EFFECTS OF THE CYCLOERGOMETER EXERCISES ON POWER AND JUMPING ABILITY MEASURED DURING JUMPS PERFORMED ON A DYNAMOMETRIC PLATFORM

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ABSTRACT: The aim of this work was the determination of the cycloergometer exercises influence on the lower limbs power changes and height of rise of the body mass centre, measured in CMJ (counter movement jump) and performed on a dynamometric platform. Forty-three students of the University of Physical Education took part in the study. They were divided into 4 groups. The cycloergometer training encompassed 5 intermittent efforts parted by 2min intervals. Students performed: group M10 – maximal efforts with the load equal 10% of body mass; group M5 – maximal efforts with the load of 5% body mass; group W80 – 3min efforts with the power of 250 W, singular effort work equal 45 kJ, pedalling rate – 80 rpm; group W45 – 3min efforts with the power of 250 W, individual effort work equal 45 kJ, pedalling rate of 45 rpm. The control measurements of lower extremities power and the height of rise of the body mass centre in CMJ jumps on the dynamometric platform, were taken every Monday: before training (0), during 4 weeks of training (1-4) and for 2 weeks after it (5-6). Four week training elicited in groups M10, M5, W45 and W45 significant increase of the maximal (except group W45 where it was unimportant) and average power and, decrease of the height of the body mass centre lift in CMJ jump: crucial in groups W45 (-4.7%) and W80 (-4.7%) and not important in M10 (-3.4%). The height of rise of the body mass centre insignificant increase in group M5 (2.1%) after 4 week training.

KEY WORDS: cycle ergometer training, CMJ, height of jump, power output

INTRODUCTION

Muscle changes elicited by training depend on its kind and structure [1]. The endurance test effects in adaptations in the aerobic metabolism (activity of the aerobic changes enzymes, oxygen intake) [20], while the speed test causes the growth of the anaerobic metabolism enzymes activity [7,25,30] and the increase of the energetic substrates amount in muscles [6,30,36]. The metabolic mechanism explaining the growth of maximal power during short, maximal efforts is not fully recognised [25]. In works of Rehunen et al. [29] and Thorstensson et al. [36] the sprint training did not cause changes in the resting levels of high-energy phosphates (adenosine triphosphate – ATP and – PCr) in muscles although, Thorstensson et al. [36] observed significant increase of the isometric strength and CMJ jump height after 8 week sprint training. The effect of sprint training on power is not univocal. Allemeier et al. [2], Esbjörnsson et al. [11], Esbjörnsson Liljedahl et al. [12], Jacobs et al. [22] and Rodas et al. [31] stated that the sprint training realised on the cycloergometer did not cause significant changes of power output measured by the Wingate test and/or calculated from the force-velocity (F-v) and power-velocity (P-v) characteristics. In works of Linossier et al. [25,26,27], Parry et al. [28], Simoneau et al. [32,33] and Stathisa et al. [35] the sprint training on the cycloergometer elicited the growth of the maximal power and the amount of performed work in the Wingate test – 10 lasting for 90 s maximal efforts and calculated from F-v and P-v characteristics. On the other hand, in work of Fidelus et al. [13] the growth of muscle torque and the power loos during maximal jump on the inclined plane was noticed after 4 week speed training.

Changes of lower limb power and height of rise of the body mass centre under the influence of training performed on the cycloergometer are not widely described in references. Only in few of works it is possible to find some significant dependences between the maximal power produced on the cycloergometer and lower extremities power [8,9] and the height of rise of the body mass centre measured in CMJ [38] and SJ jumps [19]. Namely, it might be expected that if the maximal power, calculated from F-v and P-v dependences, grows after the cycloergometer training (Wingate test) than the maximal power measured on the dynamometric platform also should be growing.

The aim of this work was the determination of the cycloergometer exercises effect on the lower limbs power changes and height of rise of the body mass centre measured in CMJ (counter movement jump) and performed on the dynamometric platform.

