THE RELATIONSHIP BETWEEN BARBELL VELOCITY AND GROUND REACTION FORCE OF ATHLETE-DEVICE SYSTEM DURING THE SNATCH

by

HENRYK KRÓL *

Introduction

The best evaluation of usefulness of particular exercises in the process of movement technique perfectioning is the knowledge about its internal and external structure. It needs a complex methodology of research (Nawrat, Król 1989). The simultaneous use of many devices registering the flow of different kinematic or dynamic variables is very often impossible when the movements are performed at large spaces, are relatively fast or three-dimensional.

The necessity of resigning from the simultaneous measuring of dynamics as well as kinematics of movement is undoubtedly a simplification, because in this situation the conclusions are based on incomplete_information. The situation seems to be a little better because of fact, that some relationships between particular variables may be observed. In case of the snatch - in weightlifting – such a relationship was determined between barbell velocity and the change of angle called “knee bend” (Król 1993). Similarly it may be done in relation to other variables describing the movement. During weight lifting the barbell and weightlifter constitute a bio-kinematic chain, in which movements of particular elements interact with each other. It was then assumed, that during the snatch in the athlete-device system a relationship exists between maximum vertical velocity of the barbell[1] and ground reaction force (GRF).

* Dr, Univ. School of PhE, Katowice, ul. Mikołowska 72a

[1] The maximal vertical velocity of the barbell according to Zekov (1976) ist the most important criterion of properness of snatch.

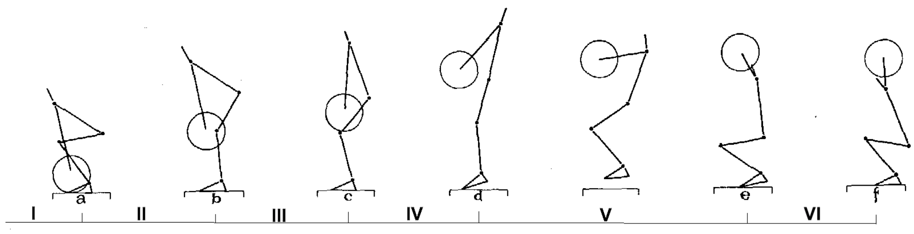

Fig. 1. Phase structure of the snatch (movement geometry). Movement phases: I – countermovement, II – initial barbell acceleration, III – knee bend, IV – final barbell acceleration, V – lowering under the barbell, VI – barbell stabilization during squat

Material and methods

In order to verify the research hypothesis 9 high level athletes (Ist and IInd sports class) performed 6 repetitions of the snatch with weight equal to 90% of the actual maximum lifted by an athlete[2]. The characteristic of the group is presented in Table 1.

Table 1

Characteristics of the athletes

Athlete	Body height [cm]	Body mass [kg]	Weight category [kg]	Age [years]	Training experience [years]	Personal best in the snatch [kG]	Sport class
M.T.	167	71,9	67,5	24	5	120	I
K.S.	167	72,4	67,5	18	2,5	100	II
J.O.	165	80,3	75,0	24	12	130	I
A.B.	167	73,0	67,5	24	9	127,5	I
J.P.	163	75,1	75,0	23	7	130	I
C.L.	165	71,9	67,5	18	2,5	110	II
P.P.	162	72,3	67,5	21	6	125	I
A.Ś.	163	75,4	67,5	22	5	120	I
M.R.	170	73,5	67,5	18	4	125	I

[2] Maximum weight lifted by an athlete during researches was assumed as 100% his actual capabilities.

