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COMPARATIVE STUDY ON THE EVALUATION OF THE ENERGETICAL PARAMETERS WHILE PERFORMING A VERTICAL JUMPING ON BOTH LEGS

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Abstract

Purpose. The paper presents different methods used for evaluation of the average power as energetical parameter on vertical jumping on both legs. The average power is calculated using Lewis's, Harman's, Johnson's & Bahamonde, Sayers's and Georgescu's formulas. A comparative analysis is performed.

Theoretical concepts. The average power can be calculated using different formulas experimentally determined, using either the mass and the vertical jump height, or the flight periods of time and the periods on the ground. Different formulas were used as follows:

- Lewis's formula uses the mass and the jump height as input data;
- Harman's formula provides the average power and the peak power, using regression method;
- Johnson's and Bahamonde formula uses the mass, the jump height and the athlete's height as input data;
- Sayers's formula provides the average power using the same input data as Lewis, but with different coefficients;
- Georgescu's formula is based on Bosco's theory and it uses the flying times and ground times as input data.

Conclusions. In order to get the average power developed by an athlete while performing vertical jumping on both legs, we can use different experimental methods.

For each method, we can reveal the input data and the energetical parameters provided by the experiment (the average and the extreme values).

The input data are different from one method to another. Most formulas are based on the vertical jump height and on the athlete's mass, except for the MGM formula which is based on the flying times and times on the ground. The average power as energetical parameter provides an accurate evaluation of the ratio force-power which is very important as training parameter. The training process can be oriented to render the value of this ratio optimum.

Key-words: energetical parameters, average power, vertical jumping.

Introduction

Experimental measurements and investigations are considered to be a real process of objective research of the qualitative and quantitative aspects of any phenomena or process.

Sports science has its own patrimony of means and methods of investigation, which provides useful information that can be adapted to specific necessities.

As the performances are higher and higher and the athletes' body is subjected to efforts bigger and bigger, it is necessary to improve the methods of investigation, to render their results more realistic and to establish mathematical models that describe more and more accurate their performances.

It is important to estimate the average power developed by an athlete in order to conduct his training to a better performance in sport (F.W. Dick, 2003).

The trainers, the MD's and other specialists involved in training process need realistic data that can ensure an exact and rigorous training process.

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The importance of measurements and investigations in sports

The main issues that reveal the importance of experimental data in sport science and training process are:

- The necessity of estimating and characterization of the athlete, of the sport field;
- The necessity of comparison between two stages of training;
- The necessity of determining the contribution of each component to the performance;
- The necessity of revealing the causes of mistakes and the errors, in order to eliminate them or to reduce their effects.

To be effective, the experimental measurements must meet the following requirements:

- To be adequate to the purpose, to correspond to the structure of motion;

- To use methods and means appropriate to the sport field. It is important to run analysis during competitions, laboratory tests and training stages;
- To be less disturbing to the training process;
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- To last a while;
- To be accessible and easy to calculate;
- To be simple;
- To be realistic.

Theoretical concepts

In this paper we intend to present different methods used for evaluation of the average power as energetical parameter on vertical jumping on both legs. The average power is calculated using Lewis's, Harman's, Johnson's & Bahamonde, Sayers's, Bosco's and Georgescu's formulas (D.L. Johnson, 1996; E.A. Harman, 1991; S. Sayers, 1999; C. Bosco, 1983). Then, a comparative analysis is performed.

Methods of expressing the mechanical power of body

The average power can be calculated using different formulas experimentally determined, using either the mass and the vertical jump height, or the flight periods of time and the periods on the ground.

The mechanical work when a vertical jump is performed can be determined as follows:

$$L = F \cdot d \qquad (1)$$

where:
L - is the mechanical work;
F - is the force;
d - is the jump height distance.

Also, the force can be written as follows:

$$F = m \cdot a \qquad (2)$$

where:
m - is the mass;
a - is the acceleration.

