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An attemp at the evaluation of the lower extremities power during a vertical jump on a dynamometric platform

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The paper presents an attempt to evaluate power of lower extremities for basketball players. Force platform with amplifier and microcomputer with A/D converter were used to measure maximal external power, average power per body weight and height of rise of the body mass center for CMJ jump, and jump with throw of the ball. Phosphagen power for the athletes were measured using Margaria-Kalamen test. In the experiments were assesed muscle torgues for twenty main muscles groups as an evaluation of strength of sportsmen. There were two groups basketball players in these experiments: 24 women and 18 men from the national teams. Significant correlation (significant level, $p<0.05$) were found between height of rise and maximal external power, average power per body weight for the CMJ jump and jump with throw of the ball for men and women. No statistical significant differences were found in the experiments between parameters characterizing CMJ and jump with the ball. The correlation coefficients between phosphagen power and parameters characterizing jump and the throw are not statistically significant ($p>0,05$). There were found correlation ($p<0,05$) between phosphagen power and sum of the muscles torques measured in static condition per body weight for lower extremities and for muscles groups, but no correlations were found between parameters characterizing jumps and muscles torques.

Key words: Jumping test — Mechanical power — Phosfagen power

Introduction

Countermovement vertical jump is often used in training practice as well as in biomechanical studies to evaluate strength-velocity characteristics of lower extremities [1, 8]. Many authors calculate velocity, force, power, and height of rise of mass center on the basis of the vertical component of the ground reaction force [2, 3, 4, 5]. This method enables quick and easy evaluation of the velocity-strength characteristics of lower extremities. However, the results obtained by using

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this method may be problematic [13]. In paper [2] it has been stated that there is no relation between power and the height of rise of the body mass center for countermovement jump on dynamometric platform. In our experiment we tried to evaluate the power of lower extremities for the basketball players basing on the countermovement jump (**CMJ**) and on the simulation of jump with a ball throw on a dynamometric platform. We also tried to examine the relationships between chosen parameters of a jump and the physical features of examined subjects.

Table 1

Characteristic of the studied groups

Group	Age	Duration of training	Body mass	Body height
Males	23.9±0.664	10±0.932	90.4±1.901	199.7±1.614
Females	23.8±0.497	10.3±0.559	72.3±2.95	181±4.84

Material and methods

The subjects of this study were 18 male and 24 female basketball players of the national teams. Groups characteristics is given in tab. 1. For all the subjects the following measurements were performed: static muscle torques, heights of rise of the body mass center and power of lower extremities for **CMJ** and jump with throw of the ball on a dynamometric platform, phosphagen power (by means of Margaria-Kalamen method).

Static muscle torques were measured in standard conditions (according to the method described by Fidelus [7]. Torques for 20 main muscles groups were examined — these were flexors and extensors of the trunk and following joints: shoulder, elbow, hip, knee, and ankle. The values of muscle torques were then related to a body mass in order to enable the comparison between the subjects.

$$\mathbf{Mm} = F x r / m \quad (1)$$

where: **Mm** — muscle torque [Nm/kg],

F — external force [N],

r — arm of the external force [m],

m — body mass [kg].

In the calculation of dynamic parameters the method developed by Bartosiewicz [2] was used. The **CMJ** as well as jump and throw of a ball were performed on a Kistler dynamometric platform. Signal from the platform was amplified and then processed using a microcomputer Neptune 184 with an A/D converter. Basing on the changes of the ground reaction force in time the following parameters were calculated:

Pmax — maximal power [W]; being the maximal value of a product of the acting vertical force and the body mass center velocity

$$P(t) = v(t) \times [Fr(t) - Q] \qquad (2)$$

where: **v** — velocity of body mass center [m/s],
Fr — ground reaction force [N],
Q — body weight [N],
h — height of rise of mass center:

$$h = v \int (t)\, dt \qquad (3)$$

P — average power [W] during the upward phase of a movement calculated from the formula:

$$P = mgh/t \qquad (4)$$

where: **h** — height of rise of mass center [m],
t — duration of a take-off [s],
m — body mass [kg],
g — acceleration of gravity [mxs].

Margaria-Kalamen test [9] was used to measure phosphagen power. It was calculated basing on the formula:

$$Pf = mxh/t \qquad (5)$$

where: **Pf** — phosphagen power [kg m/s],
m — body mass [kg],
h — level difference between degree 3 and 9 [m]
t — time of run [s]

Results

The values of measured parameters for **CMJ** and for jump and throw of a ball are given in tab. 2. To analyse the results linear correlation as well as T-Student test were calculated for all measured parameters [10]. Significant correlation (significance level $p<0.05$) was found between height of rise of mass center and both the maximal power related to body mass (for **CMJ** as well as for jump and throw). The linear correlation coefficients for the above parameters are given in tab. 3. There are no statistically significant differences inside both studied groups as far as the parameters of **CMJ** are compared with the parameters of jump and throw (based on T-Student test). Neither are there significant relationships between muscles torques (related to body mass) and dynamic parameters of **CMJ** and throw in both studied groups (basing on the linear correlation and T-Student test).

