Estimating the Physical Preparation Level of Male Athletes Using Tests for Evaluating the Energetic Parameters

ELENA MEREUTA[1], CLAUDIU MEREUTA[2]
[1] Applied Mechanics Department, [2] Theory and Individual Sports Department
"Dunarea de Jos" University of Galati
47 Domneasca Street, 800008
ROMANIA
emereuta@ugal.ro, cmereuta@ugal.ro

Abstract: - The paper presents a method for estimating the basic characteristics of athletes, such as force, velocity and strength. The influence of anthropometric parameters is also revealed. The level of training is asses using the energetic parameters, like unit power, average flying height and repetition rate. They are relevant for the specificity for each individual, characterizing the force velocity ratio. For a trainer is very important be aware of the energetic parameters of athletes. The trainer will be able to focus in the direction of uprising the energy asymmetries and improve force-velocity ratio, as characteristic of physical training.

Key-Words: - human performance, vertical jump, energetic parameters, anthropometric data

1 Introduction

Over time, many researchers have focused on the possibility of estimating the ability of athletes to use their maximal force and power developed by the muscular system.

The mechanical energy developed in muscles is consumed for certain motions, but an important part of the energy is dissipated. The training process aims to reduce the waste of muscle energy, conducting the energy consumption to the desired motions. The muscle energy is related to the elastic properties of muscles, as well as to the applied external forces.

In order to get a generally method for assessing the physical preparation level of athletes performing different sports, we have chosen the MGM test [11], [9], [10].

This test emphasizes the athlete's energetic resources, assuming that two-legged and one-legged vertical jumps are natural motions and no athlete has prior skills in performing such motions.

MGM test is a maximum force velocity test, involving the biggest muscles of the lower limbs.

The data provided by this test are, to some extent, the reflection of the basic qualities of athlete's performance and might be the starting point in conducting further training programs of athletes.

2 Review of literature

The increasing interest of scientists in assessing the energetic resources of athletes, using the vertical jump as test, has resulted in various estimations of different energetic parameters.

Thus, some authors have revealed the kinematic and temporal factors that have major influence on the vertical jump [7], relying on the power - time and force – time curves for establishing that the maximum force needed, equal to double of body weight is necessary for a better performance, but not sufficient.

Other authors have tried to estimate the maximum power developed while performing vertical jumps taking into account the body mass and the maximum height of vertical jump [8], [9].

The force, power and velocity relationship has been the subject of multiple research [1], [2], [3], [4], [13].

The repeated vertical jump tests used to assess the anaerobic power performance in athletes, involved laboratory conditions, as the force platform was needed [5], [6].

The testing method proposed by Georgescu [11] is using a portable device that can be used by coaches and physical trainers and provides information on the energetic parameters of tested athletes.

3 Testing procedures

The MGM test consists of performing 15 two-legged and one-legged vertical jumps on a carpet that contains pressure sensors. The carpet is connected to a computer and the software developed processes the data. The output consists of the time on air and on the ground for each vertical jump.

Ten vertical jumps are selected by the computer for further analysis and the final output provides the energetic parameters: unit power (UP), average flying height (AFH) and repetition rate (RR).

Fifteen male athletes, selected from the physical education students at "Dunarea de Jos" University of Galati volunteered to participate in this test and gave their consent. The Ethics Committee has approved the test, as this is a noninvasive one. The anthropometric data of the participants in the test are shown in table1.

Table 1 Anthropometric data

Anthropometric data	Mean ±SD
Height [cm]	178.2 ±6.69
Body mass [kg]	75.64 ±12.74
Foot	42.8 ±1.47

4 Results

The computer connected to the carpet provides the energetic parameter of each participant in the test. The basic energetic parameters are the unit power (UP), the average flying height (AFH) and the repetition rate (RR). The values of these parameters for the participants are shown in table 2.

Table 2 MGM test energetic parameters (two-legged vertical jump)

Participant	Unit power (UP) [W/kg]	Average flying height (AFH) [m]	Repetition rate (RR) [ms]
P1	4.87	0.38	0.21
P2	4.18	0.28	0.19
P3	4.09	0.27	0.19
P4	3.19	0.18	0.18
P5	4.63	0.36	0.23
P6	4.21	0.28	0.19
P7	4.42	0.32	0.2
P8	4.74	0.36	0.21
P9	4.02	0.26	0.19
P10	3.44	0.21	0.2
P11	5.38	0.41	0.18
P12	3.62	0.24	0.22
P13	5.35	0.41	0.18
P14	3.74	0.25	0.21
P15	3.46	0.23	0.22

The unit power energetic parameter provides information on the force-velocity ratio and is calculated using the formula:

$$UP = \frac{\frac{g}{8} \cdot \sum_{i=1}^{10} (Ta_i)^2}{\sum_{i=1}^{10} (Ta_i + Ts_i)} \qquad (1)$$

where: T_{ai} is the flying time for the jump "i" and T_{si} is the ground contact time for the jump "i" and g is the gravitational acceleration.

The best power unit energetic parameter is 26,6% higher than the group average for P13, while P3 records a value 24.4% lower than the average.