It is difficult to determine the power, because the duration of the acting force is unknown.

The mechanical power can be written as follows:

$$P = \frac{L}{t} \qquad (3)$$

Due to the fact that is rather difficult to calculate the mechanical power using formula (3), some more proper experimental methods were developed, in order to estimate the average power from vertical jump on both legs.

Lewis's formula

Lewis's formula uses the mass and the jump height as input data (E.A. Harman, 1991).

We can determine the power as follows:

$$P = \sqrt{4.9} \cdot m \cdot \sqrt{d} \qquad (4)$$

Other scientists proved that this formula is inadequate because it doesn't take gravity into account, and it doesn't state if the result is the peak or the average power.

Harman's formula

Harman's formula provides the average power and the peak power, using regression method (E.A. Harman, 1991).
The pick power is:

$$P = 61.9 \cdot d + 36 \cdot m + 1822 \qquad (5)$$

The average power is:

$$P = 21.3 \cdot d + 23 \cdot m - 1393 \qquad (6)$$

where:
d - is the height distance in cm;
m - is the mass in kg;

Johnson's and Bahamonde formula

The Johnson's and Bahamonde formula uses the mass, the jump height and the athlete's height as input data.

The pick power is:

$$P = 78.6 \cdot d + 60.3 \cdot m - 15.3 \cdot h - 1308 \qquad (7)$$

The average power is:

$$P = 43.8 \cdot d + 32.7 \cdot m - 16.8 \cdot h + 431 \qquad (8)$$

where:
d - is the jump height distance in cm;
m - is the mass in kg;
h - is the athlete's height in cm.

Sayers's formula

The Sayers's formula provides the average power using the same input data as Lewis, but with different coefficients (S. Sayers, 1999).

The average power is:

$$P = 60.7 \cdot d + 45.3 \cdot m - 2055 \qquad (9)$$

where:
d - is the height distance in cm;
m - is the mass in kg.

Bosco's formula

The Bosco's formula uses the repetitive test of jumping to estimate the average power, the flight time and the number of jumps, as follows (C. Bosco, 1983):

$$P = \frac{t_f \cdot t_t \cdot g^2}{4 \cdot n \cdot \left(t_t - t_f\right)} \qquad (10)$$

where:
t_f - the flight time;
t_t - the total time;
g - the acceleration due to gravity.

Miron Georgescu's Formula

The Miron Georgescu's formula is based on Bosco's theory and it uses the flying times and ground times as input data (MGM test description). The power unit is determined using the formula:

$$P = \frac{\frac{g}{8} \cdot \sum_{i=1}^{n} t_{fi}^{2}}{\sum_{i=1}^{n} \left(t_{fi} - t_{gi} \right)} \tag{11}$$

where:

t_{fi} - the flight time of jump i;

t_{gi} - the time on ground;

g - the acceleration due to gravity.

Numerical results

In order to get the numerical results, we performed all experimental procedures for five athletes.

For the first test (Lewis) we were able to determine the mechanical power using the jump distance and the body mass.

The results are shown in table 1 and the magnitude of the mechanical power is revealed in fig.1.

Table 1 – The Lewis' experimental results

	S1	S2	S3	S4	S5
Height [cm]	167	158	183	173	174
Mass [kg]	64	53	74	67	78
Jump distance [m]	0.32	0.4	0.39	0.34	0.35
P[Lewis]	801.4	742	1022.9	864.7	1021.4

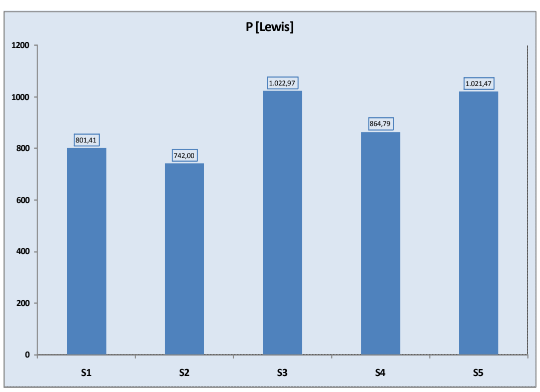

Fig.1 The magnitude of mechanical power by Lewis

The second test was the Harman's, which provide the average mechanical power developed using equation (6). The results are shown in table 2 and the magnitude of the mechanical power is revealed in fig.2.