MATERIALS AND METHODS

Research materials: Forty-three non-athletes, students of the Academy of Physical Education took part in the study. They were divided into 4 groups performing exercises on the cycloergometer: group M10 (n=9) – maximal efforts with load equal 10% of body weight (BW); group M5 (n=11) – maximal efforts with load equal 5% of BW; group W80 (n=11)- 3min efforts with power of 250 W and pedalling rate equal 80 rpm; group W45 (n=12) – 3min efforts with power of 250 W and pedalling rate of 45 rpm. Examined subjects characteristics are presented in Table 1. As regards an anthropometric features groups did not differ significantly.

TABLE 1. EXAMINED GROUPS CHARACTERISTICS (AVERAGES ±SD)

	Age (years)	Body height (cm)	Body mass (kg)
M10 (n=9)	22.2±1.8	178.1±6.5	77.8±10.5
M5 (n=11)	22.5±0.9	180.7±7.6	78.0±11.1
W80 (n=11)	23.3±1.1	182.8±7.9	80.3±12.1
W45 (n=12)	22.7±1.4	182.1±6.5	79.7±9.6

Training consisting of maximal efforts with loads: 10% BW – group M10 and 5% BW – group M5; training realised in 3min efforts with the power of 250 W and pedalling rates: 80 rpm – group W80 and 45 rpm group – W45;

The Scientific Research Board of Ethics accepted this research. Examined subjects were informed about the aim and methodology of the study. They were also informed about the possibility of the immediate resignation on every level of the experiment. Examined students accepted the above conditions in written. All measurements were conducted in mornings.

Experiment: Examined students acknowledged all measurements and performed the Wingate test on the Monark 824E (Sweden) cycloergometer according to the standard methodology described in the work of Inbar et al. [21].

In a period of one month all groups performed trainings 4 times a week. They did it on the Monark 824E (Sweden) cycloergometer joined with the computer with "MCE v. 4.0 software ("JBA" Z. Staniak, Poland). Subjects conducted the test and trainings using maximal efforts, in sitting position, not standing on pedals and beginning motionless. Feet were fastened to pedals with straps. Students were spurred to reach the maximal speed as fast as they could and keep it until the end of the test. In case of 3min efforts with power of 250 W the task was to keep constant pedalling rate. Measurements and calculations of: the maximal power, amount of performed work as well as the work and rest periods were done using the "MCE" software. The singular training encompassed:

- Group M10 – 5 maximal efforts: in the first they performed 100% of work determined earlier in the Wingate test (19.36±2.58 kJ) and in the other 4 tests – 50% of the above work (10% of body weight loaded). Efforts were divided by 2 min intervals.
- Group M5 – 5 maximal efforts: in the first they performed 100% of work determined earlier in the Wingate test (19.16±2.30 kJ) and in the other 4 tests – 50% of the above work (5% of body weight loaded). Efforts were divided by 2 min intervals.
- Group W80 – five lasting for 3min efforts with power of 250 W and work of 45 kJ (pedalling rate of 80 rpm, load of 31.0 N hanged on the cycloergometer scale). Efforts were divided by 2 min intervals.
- Group W45 – five lasting for 3min efforts with power 250 W and work of 45 kJ (pedalling rate of 45 rpm, load of 55.0 N hanged on the cycloergometer scale). Efforts were divided by 2 min intervals.

Examined students performed any additional training and used no feeding supplementation throughout the experiment.

Control measurements of lower extremities power and the height of rise of the body mass centre in CMJ jumps on the dynamometric platform were taken every Monday: before trainings (0), during 4 week training (1-4) and for 2 weeks after it (5-6).

Measurement of the lower limbs power and height of rise of the body mass centre on a dynamometric platform: The measurement of the lower limbs power and height of rise of the body mass centre in CMJ (counter movement jump) was done on the dynamometric platform equipped with Kistler Instrumente AG Winterthur Switzerland amplifier (type 9865 B 1 Y28). It was joined by the analogous-digital converter with IBM PC P100 and "MVJ v. 1.0" software ("JBA" Z. Staniak, Poland). Following jumping parameters were calculated according to the measured: maximal power (Pmax) and mean power (Pm), maximal height of rise of the body mass centre (h) and lowering (l) of the body mass centre before the jump [5,34]. Every examined subject performed 2 vertical jumps from the straight position and prefaced by the downward movement of body (CMJ). The resting interval between jumps lasted for 3 min. Jumps with the highest height of rise of the body mass centre were analysed.

