THE INFLUENCE OF SELECTED BODY DIMENSIONAL VARIABLES ON THE MECHANICAL PARAMETERS OF THE VERTICAL JUMP

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INTRODUCTION: It can be stated that the height of a jump is a relatively steady variable characterizing the jumping ability of a subject, when maximal power depends mostly on the take-off technique applied (Gajewski et al., 1996; Aragón-Vargas & Gross, 1997). Bartosiewicz et al. (1990) demonstrated that the maximal power was a linear function of the counter-movement depth in the CMJs performed by the same subject. Dependency of maximal power upon knee angle was also reported by Harley & Doust (1994). As shown in our previous study (Gajewski et al., 1996), the height of a jump, the counter-movement depth and body mass explained nearly 90% of the total variance of the maximal power, while the height of a jump did not depend on the counter-movement depth. Gender (Komi & Bosco, 1978; Dowling & Vamos, 1993) as well as muscle fiber composition (Aura & Viitasalo, 1989) are known to affect the height of jumps. Therefore, the question arises about additional determinants of the height of jumps and other mechanical parameters describing the CMJ.
The purpose of the present study was to determine the influence of body fat content and selected limb lengths and proportions on the maximal mechanical power and height of the counter-movement jump.

METHODS AND PROCEDURES: Two groups of untrained students (56 females and 38 males) volunteered as subjects for the present study. Morphological characteristics of both groups are presented in Table 1.

Table 1. Age, body mass and height of the tested subjects

	Age [years]	Body mass [kg]		Body height [m]	
	Range	Range	Mean±SD	Range	Mean±SD
Female	19-23	44.4-72.0	58.7±7.1	1.57- 1.88	1.672±0.059
Male	19-24	61.3-92.5	74.4±8.6	1.68-1.95	1.801±0.071

Each subject performed three consecutive counter-movement jumps on a Kistler force plate separated by one-minute intervals. The task for the tested persons was to achieve maximal height in each jump. Different values of the counter-movement depth were suggested for each jump. Data recorded for the highest jumps were used in further analysis. The preamplified signal of the vertical component of the ground reaction force was digitized at a sampling frequency of 250 Hz using a 12 bit A/D converter. Specially designed software was employed to calculate the mechanical parameters of the jumps. The following parameters were taken for statistical analysis: height of jump (H), lowering of the body center of mass before take-off (L) and maximal mechanical power (P_{max}) developed during the take-off. Additionally, the following anthropometric parameters were estimated for each subject: body mass (m) and height (BH), trunk, leg, tight, shank and foot lengths (TL, LL, UL, SL and FL, respectively) as well as body fat content (FM). The shank-to-leg length ratio (sl) was also included into analysis. Correlation analysis was used to estimate the contribution of the selected jump and body dimensional parameters to the maximal value of jumping power and height. Normality of distributions required by the applied statistical method was examined using the Shapiro-Wilk test. The S-W values of $p>0.20$ were considered as confirming normality.

RESULTS: Distributions of most variables studied can be considered normal. The logarithm transformation was applied to the body fat content. Log fat content (LFM) was used in further calculations. Descriptive statistics of the variables is presented in Table 2. The S-W values of $p < 0.05$ mean significant deviation from normality.

Table 2.a Statistical parameters of the tested variables (female group)

n=56	Mean	SD	Range	S-W p
P_{max} [W]	1395	289	886-2179	0.352
H [m]	0.350	0.045	0.24-0.47	0.995
L [m]	0.246	0.050	0.15-0.37	0.205
M [kg]	58.7	7.1	44.4-72.0	0.205
BH [m]	1.672	0.059	1.570-1.880	0.059
FL [m]	0.249	0.922	0.219-0.268	0.887
TL [m]	0.450	0.024	0.545-0.590	0.012*
LL [m]	0.869	0.042	0.795-0.996	0.203
SL [m]	0.455	0.025	0.409-0.547	0.015*
Sl [-]	0.524	0.014	0.499-0.557	0.188
LFM [-]	2.474	0.311	1.847-3.200	0.483