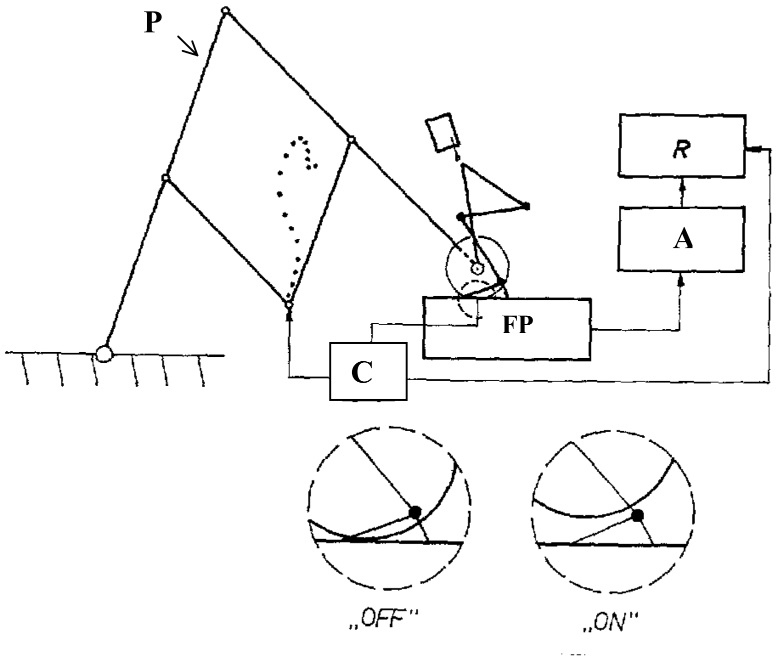

Fig. 2. Measuring system: P – pantograph, FP – force plate; A – amplifier; R – recorder; C – contactor; OFF – before barbell movement take-off; ON – beginning of measurement recording

Trajectory of the barbell was registered by a pantograph (Fig. 2) in a discrete way, with a scale of 1:2 and sampling frequency 50 Hz (Nawrat, Król 1989). Velocity of the barbell was calculated from its momentary positions by means of compensatory calculation, so called "weight average" (Morecki 1985). Measurements of the vertical component of ground reaction of the athlete-barbell system were performed by means of a force plate PD-6 (Fig. 2, made in Poland) with tensometric bridge TDA-6 (made in Czech Republic) and loop oscillograph H-120 (made in the Soviet Union). Sampling frequency amounted to 100 Hz. Taking advantage of proportional relationships between force values and mechanical strain of the platform with tensometric sensors, the linearity of strain vs. stress was determined. It was checked before each measurement and again after its completion. Error of a dynamographic method was evaluated at the level of 5-8% (Nawrat, Król 1989).

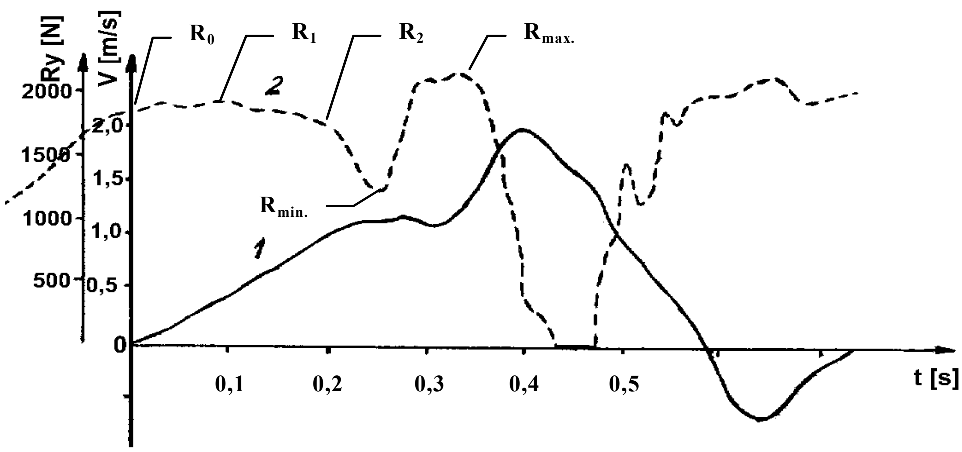

Fig. 3. Vertical velocity of the barbell (solid line) and vertical ground reaction forces of the athlete-barbell system (broken line) time history

An example of barbell vertical velocity $V_y(t)$ and vertical component of GRF of the athlete-barbell system R_y (t) is presented in Figure 3. The barbell velocity in the moment of maximal value (V_{max}) was correlated with ground reaction forces registered in chosen intervals (Fig. 3) using the STATISTICA PL program (Stanisz 1998).