Table 2

Mean values and standard deviations of measured parameters

Parameters		Males	Females
Mm:	Kgp	4.81±0.486	3.37±0.41
	Kgl	4.68±0.564	3.26±0.375
	Kdp	15.68±1.987	12.47±1.884
	Kdl	15.00±1.884	12.32±1.822
	tz	3.91±1.084	2.58±0.543
	tp	7.57±2.089	5.46±1.717
CMJ:	Pmax	3222.60±356.019	2099.10±301.148
	P/m	18.06±2.965	16.84±2.846
	h	0.477±0.057	0.371±0.050
Throw:	Pmax	2951.70±524.597	1876.80±301.366
	P/m	18.61±3.055	16.25±2.921
	h	0.443±0.061	0.359±0.05
Phosphagen power		187.6±14.964	

Notation: Mm — muscles torques, kgp — right upper extremitie, kgl — left upper extremitie, kdp — right lower extremitie, kdl — left lower extremitie, tz — flexors of trunk, tp — extensors of trunk, Pmax — maximal power, P/m — average power related to body mass, h — height of rise of mass center.

Units: Mm (Nm/kg), Pmax (W), P/m (w/kg), h (m), phosphagen power (kg·m/s)

There were not found statistically significant correlations ($p>0.05$) between the value of phosphagen power and the following parameters: maximal power, average power related to body mass, and height of rise of mass center. For the same significance level the following correlation coefficients were found between phosphagen power and muscle torques of: lower extremitie (0.732), lower extremities (0.679), all the muscles groups (0.538).

Table 3

Linear correlation coefficients between height of jump and both maximal power and average power related to body mass for CMJ (above the diagonal) and throw (under the diagonal) for females (A) and males (B), respectively.

A.	h	Pmax	P/m
h		0.57	0.586
Pmax	0.546		0.585
P/m	0.521	0.611	

B.	h	Pmax	P/m
h		0.558	0.587
Pmax	0.642		0.71
P/m	0.675	0.708	

Discusion

Countermovement jump is often used to measure power of athletes of different sport disciplines [4, 11, 12, 13]. Bartosiewicz and Wit [2] reported, that for national volleyball team they recorded maximal power values in range from 2975 W to 4320 W, and height of rise of mass center ranging from 0.326 m to 0.539 m. Bosco and Komi [5] reported the mean value of height of rise of mass center for national volleyball team equal 0.434±0.052 m. There was no signifficant correlation found [2] between the height of jump and power for volleyball players (men and women), and judo competitors. For the group of fencers the same relation was found to be significant [3]. In presented study the statistically significant relations were observed between the height of rise of mass center and both the maximal power and the average power related to body mass. There seems to be a significant relation between the parameters of a vertical jump. The lack of such relation in paper [2] may be due to the small number of subjects or too big scatter of the results achieved by the subjects. There were no significant differences found between the muscle torques values reported for basketball players by Fidelus and Skorupski [6] and those measured in presented study. This may imply the stability of the development of this feature for basketball players. In some papers [9, 14] statistically significant relationships were reported between phosphagen power and the results of some physical fittnes tests: Seargent test, sprints (30-60 m), multijumps. In this study the above relation was not significant. It seems to be due to the different movements in jump and Margaria-Kalamen tests, even though they both measure anaerobic power.

Presented methods can be used to measure power of the lower extremities. There seems to be a significant relationship between height of rise of mass center and power fot both CMJ and jump and throw on a dynamometric platform.

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Streszczenie

W pracy tej podjęto próbę pomiaru mocy kończyn dolnych koszykarzy Do pomiaru mocy użyto platformy dynamometrycznej, wzmacniacza i mikrokomputera z przetwornikiem A/C. Rejestrowano moc maksymalną, moc średnią na kilogram masy ciała i wysokość uniesienia środka masy w wyskoku CMJ i rzucie z wyskoku z miejsca. Testem Margarii-Kalamena zmierzono moc fosfagenową badanych zawodników. Na podstawie pomiaru momentów sił 20 zespołów mięśniowych w statyce określono siłę statyczną badanych. W badaniach uczestniczyli: 24 zawodniczki i 18 zawodników kadry narodowej w piłce koszykowej. Uzyskane współczynniki korelacji liniowej między parametrami szybkościowo-siłowymi ujawniły istotną zależność ($p<0,05$) między wysokością uniesienia środka masy a mocą maksymalną i mocą średnią na kilogram masy ciała wyskoku CMJ i rzutu z wyskoku z miejsca zawodniczek i zawodników. Porównując parametry wyskoku CMJ z parametrami rzutu z wyskoku z miejsca testem t-Studenta nie stwierdzono istotnych statystycznie różnic. Współczynniki korelacji liniowej między wartością mocy fosfagenowej a mocą maksymalną, mocą średnią na kilogram masy ciała i wysokością uniesienia środka masy uzyskanych w wyskoku CMJ i rzucie z wyskoku z miejsca były nieistotne

statystycznie ($p>0,05$). W obu badanych grupach, nie stwierdzono testem t-Studenta i korelacją liniową istotnych statystycznie zależności między momentami sił mięśniowych w statyce a parametrami wyskoku i rzutu z wyskoku z miejsca. Istotna statystycznie zależność ($p<0,05$) wystąpiła między mocą fosfagenową a sumą momentów sił względnych, kończyn dolnych i wszystkich badanych zespołów mięśniowych.

Резюме

В работе представлено метод косых компонент, который содержит свойства метод группиро: ки признаков и метод факторного анализа. Проблема группировки признаков имеет следующий вид: для данного p, погруппировать признаки $x_1, \ldots, x_k$ в группы $G_1, \ldots, G_p$ так чтобы сумма найбольших собственных значений корреляционных матриц групп признаков достигнула максимума по всех группировках. При использовани таково метода одновременно получаем главные компоненты групп признаков которые являются общими факторами. Отсюда следует что этот метод позваляет проводить анализ группировки и факторный анализ множества признаков. В работе показано тоже два алгоритма метода и критерий поиска оптимального числа групп. Работу заканчивает пример использования этих алгоритмов для гипотетической корреляционной матрицы.