As for the experiment results comparison the AVOVA analysis of variance with repeated measurements was applied. The significance of the averages difference was evaluated post hoc – using the LSD test (least significant difference test). The degree of the dependence between values of the lower limbs and height of the body mass centre lift and the body mass itself was estimated basing on the Pearson's correlation coefficients. All calculations were done with the use of the STATISTICA (v.5.5, StatSoft, USA).

RESULTS

Research results (averages±SD) are presented in Tables 2-3. Trainings performed on the cycloergometer elicited the significant growth of the maximal power in groups M10, M5 and W80 and unimportant

TABLE 2. AVERAGE VALUES (±SD) OF MAXIMAL POWER (Pmax) IN THE CMJ JUMP AND THE SIGNIFICANCE OF AVERAGE DIFFERENCES BETWEEN MEASUREMENT TAKEN BEFORE EXAMINATION (0) AND FOLLOWING ONES: (1-4) – 4 WEEK TRAINING, (5-6) 2 WEEK AFTER TRAINING PERIOD (*P<0.05)

Variable		0	1	2	3	4	5	6
Pmax (W)	M10	2329.0	2278.6	2267.0	2298.0	2375.8	2491.1*	2349.4
		±555.6	±457.4	±497.8	±369.5	±496.4	±501.6	±466.4
	M5	2571.7	2420.9	2640.4	2674.2	2814.3*	2572.0#	2588.1#
		±487.3	±490.4	±472.9	±500.1	±634.9	±453.4	±375.2
	W80	2514.5	2606.0	2592.9	2649.5	2745.2*	2845.6*	2640.0◊
		±386.2	±317.9	±359.8	±368.1	±428.8	±463.8	±391.4
	W45	2483.7	2441.2	2668.8	2553.6	2512.3	2584.2	2449.4
		±577.9	±584.7	±675.2	±577.3	±551.8	±532.7	±591.7
Pm/mass (W/kg)	M10	30.99	30.06	29.92	30.39	31.23	32.95	30.96
		±6.83	±5.19	±5.36	±3.90	±4.90	±6.01	±5.09
	M5	33.96	32.21	34.90	35.33	37.09*[a]	34.10#	34.29#
		±5.01	±5.92	±5.30	±5.97	±6.99	±5.88	±5.27
	W80	31.66	32.71	33.43	33.69	34.95*	36.07*	33.74
		±4.98	±3.03	±5.80	±4.93	±5.68	±5.02	±4.75
	W45	31.28	30.71	33.96	32.32	32.03	33.08	31.17
		±6.68	±6.21	±6.87	±6.34	±6.47	±6.61	±7.11

Training encompassing maximal efforts with loads: 10% BW – group M10 and 5% BW – group M5; training performed in 3min efforts with the power of 250 W and pedalling rates: 80 rpm – group W80 and 45 rpm – group W45; # - averages differ significantly between 4th, 5th and 6th recording, ◊ - averages differ crucially between 5th and 6th measurement; M10 vs. M5, W80 and W45; a - p<0.05;

TABLE 3. AVERAGE VALUES (±SD) OF: MEAN POWER (Pm), HEIGHT OF RISE OF THE BODY MASS CENTRE (h) IN THE CMJ JUMP AND THE SIGNIFICANCE OF AVERAGE DIFFERENCES BETWEEN MEASUREMENT TAKEN BEFORE EXAMINATION (0) AND FOLLOWING ONES: (1-4) – 4 WEEK TRAINING, (5-6) 2 WEEK AFTER TRAINING PERIOD (*P<0.05)