Table 2 – The Harman' experimental results

	S1	S2	S3	S4	S5
Height [cm]	167	158	183	173	174
Mass [kg]	64	53	74	67	78
Jump distance [m]	0.32	0.4	0.39	0.34	0.35
P[Harman]	751.96	667.2	1129.17	863.02	1137.05

The third test of Johnson and Bahamonde provide also the average power using the jump height, the mass and the athlete's height. For the considered subjects, the results are shown in table 3 and the diagram in fig.3 reveals the magnitude of the average power.

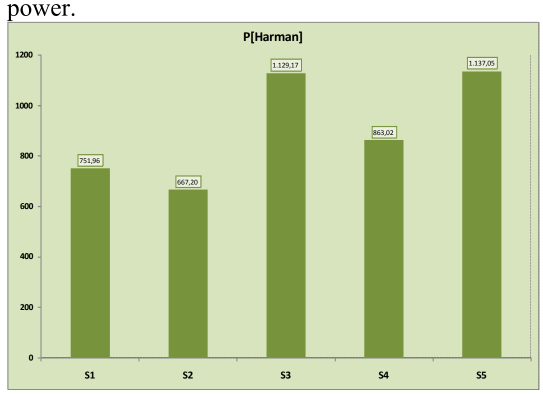

Fig.2 The magnitude of mechanical power by Harman

Table 3 – The Johnson's and Bahamonde experimental results

	S1	S2	S3	S4	S5
Height [cm]	167	158	183	173	174
Mass [kg]	64	53	74	67	78
Jump distance [m]	0.32	0.4	0.39	0.34	0.35
P[Johnson, Bahamonde]	1119.8	1261.7	1484.6	1204.7	1591.4

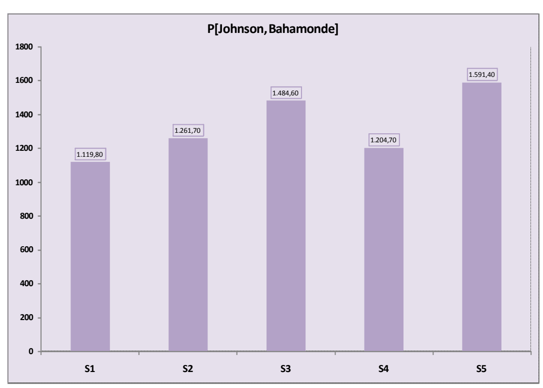

Fig.3 The magnitude of mechanical power by Johnson and Bahamonde

The fourth test provides the average mechanical power using the Sayer's formula, which depends on the mass and on the jump distance.

The results are shown in table 4 and the magnitude of the mechanical power is revealed in fig.4.

Table 4 – The Sayer's experimental results

	S1	S2	S3	S4	S5
Height [cm]	167	158	183	173	174
Mass [kg]	64	53	74	67	78
Jump distance [m]	0.32	0.4	0.39	0.34	0.35
P[Sayer]	863.624	370.18	1320.87	1000.73	1499.64

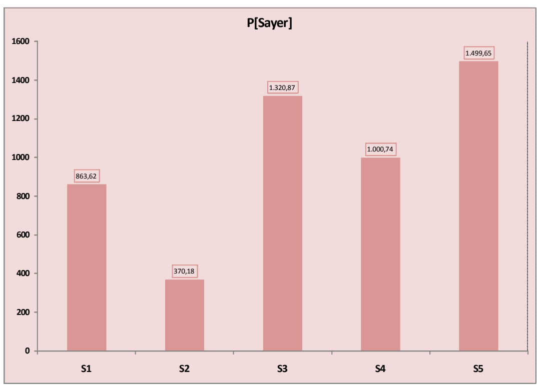

Fig.4 The magnitude of mechanical power by Sayer

The fifth and the sixth tests are using as input data (experimentally measured) the time variables on air and on ground.

