THE RELATIONSHIPS BETWEEN ANTHROPOMETRIC BODY DIMENSIONS AND THE FORCE-TIME STRUCTURE OF THE VERTICAL JUMP

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KEY WORDS: vertical jump, body dimensions, structure, relationships

INTRODUCTION: Take-off activities are quite various, and many of their modifications are used in practice as well as in research. The center of mass (CM) concept (Brügemann, 1994) is a very frequent model for the solution of the take-off activity in the vertical direction, and the height of jump or final take-off velocity are taken as criteria for the jump. The final result of the jump is influenced by a great variety of factors, e.g., the influence of muscle functions (Komi & Bosco, 1978; Bosco & Komi, 1981), arm activity (Lees & Barton, 1996), the range of the center of mass movement (Sanders et al.,1993), different patterns of take-off (Fujii & Moriwaki, 1993; Bobbert et al., 1995), the influence of additional weight (Boudolos, 1995), the time of contact with the ground (Türk-Noack et al., 1995) and others.
The problem of the relationships between body dimensions and the counter-movement vertical jump (CMJ) has been studied in only a partial way (e.g., Yongyan & Yihua, 1995). The body's dimensions often influence the pattern of movement activity for humans. From the theory of physics it follows that the height of the CMJ is computed based on a measured force impulse and the body mass of a subject. It can be supposed that the length variables of the lower extremities influence the range of the CM movement in the braking and accelerating phases. The above mentioned relationships between body dimensions and the structure of the CMJ are at the center of our interest. The main goal of this paper is the study of the relationships between body dimensions and the force-time structure of the CMJ (time, distance, velocity, and take-off force variables, and final results of the jump).
Hypothesis: We expect to find significant relationships between the anthropometric and CMJ variables.

METHODS: The standard performed CMJ with an arm swing was registered on a KISTLER platform. The force-time curve Fz(t) was analyzed on an ON-LINE system by using software developed in our laboratory. 23 variables describing the structure of the CMJ from the points of view of time, distance, velocity of the CM and produced take-off force were computed in real time. A detailed description of measured variables can be found in Vaverka et. al (1997). The anthropometric measurements were provided by using the methodology of Martin & Saller (1959), and 11 variables were measured: (Body height - BH, Body mass - BM, Length of the trunk - TR, Lower extremity - LE, Thigh length - TH, Calf length - CA, Ankle height - AH, Symphysyon - SY, Knee breadth - KB, Ankle breadth - AB, Foot length - FL). Two groups of physical education students were the subjects of this investigation (men, n=54, age: 18-20 years, height: 178.00 ± 6.12 cm, body mass: 79.00 ± 6.36 kg, women, n=47, height: 168.48 ± 6.20 cm, body mass: 59.77 ± 6.44 kg). Correlation and factor analysis were used for the statistical analysis (STATGRAPHICS package).

RESULTS: Measured data were elaborated in three steps: the relationships among the anthropometric variables, CMJ variables and final anthropometric and CMJ variables. The correlation analysis has produced a large amount of partial information in the form of correlation coefficients (one matrix of one group contains 578 correlation coefficients). Two, three and four factor solutions have been calculated, and due to the scope of this paper we present only a single solution from the factor analysis: the two-factor model for the anthropometric variables and the three-factor model for the CMJ. Table 1 shows 6 matrices of the rotated factor loading in a graphic form. The relationships among the anthropometric variables (Tab. 1A) are slightly different for the set of men in comparison with the women. Anthropometric variables are structured in the two factors in the set of women (length variables in the 1st factor and BM, TR, KB and AB in the 2nd factor). Most of the anthropometric variables in the set of men are included in the 1st factor (except TH and KB).

The factor analysis of the CMJ (Tab. 1B) has confirmed almost the same structure of factor loading in both sets for men and women. The significant loading of the variables of the preparatory and acceleration phases and the total time of the take-off are included in the 1st factor. The 2nd factor contains significant loading of the final variables of the take-off (take-off velocity, force impulse of the acceleration phase, velocity at the beginning of flight, the time of the flight, and the height of the jump). The 3rd factor collected the significant loading of the braking phase of the CMJ. The results of the main goal of this paper are given in Table 1C. The three-factor model has shown the independence of the CMJ structure from the variables of body dimensions. The anthropometric variables are concentrated in the 1st factor and the CMJ variables in the 2nd and 3rd factors. Only the total time of the take-off (TTO) in the set of men and the accelerating force-impulse (FIAP) in the set of women have significant loading in the factor of anthropometric variables. The results of the statistical analysis did not confirm the hypothesis. Based on statistical analysis, it seems that the quality of the take-off is influenced by factors other than anthropometric dimensions.

CONCLUSIONS:

1. The structure of the CMJ is very similar in both sets of men and women.
2. The factor analysis of the CMJ clustered three groups of variables (the preparatory and acceleration phase and total time of the take-off, final variables of the take-off, and variables of the braking phase).
3. The body dimensions and the structure of the CMJ are independent groups of variables. Only the total time of the take-off in the set of men and the accelerating force-impulse in the set of women have significant relationships to the anthropometric variables.

Tab. 1 Matrix of rotated factor loading

	A					C				
	Factor			Communality		Factor			Communality	
	I	II	III	men	women	I	II	III	men	women
BH	o¡		—	0.91	0.94	o¡			0.65	0.85
BM	o	¡	—	0.63	0.73	o¡			0.58	0.68
TR	o	¡	—	0.41	0.48				0.25	0.17
LE	o¡		—	0.80	0.98	o¡			0.59	0.82
TH	¡	o	—	0.77	0.64	¡			0.26	0.53
CA	o¡		—	0.79	0.42				0.16	0.37
AH			—	0.36	0.35				0.36	0.30
SY	o¡		—	0.76	0.87	o¡			0.56	0.72
KB		o¡	—	0.44	0.66				0.25	0.36
AB		¡	—	0.23	0.72	¡			0.22	0.56
FL	¡		—	0.57	0.81	o¡			0.43	0.73
B										
TPP	¡		n	0.71	0.56	o	¡		0.50	0.63
DPP	o¡			0.76	0.71		o¡		0.75	0.67
TIBR	o¡			0.47	0.70		¡		0.43	0.70
DBP	o¡		o	0.87	0.89		o¡	¡	0.84	0.86
VPP			o¡	0.97	0.96		o	¡	0.71	0.86
FBPM				0.60	0.68				0.43	0.69
IBP			o¡	0.89	0.91			¡	0.49	0.82
DLCM	o¡			0.92	0.91		o¡		0.93	0.89
TIAC	o¡			0.88	0.90		o¡		0.79	0.91
DACP	o¡			0.85	0.90		o¡		0.79	0.89
VTO		o¡		0.93	0.95			o¡	0.88	0.47
FACM	n	¡		0.58	0.59				0.56	0.42
FACA	nl			0.80	0.78		nl		0.72	0.82
IACP		o¡		0.49	0.59	¡		o	0.82	0.80
TTO	o¡			0.90	0.90	o	¡		0.64	0.92
VBFL		o¡		0.93	0.95			o¡	0.87	0.45
TFL		o¡		0.77	0.87			o¡	0.76	0.47
HJ		o¡		0.93	0.95			o¡	0.88	0.49
TBAC			o¡	0.86	0.78			¡	0.40	0.71
KAP			o¡	0.97	0.97		o	¡	0.63	0.61

o men, factor loading > 0.6, ¡ women, factor loading > 0.6
n men, factor loading > -0.6, l women, factor loading > -0.6

Factor analysis: A - anthropometric variables
B - CMJ
C - anthropometric variables and CMJ

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