Variable		0	1	2	3	4	5	6
Pm (W)	M10	1086.7	1018.3	1012.3	1050.0	1071.0	1122.4	1050.1
		±347.5	±262.2	±240.9	±205.3	±241.3	±241.5	±244.2
	M5	1161.2	1112.5	1215.0	1204.2	1282.6*	1169.0	1149.4#
		±237.3	±288.3	±322.2	±311.0	±359.0	±287.6	±277.8
	W80	1149.0	1151.3	1158.8	1130.5	1220.3	1251.7*	1198.8
		±285.8	±199.5	± 242.1	±238.4	±271.5	±293.9	±256.3
	W45	1101.9	1106.8	1176.8	1163.0	1142.1	1166.9	1119.1
		±259.7	±267.9	±294.0	±248.8	±245.3	±257.5	±272.9
Pm/mass (W/kg)	M10	14.38	13.50	13.42	13.90	14.03	14.85	13.80
		±3.88	±3.24	±3.04	±2.37	±2.31	±2.99	±2.67
	M5	15.36	14.76	16.05	15.88	16.87*	15.49#	15.16#
		±2.77	±3.34	±3.85	±3.85	±4.16	±3.71	±3.47
	W80	14.42	14.49	14.98	14.41	15.56	15.90*	15.31
		±3.30	±2.34	±3.63	±3.15	±3.65	±3.69	±3.06
	W45	13.93	13.90	15.18	14.71	14.55	14.91	14.20
		±3.41	±2.81	±3.26	±2.61	±2.71	±3.06	±3.14
h (m)	M10	0.461	0.456	0.452	0.444	0.445	0.445	0.446
		±0.062	±0.063	±0.067	±0.058	±0.075	±0.075	±0.057
	M5	0.458	0.452	0.463	0.455	0.461	0.468	0.455
		±0.039	±0.038	±0.036	±0.046	±0.048	±0.050	±0.038
	W80	0.477	0.448*	0.453*	0.447*	0.453*	0.467	0.451*◊
		±0.050	±0.036	±0.042	±0.044	±0.046	±0.036	±0.040
	W45	0.469	0.443*	0.461	0.451*	0.446*	0.457	0.451*
		±0.056	±0.050	±0.059	±0.064	±0.060	±0.070	±0.055

Training encompassing maximal efforts with loads: 10% BW – group M10 and 5% BW – group M5; training performed in 3min efforts with the power of 250 W and pedalling rates: 80 rpm – group W80 and 45 rpm – group W45; # - averages differ significantly between 4th, 5th and 6th recording, ◊ - averages differ crucially between 5th and 6th measurement;

in group W45 (Fig. 1). Subjects of the M10 group revealed essentially lower maximal power after 4 weeks of training in comparison to M5 group. It also caused the crucial increase of the mean power in groups M5 and W80 and insignificant in group M10 and W45 (Fig. 2). The height of rise of the body mass centre insignificant increase in group M5 (2.1%) and decrease significant in groups W45 (-4.7%) and W80 (-4.7%) and not important in M10 (-3.4%) after 4 week training (Fig. 3).

DISCUSSION

References present various results regarding changes of the power elicited by different types of trainings employing short efforts with the high intensity. In the work of Thorstensson et al. [36] the 8 week sprint training consisting of 5-s runs on a treadmill elicited the significant growth of the isometric strength of lower limbs, the anaerobic power measured with the Margarii test and the height of CMJ jump as well as the shortening of the 25 m run time. Häkkinen et al. [18] did not stated significant changes in the lower limbs extensors isometric strength (3.5%) and force-velocity characteristics measured in SJ, CMJ and DJ jumps (drop jump) in heavy-weight lifters after one year training. The height of rise of the body mass centre increased in the SJ jump for 9.2% and was statistically essential. In works of Fowler et al. [14] and Trzaskoma [37] the strength training enriched by maximal jumps on a pendulum swing elicited higher accession of the lower limbs power and height of rise of the body mass centre in CMJ jump as well as the smaller changes of the lower limbs muscle torque in comparison to regular trainings. Allemeier et al. [2], Esbjörnsson et al. [11], Esbjörnsson Liljedahl et al. [12], Jacobs et al. [22] and Rodas et al. [31] stated that the sprint training on the cycloergometer did not cause changes of power output measured in tests on this device. In the work of Parry et al. [28] any after-training changes of the power peak and average power measured in the Wingate test were observed in the group of subjects practising every day for 2 weeks. In the group having a 2-day brake after each training the power peak and average power in 30 s test grew over 20 and 14%. Linossier et al. [25,26,27], Stathisa et al. [35] noticed the growth of the maximal power and average power measured by the Wngate test and maximal power calculated from force-velocity (F-v) and power-velocity (P-v) characteristics after 7 week training with the use of short, highly intensified efforts on the cycloergometer. Basing on presented in works of Davies and Young [9], Davies et al. [8], Hautier et al. [19] and Vandewalle et al. [38] significant dependences between the lower limbs power, height of rise of the body mass centre in CMJ and SJ jumps and the lower limbs power measured on the cycloergometer in the Wingate test and calculated from F-v and P-v characteristics an assumption arisen that if the cycloergometer training causes the power increase than the power and the height of rise of the body mass centre measured in the vertical jump on the platform also should be growing. Our research results showed that the significant increase of the maximal power was observed in CMJ jump in group M5 (8.9%) after 4 week training and in group W80 (14.8%), M10 (8.9%)