The values for Bosco's test are shown in table 5 and the diagram in fig.5 shows the magnitude of each athlete involved in the experiment.

Table 5 Values of Bosco's test

S1	Total time	7.739
	Time on air	5.341
	Power	41.478
S2	Total time	7.867
	Time on air	5.944
	Power	58.515
S3	Total time	8.237
	Time on air	5.926
	Power	50.827
S4	Total time	6.074
	Time on air	3.949
	Power	27.155
S5	Total time	7.8
	Time on air	5.351
	Power	41.014

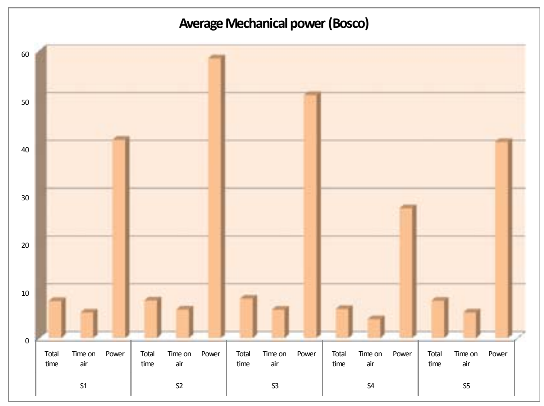

Fig.5 The magnitude of average mechanical power by Bosco

The values for Miron Georgescu's test are shown in table 6 and the diagram in fig.6 reveals the magnitude of the average mechanical power.

Table 6 Values of Gergescu's test

S1		S2		S3		S4		S5	
Ground	**Air**	**Ground**	**Air**	**Ground**	**Air**	**Ground**	**Air**	**Ground**	**Air**
0.223	0.484	0.17	0.57	0.226	0.559	0.213	0.486	0.237	0.446
0.217	0.46	0.19	0.519	0.202	0.561	0.174	0.516	0.231	0.438
0.217	0.514	0.175	0.562	0.201	0.558	0.169	0.506	0.223	0.459
0.22	0.45	0.183	0.567	0.211	0.532	0.171	0.528	0.211	0.494
0.212	0.51	0.176	0.536	0.202	0.556	0.244	0.042	0.219	0.472
0.211	0.502	0.166	0.555	0.229	0.542	0.197	0.011	0.225	0.484
0.22	0.486	0.161	0.546	0.198	0.535	0.194	0.507	0.228	0.517
0.212	0.487	0.2	0.502	0.215	0.552	0.18	0.487	0.213	0.532
0.214	0.499	0.164	0.533	0.22	0.489	0.207	0.494	0.223	0.518
0.234	0.464	0.163	0.514	0.197	0.504	0.183	0.013	0.216	0.505

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0.218	0.4856	0.1748	0.5404	0.2101	0.5388	0.1932	0.359	0.2226	0.4865

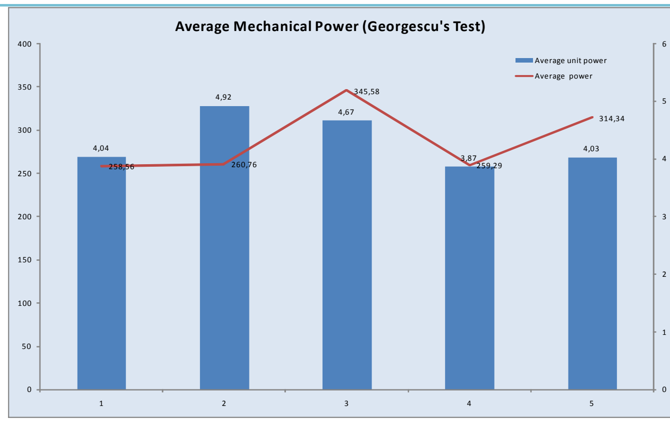

Fig.6 The average mechanical power by Miron Georgescu

Discussions

Based on the results obtained by the tests performed on five athletes, we can state that there are significant differences between the determined values.

