

The influence of a four-week training on an inclined plane on the isokinetic knee power

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The aim of this study was to compare the changes in the power of knee flexors and extensors being the effect of two trainings with different structure of load. The effort depended on performing 40 repetitions in 4 series (group A) as well as 40 repetition in 1 run (group B). The power was estimated based on the value obtained under isokinetic conditions.

1. Introduction

A good choice and control of training loads are possible only if the mechanical factors of a given exercise are known. In most disciplines and events, satisfactory results depend on the important role played by different forms of power. In training practice, power is understood as the ability to overcome resistance at the highest possible velocity. Power is the most versatile factor describing exercise, because it contains information about time, distance, force and velocity of movement and human physical ability in the form of strength, speed and also endurance (as function of time) [7], [13].

In the experiment, all the participants performed a series of take-offs on an inclined plane. Plyometric training (explosive force exercises) develops fast muscle fibres. It is related to the fact that a contraction is greater directly after the stretching of the same muscles. Plyometrics is a form of training, combining speed and strength to create faster motion in many specific movements. Plyometric training is being used in exercises of lower body [1], [8], upper body [10] and trunk [9]. This kind of training can help athletes to improve their coordination, speed, agility, velocity of movement and power. Plyometrics uses elastic energy being stored by muscles during stretching. Because of this energy, stretching–contraction cycle shortens and all mechanisms using elastic energy accumulated in kinetic apparatus get improved, resulting in much higher power [6], [11], [12].

After the analysis of bibliography one can ascertain that intensive anaerobic training of large muscle groups lasting for 4 weeks, with 5 sessions per week, is enough to estimate the training cumulative effects.

The aim of the study was to compare the changes in the power of a knee joint flexors and extensors as a result of training programs consisting of two differently structured workloads. In the study, every single training unit consisted of the same number of repetitions and rounds, but different times of rest. Power values were tested in isokinetic conditions.

2. Material and methods

Twenty-six students of the University of Physical Education in Warsaw took part in the study (aged 22 ± 2 , mean body mass of 79 ± 8 kg, height of 181 ± 6 cm). In the period preceding the research, during the research and two weeks after the study, students neither practiced any sport nor participated in any other research or any form of physical training. Students were divided into two groups (thirteen students in each group). Each group comprised the students of a similar body mass and strength ability in lower extremities.

Power measurements under isokinetics conditions took place on "Biodex 3" device. Subject, in a sitting position, was flexing and extending his knee with a maximum force, pulling the testing device lever attached to his shank. Movement range was 90 deg, from flexed knee (90 deg) to full extension (180 deg). Four different velocities, i.e., 240 deg/sec, 180 deg/sec, 60 deg/sec, and 30 deg/sec, were used for power measurements. The intervals between each measurement lasted for 15 sec each.

The experiment lasted 7 weeks. During four weeks the subjects took part in the training on inclined plane, with five sessions per week (Monday to Friday). Every Monday, before the training session, power levels were measured under isokinetic conditions. The above factors were measured four times in the post-training period again.

The exercise consisted of a series of thrusts on an inclined plane. Subject was taking off with a maximum force from the dynamometric platform. Two groups of the same number of take-offs in a single training unit were formed, but their training intensity was different. Over the four-week training period every student performed the same workload of 800 take-offs. The intensity of exercise was different for each group. Group B performed a continuous training of 40 take-offs in one round, while group A – 40 take-offs in 4 rounds with 90-second intervals between rounds.

Non-parametric analysis of variances for relative data (Friedman's ANOVA) was used to evaluate power level and parameter changes in each group in subsequent weeks. The probability level $p < 0.05$ was used as critical for the dependence evaluation.

3. Results

During the whole training period the students in group A, training with 90 sec intervals between rounds, accomplished higher average work value of take-offs (881 ± 94 J) and restraining (632 ± 77 J) than the subjects in group B (respectively 779 ± 80 J and 570 ± 65 J). The differences in the values of take-offs and restraining work were significant for both groups, i.e., on the level of $p < 0.05$. Similar differences in the value of the take-off achieved and restraining power were relevant for both groups ($p < 0.05$). During a given workout the individuals in group A achieved average take-off maximum power (peak power) of 3860 ± 536 W by about 20% higher than that in group B (3226 ± 332 W). To a large extent, maximum power informs us about the motion dynamics. Work and power values of both take-off and restraining increased critically ($p < 0.001$) during the whole training.