AFH provides information mainly on the force developed in muscles and is calculated using the formula:

$$AFH = \frac{\frac{g}{8} \cdot \sum_{i=1}^{10} (Ta_i)^2}{10} \qquad (2)$$

The best average flying height is 38,5% higher than the average group for P13 and P11, while P4 records a value 39.1% lower.

The repetition rate energetic parameter provides information mainly on the velocity, distinguishing the excitation and inhibition processes of nerve cells and the relaxation and contraction processes in muscles. The repetition rate can be calculated using the formula:

$$RR = \frac{\sum_{i=1}^{10} Ts_i}{10} \qquad (3)$$

The repetition rate is 10% higher than the average for P12 and P15, but the smallest values of this energetic parameters are 10% lower than the average for P4, P11 and P13.

The same quantitative approach can be emphasized for the energetic parameters while performing one-legged vertical jump.

Some additional energetic parameters can also be computed using the input data for each participant in the test. Their values together with the standard energetic parameters are shown in fig. 1 and table 3.

Table 3 Additional energetic parameters

Energetic parameters	Two-legged vertical	One-legged vertical jump	
		right leg	left leg
Unit Power (UP)	4.22 ±0.66	2.45±0.43	2.52 ±0.52
Medium flying height (MFH)	0.29 ±0.01	0.15 ±0.03	0.16 ±0.03
Repetition rate (RR)	0.2 ±0.01	0.27 ±0.03	0.27 ±0.03

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Maximal unit power (MUP)	4.72 ±0.71	2.86 ±0.43	2.97 ±0.60
Possible maximal unit power (PMUP)	4.82 ±0.72	2.99 ±0.50	3.12 ±0.65

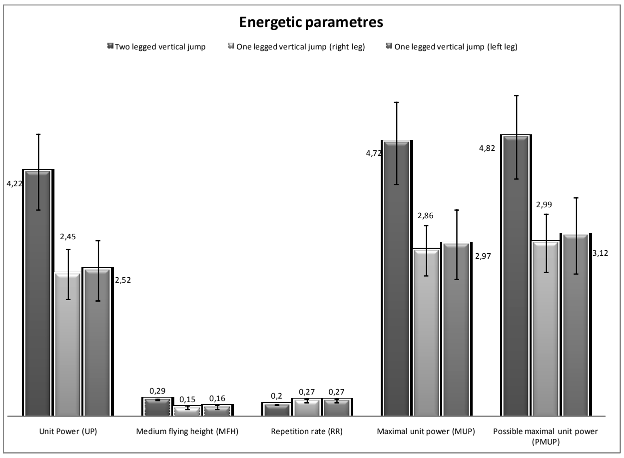

Fig.1 Energetic parameters

5 Discussions

Based on the energetic parameters provided by MGM test, we are able now to estimate the medium velocity for each participant in the test.

Thus, considering that total energy is the sum of kinetic and potential energy, and at the maximum vertical height the energy is only potential, we get:

$$\left.\begin{aligned} E_t &= mgh_{\max} \\ E_t &= mgh + \frac{mv^2}{2} \end{aligned}\right\} \Rightarrow v = \sqrt{2g \cdot \left(h_{\max} - h\right)} \qquad (4)$$

The MGM test provides also the maximum height, and the medium velocity can be obtained from equation 4 (fig.2, table 4).

Table 4 – Kinetic, potential and total energy

Partici-pant	Total energy	Potential energy	Kinetic energy	Velocity
P1	358.56	316.86	41.69	0.99
P2	252.16	207.66	44.50	1.08
P3	228.08	198.65	29.43	0.89
P4	200.12	180.11	20.01	0.63
P5	307.94	257.81	50.13	1.17
P6	310.78	241.72	69.06	1.25
P7	254.04	208.44	45.60	1.17
P8	304.89	261.34	43.56	1.08
P9	193.06	167.32	25.74	0.89
P10	183.64	148.33	35.32	0.99
P11	259.93	231.67	28.25	0.99
P12	190.71	152.57	38.14	1.08
P13	266.04	232.08	33.96	1.08
P14	258.89	223.18	35.71	0.89
P15	230.44	196.30	34.14	0.89

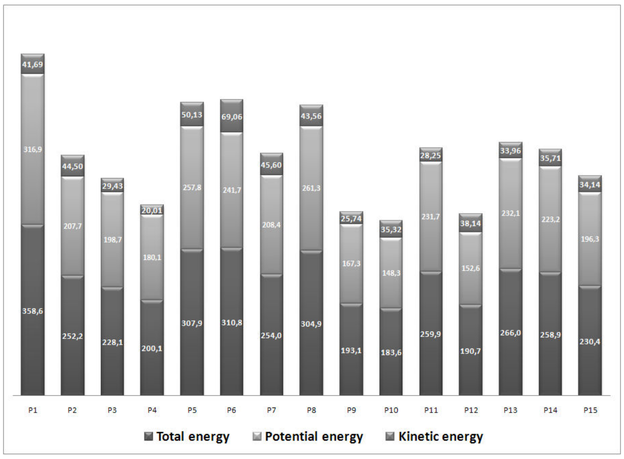

Fig.2 Kinetic, potential and total energy

Comparing the medium velocity of each participant in the test to the mean of the group, we find that the velocity is 24.6% higher than the average for P6, but the smallest values of the velocity parameters are 11.8% lower than the average for P3, P9, P14 and P15 (fig. 3).