Results and discussion

It was determined that the correlation was statistically significant between maximum vertical velocity of the barbell (V_{max}) and ground reaction forces (expressed in percent of the weight of athlete-barbell system) registered in chosen moments: R_0 – in moment of the barbell take-off, R_1 – at the beginning of the 2nd phase, R_2 – at the end of the 2nd phase, R_{min}. – during the knee bend phase, R_{max} – in the final phase of barbell acceleration (Tab. 2, Fig. 3).

Especially interesting is the negative correlation between maximal vertical velocity of the barbell (V_{max}) and ground reaction forces at the beginning of the "knee bend phase" (R_2).

It should be noted that ground reaction force is the answer for the weight of the barbell, the athlete and the inertial forces, caused by movement of particular parts of the system. While the barbell movement (from the moment of take-off from the ground till its maximal height) is performed in upwards direction, so the movements of particular elements of athlete's body during "the knee bend phase" (phase 3, Fig. 1) are performed partially upwards (body, upper limbs and head) and partially downwards (lower limbs) (Frolov 1976, Vorobiev 1977).

Sudden extension in the hip joints causes a flexion in knee and ankle joints. When in phase 2 (initial phase of acceleration) the barbell is lifted in effect of work of muscles extending the lower limbs joints, then in phase 3 (knee bend) the trunk is included to the performance. According to Roman (1986) "*in effect of body movement and extension in the hip joints the pressure on the opposite side grows extremely. It causes the flexion of lower limbs in knee joints and translation of them forward, under the barbell*". Such an activity decreases the value of moment of loosing equilibrium, caused by the barbell and upper body parts weight forces and creates more efficient conditions for the work of dorsal muscles and extensors of hip joints.

It was confirmed by Baumann (1988), who showed that great trunk inclination at the end of the initial acceleration phase (phase 2) causes significant moments of force (torque) in hip joints (Baumann 1988). It "forces" athletes to take a more comfortable position, where moments of force in hip joints will be smaller. It can be achieved, with stable athletes' body and barbell weight during lifting, only by decrease of the force arm. "*Regrouping*" of elements during phase 3 will reflect in movement flow of the barbell (its velocity decreases).

The above-mentioned negative correlation between maximal vertical velocity of the barbell and GRF at the beginning of the "knee bend phase" may be caused by fact, that the phase of "final acceleration" (phase 4) is a kind of correction of barbell movement. If its velocity, at the moment of the end of phase 3 ("beginning of the acceleration phase"), is high, and the barbell achieved the proper height, in case of an optimal knee bend, there is no need to increase the velocity of the barbell.

Table 2

The correlation coefficients between maximal vertical velocity of the barbell (V_{max}) and the strength of ground reaction forces of athlete-device system in chosen time moments (R_0, R_1, R_2, R_{min} and R_{max})

Barbell velocity [m/s]			Ground reaction force [%]				
	V_1	V_{min}	R_0	R_1	R_2	R_{min}	R_{max}
V max	- 0,0361	0,0840	0,5763	0,5326	- 0,3492	0,3239	0,3747
	N = 54	N = 54	N = 54	N = 54	N = 45	N = 54	N = 54
	p = 0,976	p = 0,546	p = 0,000	p = 0,000	p = 0,019	p = 0,017	p = 0,005

There are many snatch performance techniques. Many athletes apply great forces on the barbell in the initial phase (for instance athlete P.P. or Shalamanov in Baumann 1988), while others begin the movement slower and from the "knee bend" phase started to increase the power (athlete J.P.)

The performed statistical analysis between basic barbell movements parameters, as maximal vertical velocity of the barbell and ground reaction forces of the athlete-barbell system in chosen time moments showed significant relationships. It seems, that in situation, when from the objective reasons (costs, external circumstances and others), there is no possibility to register simultaneously the barbell movements and ground reaction forces. It is possible to "conclude" indirectly about the flow of chosen variables on the basis of information acquired with the use of the second method.

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