Weekly control tests, carried out on “Biodex 3” system device, allowed the power value changes during the whole experiment to be evaluated. At the angular velocities analyzed no significant changes were found during the progress of the experiment in each of the movements tested. Power values for flexing in knee joint were significantly lower ($p < 0.001$) than these for extending in the same joint. In the velocity range applied, at the higher angular velocity the higher power was achieved. Average values of extending and flexing power in the consecutive days of tests are shown in the table.

Table. Average values of extending and flexing power achieved at given angular velocities under isokinetic conditions over consecutive days of test

Days	Extensors (group A)				Extensors (group B)				Flexors (group A)				Flexors (group B)			
	240	180	60	30	240	180	60	30	240	180	60	30	240	180	60	30
1	564 ± 145	519 ± 100	263 ± 46	138 ± 23	578 ± 84	514 ± 51	253 ± 29	135 ± 19	310 ± 70	278 ± 98	138 ± 25	72 ± 16	282 ± 68	254 ± 53	114 ± 23	70 ± 11
8	552 ± 128	483 ± 106	227 ± 46	121 ± 23	509 ± 115	470 ± 87	216 ± 35	118 ± 16	343 ± 83	309 ± 63	124 ± 28	69 ± 10	314 ± 65	286 ± 49	131 ± 18	70 ± 8
15	566 ± 115	491 ± 100	223 ± 42	123 ± 21	527 ± 108	463 ± 96	227 ± 33	117 ± 16	369 ± 68	311 ± 67	125 ± 20	69 ± 9	359 ± 48	296 ± 47	132 ± 17	71 ± 11
22	563 ± 125	477 ± 85	226 ± 41	117 ± 19	533 ± 113	451 ± 98	216 ± 32	115 ± 20	377 ± 73	315 ± 59	128 ± 24	71 ± 11	353 ± 83	289 ± 75	129 ± 21	68 ± 16
30	561 ± 112	466 ± 101	214 ± 49	114 ± 21	510 ± 107	430 ± 79	211 ± 36	114 ± 20	373 ± 63	304 ± 53	126 ± 24	68 ± 13	365 ± 66	291 ± 68	131 ± 22	72 ± 15
36	572 ± 110	461 ± 96	220 ± 39	115 ± 26	521 ± 61	433 ± 49	202 ± 32	109 ± 13	388 ± 73	308 ± 39	132 ± 16	68 ± 8	357 ± 56	283 ± 30	115 ± 12	63 ± 10
43	582 ± 111	463 ± 77	225 ± 46	119 ± 26	531 ± 98	445 ± 88	208 ± 37	114 ± 20	383 ± 89	303 ± 64	125 ± 25	71 ± 12	333 ± 75	270 ± 54	121 ± 23	61 ± 11

At the angular velocities of 240 [deg/sec] and 180 [deg/sec] the power of knee joint extensors and flexors had significantly higher ($p < 0.05$) values in consecutive test

days in the group doing a workout divided into rounds in comparison to the group doing continuous exercises. During trials at two lower velocities no differences in groups were noted.

Due to the fact that no significant changes in the power values were noted at given angular velocities the attempt was made to specify theoretically characteristics of these changes at higher velocities, and also to find the point at which power reaches its maximum value. Power values at all velocities achieved in given test days are placed along parabola, described by a second-order polynomial equation as follows:

$$y = ax^2 + bx + c,$$

where y is the power value, and x is an angular velocity value.

If we assume that the curve described is a trend line, it can be possible to predict the power change characteristics in relation to velocity and to calculate the maximum point of parabola: $x_{P_{\max}} = -b/2a$ and the value of this maximum: $y(x_{P_{\max}}) = ax_{P_{\max}}^2 + bx_{P_{\max}} + c$.

There are the graphs that show the power values as points at all velocities in consecutive days of test, with trend lines representing those points.

