators provided an opportunity to control the design of the training process in detail, depending on the characteristics of the load regime and the level of physical training of a person.

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