Table 2b Statistical parameters of the tested variables (male group)

n=38	Mean	SD	Range	S-W p
P_{max} [W]	2535	547	1438-3748	0.722
H [m]	0.494	0.052	0.41-0.62	0.348
L [m]	0.307	0.082	0.13-0.51	0.336
m [kg]	74.5	8.6	61.3-92.5	0.046*
BH [m]	1.801	0.071	1.685-1.950	0.185
FL [m]	0.272	0.012	0.250-0.296	0.034*
TL [m]	0.532	0.021	0.499-0.585	0.030*
LL [m]	0.939	0.051	0.856-1.030	0.085
SL [m]	0.492	0.031	0.443-9.560	0.056
sl [-]	0.524	0.015	0.497-0.563	0.821
LFM [-]	2.053	0.319	1.636-2.798	0.002*

Associations between the tested variables are illustrated in correlation matrices presented in Table 3.

Table 3a. Correlation matrix (female group); only significant ($p<0.05$) correlations indicated

	P_{max}	H	L	m	BH	FL	TL	LL	SL	sl	LFM
P_{max}	x	0.51	-								
H	0.51	x									-
L	-		x								
M				x	0.58	0.54		0.56	0.50		0.64
BH				0.58	x	0.66	0.54	0.87	0.79		
FL				0.54	0.66	x	0.41	0.63	0.60		
TL					0.54	0.41	x		0.29		
LL				0.56	0.87	0.63		x	0.88		
SL				0.50	0.79	0.60	0.29	0.88	x	0.49	
Sl									0.49	x	
LFM		-		0.64							x

Table 3a. Correlation matrix (male group); only significant ($p<0.05$) correlations indicated

	P_{max}	H	L	m	BH	FL	TL	LL	SL	sl	LFM
P_{max}	x	0.45	-								
H	0.45	x								-	-
L	-		x								
M				x	0.52	0.61		0.53	0.66	0.46	0.53
BH				0.52	x	0.70	0.58	0.94	0.87		
FL				0.61	0.70	x		0.72	0.76	0.33	
TL					0.58		x		0.36		
LL				0.53	0.94	0.72		x	0.90		
SL				0.66	0.87	0.76	0.36	0.90	x	0.52	
Sl		-		0.46		0.33			0.52	x	0.36
LFM		-		0.53						0.36	x

Rather high correlations between P_{max}, H and L have been reported and discussed in our previous study (Gajewski et al., 1996). The multiple regression model for P_{max} determinants has been presented there.
Low, but still significant ($p<0.05$), correlations were found in both males and females between the height of jump and the log fat content ($r=-0.37$). The same was observed for males ($r=-0.34$ and -0.34, respectively). In the male group the height of jump and the shank-to-leg ratio correlated significantly as well ($r=-0.34$). None of the other anthropometric variables significantly affected the vertical jump parameters. An attempt to include the analyzed variables in the multiple regression model explaining either P_{max} or H variability failed.

DISCUSSION: The above presented results suggest that limb lengths have no significant effect on vertical jump performance. The negative correlations found in both male and female groups between the log fat content and the height of jumps do not require any additional explanation. Their rather low absolute values, however, can be attributed to respectively small variability of the body fat content among tested groups. The negative correlation between the shank-to-leg length

ratio (sl) and the height of jump (found in the male group) means that a respectively short thigh (short quadriceps muscle) is unfavorable to jump performance. This is in line with Edgerton et al. (1986), who suggested that short muscles could not be as effective in rapid movements as longer ones. This finding could be interesting from the practical point of view, being helpful in selection for sports in which jump performance is essential.
The problem of jump performance determinants still remains unclear. Although Aragón-Vargas & Gross (1997) suggested a significant influence of maximal muscle strength on jump performance, our previous results (Gajewski & Janiak, 1997) did not fully confirm such a conclusion. It seems that muscle architecture could be considered as a subject for further investigations.

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