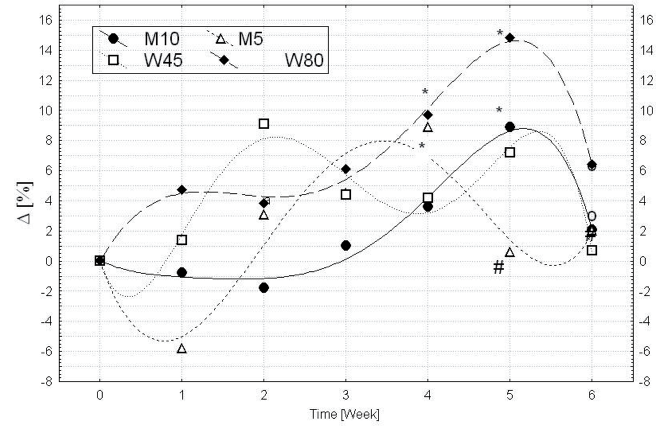

FIG. 1. AVERAGE VALUES (%) OF THE MAXIMAL POWER CHANGES (Pmax) PRODUCED IN CMJ JUMP AND COUNTED ACCORDING TO RECORDINGS TAKEN BEFORE TESTS – PRESENTED IN PERCENTS AS WELL THE SIGNIFICANCE OF AVERAGE DIFFERENCES BETWEEN THE MEASUREMENTS COLLECTED BEFORE THE EXPERIMENT (0) AND FOLLOWING ONES: (1-4) – 4 WEEK TRAINING, (5-6) – 2 WEEK RESTING PERIOD (*p<0.05); # - AVERAGES DIFFER SIGNIFICANTLY BETWEEN 4TH, 5TH AND 6TH RECORDING;

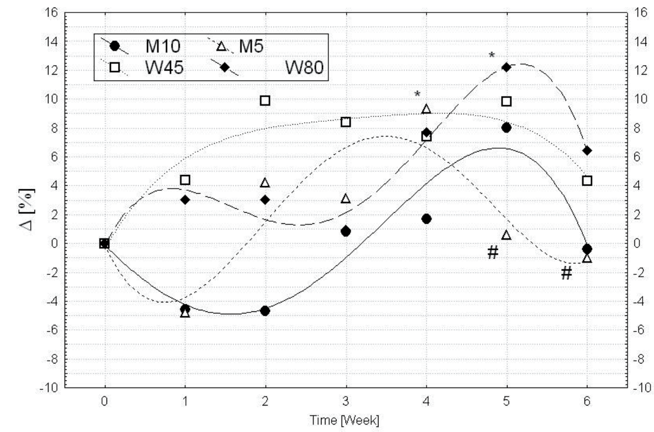

FIG. 2. AVERAGE VALUES (%) OF THE MEAN POWER CHANGES (PM) DEVELOPED DURING CMJ JUMP AND CALCULATED REGARDING THE MEASUREMENT GATHERED BEFORE EXAMINATIONS – PRESENTED IN PERCENTS LIKEWISE THE IMPORTANCE OF AVERAGE DIFFERENCES BETWEEN RECORDING TAKEN BEFORE TRAINING (0) AND FOLLOWING ONES: (1-4) – 4 WEEK TRAINING, (5-6) – 2 WEEK AFTER TEST PERIOD (*p<0.05); # - AVERAGES DIFFER SIGNIFICANTLY BETWEEN 4TH, 5TH AND 6TH RECORDING;