Figure 1 shows an average power of knee joint extensors relative to angular velocities for group A. The power values represented by the trend line show the tendency to achieve ever-increasing values in consecutive days of the test. As during training the predicted values rise slighter than in the rest period (between the 29th–43rd days), they achieve significantly higher values than before training.

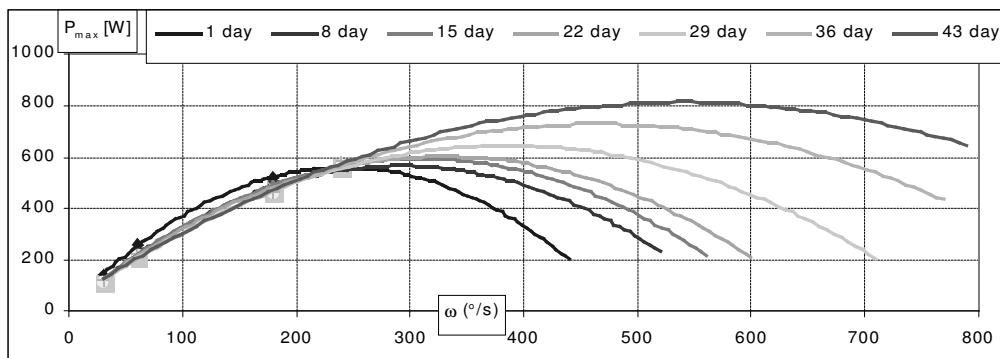


Fig. 1. The estimation of the maximal power changes relative to predicted angular velocities during extending in group A

Maximum values would have been achieved at the ever-increasing angular velocities. Average results achieved by group B do not show any tendency to increase (figure 2). In consecutive days of the test, the maximum of power values at four angular velocities analyzed appear to be on a similar level.

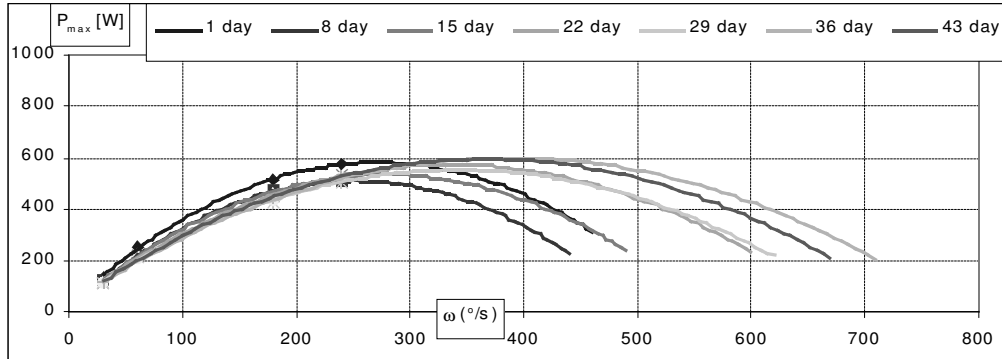


Fig. 2. The estimation of the maximal power changes relative to predicted angular velocities during extending in group B

Figure 3 shows the expected changes in the power value in knee joint flexors for group A. As in the tests on extensors, there is a slight tendency towards higher power values in consecutive days of the test. Again there is a tendency to achieve P_{max} at ever-increasing velocities. Similar effects can be observed in group B, but maximal power appears on the 29th and 36th days of the experiment (figure 4).

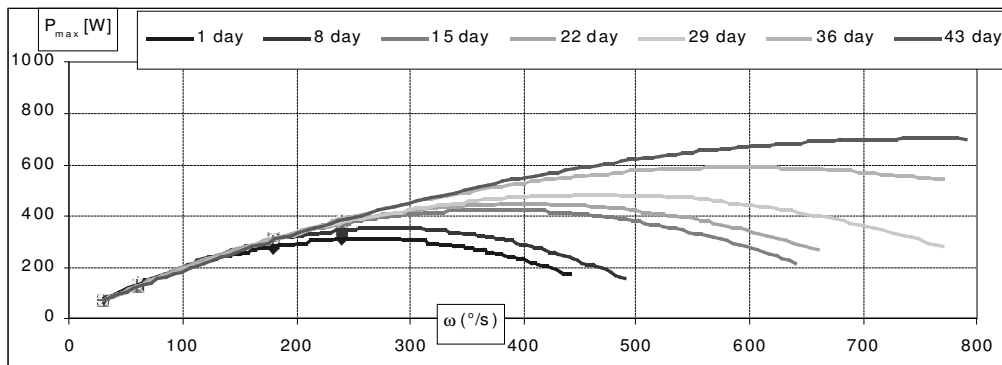


Fig. 3. The estimation of the maximal power changes relative to predicted angular velocities during flexing in group A