Thus, we conclude that the first four tests (Lewis, Harman, Johnson & Bahamonde and Sayer) provide results (table 7) that are comparable, as follows:

Table 7 Comparative results

	P[Lewis]	P[Harman]	P[Johnson, Bahamonde]	P[Sayer]
S1	801.4	751.9	1119.8	863.6
S2	742	667.2	1261.7	370.1
S3	1022.9	1129.1	1484.6	1320.8
S4	864.7	863	1204.7	1000.7
S5	1021.4	1137	1591.4	1499.6

We can see that the Harman's test can be considered as the most accurate test for average mechanical power, as its procentual deviation from the average power is smaller than the other tests (fig.8).

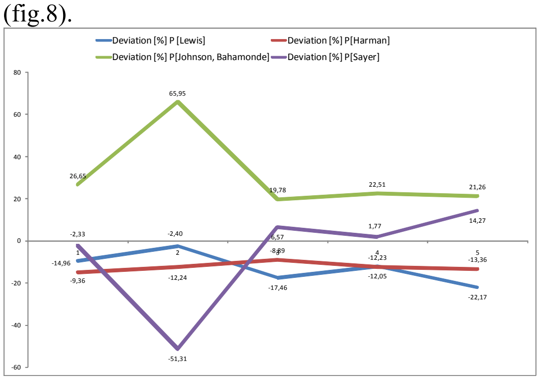

Fig.8 Deviation of average mechanical power determined with different test from the average

There are important differences between one test to another, regarding the magnitude of the average mechanical power, although they are using the same input data. Thus, the comparison shows that for subject 4 the difference between the average power calculated with Lewis's formula and the average power calculated with Farman's formula is the smallest (-0,2%), while for subject 2 we get the maximum difference between the average power calculated with Lewis's formula and the average power calculated with Johnson's & Bahamonde formula (70,04%).

Such large differences (fig.9) prove that none of the fourth test is relevant to the estimation of average power.

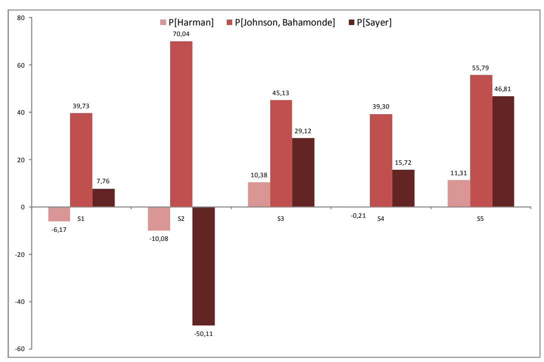

Fig. 9 Differences between one test to onother

As for the last two tests (based on the multiple vertical jumps) we can reveal that there are also significant differences due to the fact that Miron Georgescu's test provides the average unit power (fig.10).

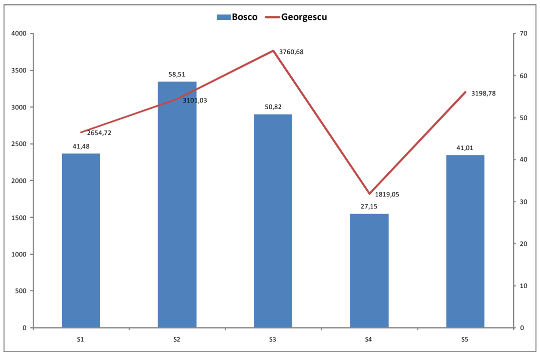

Fig. 9 Differences between Bosco and Georgescu test

Conclusions

In order to get the average power developed by an athlete while performing vertical jumping on both legs, we can use different experimental methods.