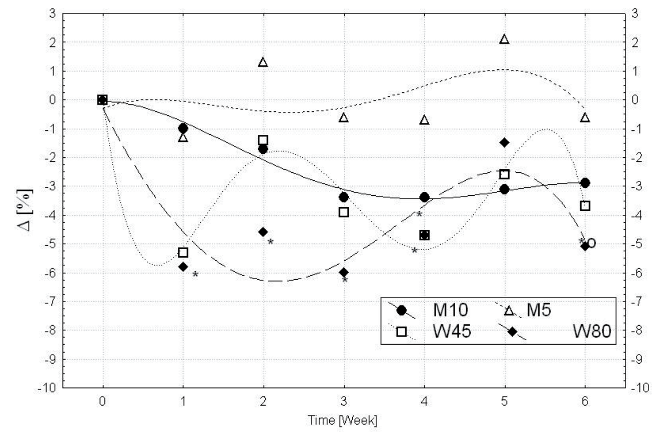

FIG. 3. AVERAGE VALUES (%) OF THE HEIGHT OF RISE OF THE BODY MASS CENTRE CHANGE (H) IN CMJ JUMP COUNTED ACCORDING TO MENSURATION COLLECTED BEFORE TESTS – EXPRESSED BY PERCENTS AND THE SIGNIFICANCE OF AVERAGE DIFFERENCES BETWEEN THE MEASUREMENT GATHERED BEFORE THE RESEARCH (0) AND FURTHER MENSURATIONS: (1-4) – 4 WEEK PRACTICE, (5-6) – 2 WEEK RESTING TIME (*p<0.05);

and W45 (7.2% - insignificant) in the first week from it. The mean power grew after the first week of resting in groups M10, M5, W45 and W80 for 8.0, 11.5, 7.4 and 9.7% respectively. The height of rise of the body mass centre fell insignificantly in group M10 (-3.4%) and crucially in groups W45 (-4.7%) and W80 (-4.7%). The unimportant growth for 2.1% occurred in group M5.

The influence of many factors on values of power obtained in the vertical jump was searched in many works. Among them were jump kind [5,23] and connected with it spar amount before jump [4,15,24] or chosen anthropometric traits [10,16]. Bartosiewicz et al. [4] showed that the height reached in the spared jump (CMJ) does not depend on the spar amplitude (in some range I) and that the maximal mechanical power values are decreasing along with the spar ampleness. Harley and Doust [17] stated that the maximal angle of the knee joint deflection effects the power value. It was proved that too big spar diminishes the power [4] although, it does not have to influence negatively on the jump height [24]. In the work of Gajewski and Wit [16] the maximal power correlated significantly with the jump height (r=0.51 and r=-0.63) in the female group of subjects. In our researches, the crucial dependence between the maximal power and the height of the body mass centre lift measured in CMJ (r=0.63-0.95) jumps was noticed in groups M10 and W45 and the lack of such a connection in groups M5 and W80. These results are coherent with results attained by Bartosiewicz and Wit [3] who stated unsystematic occurrence of correlation between the height of the body mass centre lift and the maximal power measured in various sport disciplines athletes.

CONCLUSIONS

1. Four week training elicited in all groups significant increase of the maximal power (except group W45 where it was unimportant).
2. Training consisting of efforts with power of 250 W performed with the pedalling rate of 80 rpm elicited the highest power accretion after 4 week training and first week from tests.
3. Training on the cycloergometer realised in 3min efforts with the power of 250 W elicited significant lowering of jumping ability measured by the height of rise of the body mass centre in CMJ jump, regardless of the pedalling rate.
4. The cycloergometer training engendered lower lifting of the body mass centre in CMJ jump in all groups (with except W5 group) although, the produced maximal (M10, M5, W80) and average (M5, W80) power significantly grew.
5. In most analysed cases the differences between groups were insignificant.

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