In measurements carried out before training and after the first week of training, the maximum power of extensors and flexors in both groups tested appeared at similar angular velocities of 243–292 [deg/sec]. Since the second week of training, the maximum power achieved for flexors occurred at higher velocities, while for extensors this increase in power was less apparent. In group A, the trend of rising velocity was constant throughout the experiment, while in group B one week after the

end of training, the velocity necessary for achieving the maximum power was getting lower.

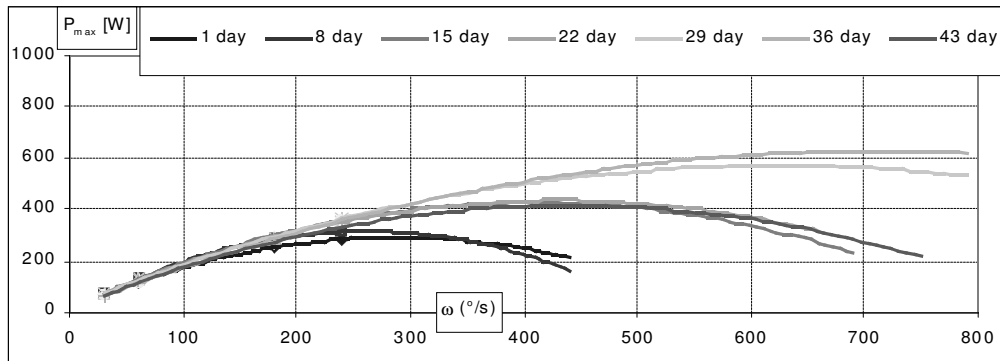


Fig. 4. The estimation of the maximal power changes relative to predicted angular velocities during flexing in group B

4. Summary

The results of this survey did not confirm any significant rise in power value for knee joint extensors and flexors measured under conditions of isokinetics at four given angular velocities. A parabolic curve of trend, along which a position of the maximal point can be established, confirms characteristics of the power changes. In order to use the equation that represents the results, one can find that during the whole experiment the power values of knee joint extensors in group A had a tendency to achieve higher power values and maximum at higher angular velocities. An increase in the power value was not observed in group B, but the point representing its maximum value appeared to be shifted towards higher velocities.

The power achieved by flexors also has the tendency to rise over the subsequent days of the test in both groups. Also, in both the cases the shift of the maximum points towards higher velocities could be observed. It is worth mentioning that in group A an anticipated maximum power of knee joint extensors and flexors rises significantly after the end of training. In group B, the maximum power occurs one week after the end of training, and then assumes a declining trend. Higher anticipated values of maximum power confirm that the training workload divided into series contributed to an increase in both velocity and motion dynamics. This dependence is corroborated by relevantly higher power values in this survey group, being revealed only in connection with two higher control velocities.

Lack of a distinct increase in power in consecutive days could be explained by the fact that knee joint extensors are that group of muscles that slowly reacts to training

loads. Similar conclusions were drawn, among others, by URBANIK [13], who found that after four-week training on an inclined plane, knee joint extensors were the group of muscles characterized by the slowest reaction to training. In the series of studies, FIDELUS [2]–[5] described different kinds of training lasting for 4–6 weeks. Irrespective of the type of muscle work, in high-load exercises of lower extremities, the highest increase was noted for hip joint extensors, and the smallest – for knee joint extensors.

The rest intervals in a given workload meant that students in these tests were able to do subsequent rounds with a similar high intensity manifested itself in a higher power achieved. Significantly higher average power values achieved during training were transposed into higher maximum power anticipated under isokinetic conditions.

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