For each method, we can reveal the input data and the energetical parameters provided by the experiment (the average and the extreme values).

The input data are different from one method to another. Most formulas are based on the vertical jump height and on the athlete's mass, except for the MGM formula which is based on the flying times and times on the ground.

The average power as energetical parameter provides an accurate evaluation of the ratio force-power which is very important as training parameter. The training process can be oriented to render the value of this ratio optimum.

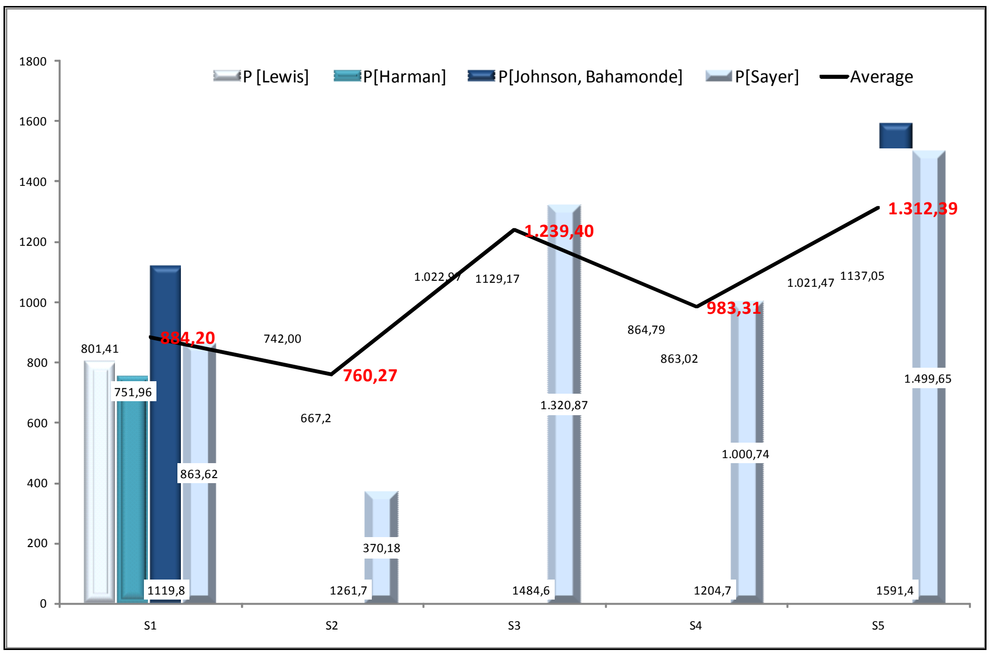

Fig.7 Comparative diagrams of average mechanical power

References

DICK, F.W., 2003, *Sports Training Principles***.** (4th ed.) London: A & C Black

BOSCO, C, LUHTANEN P, KOMI, PV., 1983, *A simple method for measurement of mechanical power in jumping***.** European Journal of Applied Physiology 50:273-282.

HARMAN, E.A., ROSENSTEIN, M.T., FRYKMAN, P.N., ROSENSTEIN, R.M., AND KRAEMER, W.J., 1991, *Estimation of Human Power Output From Vertical Jump***.** Journal of Applied Sport Science Research, 5(3), 116-120.

JOHNSON, D.L., AND BAHAMONDE, R., 1996, *Power Output Estimate in University Athletes***.** Journal of strength and Conditioning Research, 10(3), 161-166.

SAYERS, S., ET AL., 1999, *Cross-validation of three jump power equations***.** Med Sci Sports Exerc. 31: 572**.**