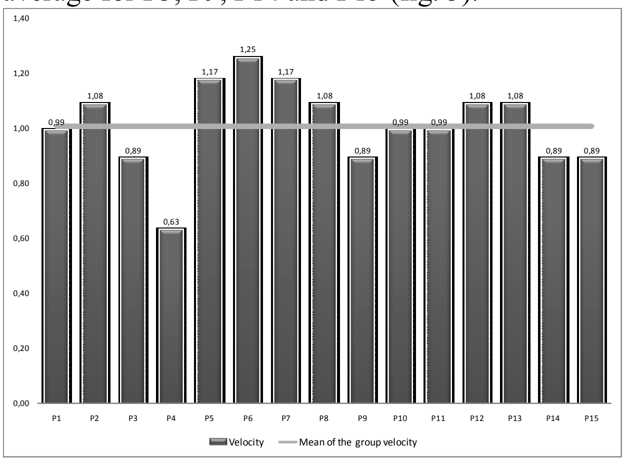

Fig.3. The medium velocity of participants

We analyze the test data for each energetic parameter and for each participant and we find that as the parameter is greater, the force-velocity ratio is better and the athlete develops greater muscle energy. Thus, we find that participant 11 has the best force-velocity ratio, while participant's 4 is the lowest. Thus, for participant 11 we can estimate that he develops an unit power which is 92.98% of the PMUP at two-legged vertical jump, 85.9% of the PMUP at one-legged vertical jump (right leg) and 88.25% of the PMUP at one-legged vertical jump (left leg).

The force-velocity ratio (-1.05) (table 5) reveals a normal physical preparation for this athlete, while the asymmetry of energy (fig. 4) reveals better results for the left leg (-10.85%).

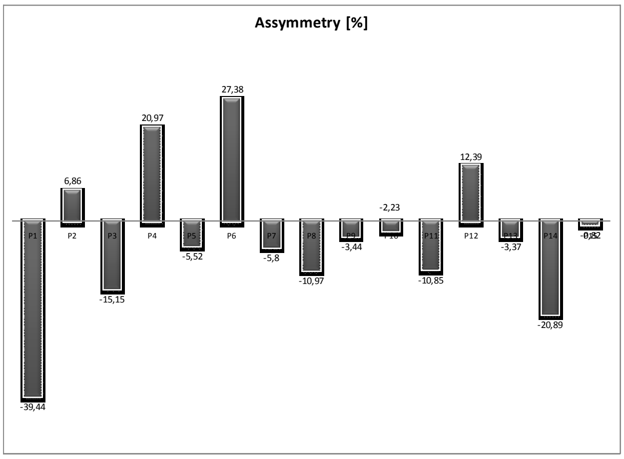

Fig.4 Asymmetry

As for participant 4, we find that he develops a unit power which is 92.73% of the PMUP at two-legged vertical jump, 81.73% of the PMUP at one-legged vertical jump (right leg) and 78.36% of the PMUP at one-legged vertical jump (left leg).

Table 5 Power differences

Participant	Force-velocity ratio	Asymmetry [%]
P1	-0.75	-39.44
P2	-0.75	6.86
P3	-0.84	-15.15
P4	0.15	20.97
P5	-0.8	-5.52
P6	-0.84	27.38
P7	-0.9	-5.8
P8	-0.18	-10.97
P9	-0.88	-3.44
P10	-1.27	-2.23
P11	-1.05	-10.85
P12	-1.76	12.39
P13	-0.93	-3.37
P14	0.05	-20.89
P15	-0.73	-0.82

The ratio force-velocity (0.15) reveals an unbalanced training, consisting in a lack of force for this athlete, while the asymmetry of energy (fig. 4) reveals better results for the right leg (20.97%).

The average flying height characterizes the effort as a matter of force. Thus, participant 11 develops: 89% of the maximum possible height at two-legged vertical jump, 83.33% of the maximum possible height at one-legged vertical jump (right leg) and 85.71 of the maximum possible height at one-legged vertical jump (left leg).

As for participant 4, he proves to be unbalanced as he develops 90% of the maximum possible height at two-legged vertical jump, but only 72.72% of the maximum possible height at one-legged vertical jump (right leg) and 66.67% of the maximum possible height at one-legged vertical jump (left leg).

The repetition rate characterizes the effort as a matter of speed, highlighting the speed of succession processes of excitation and inhibition of nerve cells, on the one hand and processes of contraction and relaxation of muscles, on the other.

Same analysis can be conducted for each athlete in the study and the trainers will prepare a customized training program to improve athletes' performances.

6 Conclusions

For a trainer is very important be aware of the energetic parameters of athletes. The trainer will be able to focus in the direction of uprising the energy asymmetries and improve force-velocity ratio, as characteristic of physical training.

Analysis performed on the coach will allow athletes to customize training and monitoring the same energy parameters after training period to see the improvement of the results.

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