COMPARISON OF DIFFERENT STRENGTH TRAININGS METHODS FOR THE DEVELOPMENT OF POWER

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The purpose of this study was to identify the effect of three different training methods for increasing power output of the leg extension chain. Therefore three groups had to go through an eight week training program. One of the three groups had to perform counter movement jumps (CMJ) twice a week (group J) while the second group had to do two sessions with parallel squats every week. The third group (J + S) had to do the CMJs as well as the parallel squats twice a week. After the training period SJ and CMJ significantly increased in all experimental groups. No significant changes were found in the control group. Group J received an 8,8% increase in the SJ and an 8,9% increase in the CMJ while group S was able to enhance their jumping performance by 12,6% (SJ) and 11,8% (CMJ). Group J + S showed the biggest improvement by 15,5% in the SJ and 14,7% in the CMJ. The only significant difference between the three groups was found between group J and J + S in both testing conditions.

KEY WORDS: strength training, power, stretch-shortening-cycle.

INTRODUCTION: In a lot of sports beside absolute strength, power is one of the most decisive factors for high performance. Controversy exists about the best way to develop power. Absolute strength is one of the most important basic components. On the other hand intermuscular coordination plays a major role in movements with high joint velocities. Aim of the study was (and still is, cause six more training groups will follow) to analyse the effect of different training methods on the development of power. For the detection of changes in power output of the leg extension chain we used the Squat Jump (SJ) and the Counter Movement Jump (CMJ).

METHOD:

Data Collection: 108 physical education students volunteered in this investigation. They were divided in a control and three experimental groups (n = 27). Cause of different reason not all subject finished the study. The three experimental groups had to go through an eight week strength training program. The first group only performed counter-movement-jumps twice a week (group J), the second had to do parallel squats twice a week (group S) and the third group had to perform counter-movement-jumps as well as parallel squats twice a week (group J+S).

Table 1: Means and standard deviation of the anthroprometrical data of the control and the three experimental groups

group	n	Age	hight (cm)	weight (kg)
C	27	24,2 ± 2,6	177,8 ± 7,3	72,9 ± 11,2
J	20	23,0 ± 1,8	178,0 ± 11,2	74,5 ± 12,2
S	19	24,0 ± 2,1	179,3 ± 12,0	77,4 ± 14,9
J + S	24	23,2 ± 2,6	177,4 ± 7,1	76,0 ± 11,2

Group J and group J+S had to do 5 x 6 jumps with a five minute rest period between the sets. Group S and group J+S had to go through a periodized strength training program including parallel squats in the following manner:

- week 1 – 3: five sets of ten repetitions with a restinterval of five minutes
- week 4 – 6: five sets of six repetitions with a restinterval of five minutes
- week 7 – 8: five sets of three repetitions with a restinterval of five minutes

Every set was performed with maximal possible load on the condition of doing the squat with a good technique. The groups (J, S) with two workouts per week exercised on Monday and Thursday or on Tuesday and Friday. Group J+S had to do the workouts including jumps on Monday and Thursday and the parallel squats on Tuesday and Friday. The jumps were done on the day before the heavy strength training session to guarantee lowest possible fatigue. Before and after the eight week training period squat-jumps (SJ) and counter-movement-jumps (CMJ) were tested for maximal hight of center of gravity (COG).

Data Analysis: Normal distribution was tested with the Shapiro-Wilks-Test and homogeneity of variance with the Levene-Test. For the comparison between pre- and post-Test and between the three training groups and the control group an analyse of variance with repeated measures and the Scheffé-test ($p < 0,05$) as a post-hoc test was used.

RESULTS: No significant changes were found in the control group while all experimental groups showed significant gains in hight of COG height in both testing conditions. The changes of jumping performance in all three experimental groups differed significantly from the results of the control group. The analysis of group differences for the experimental groups showed only for group J and group J + S a significant difference in the SJ and the CMJ.

Table 2: Means and standard deviation of CMJ and SJ at the pre- and post-tests of the experimental group; * = significantly different from pre-test

	CMJ		SJ	
Group	**T1 (cm)**	**T2 (cm)**	**T1 (cm)**	**T2 (cm)**
J	37,1 ± 5,7*	40,3 ± 6,4*	34,2 ± 5,0*	37,1 ± 6,2*
S	34,7 ± 5,2*	38,7 ± 5,9*	32,0 ± 4,8*	35,9 ± 4,9*
J + S	38,3 ± 6,2*	43,6 ± 5,6*	34,9 ± 5,5*	39,9 ± 5,0*

Group J only exercising the CMJ´s increased their SJ height of COG by 8,8 % an the CMJ by 8,9 %. Just performing heavy parallel squats let to an improvement of 12,6 % in the SJ and 11,8 % in the CMJ. Group J + S, training the CMJ and using heavy parallel squats for maximal strength development, showed the biggest increase in SJ (15,5 %) an CMJ (14,7 %).

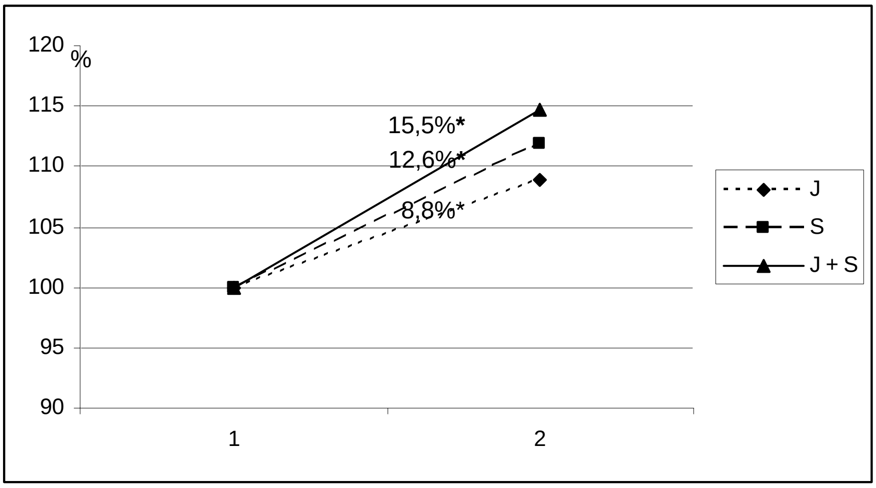

Figure 1: Mean percentage gains in squat-jump of the three experimental groups

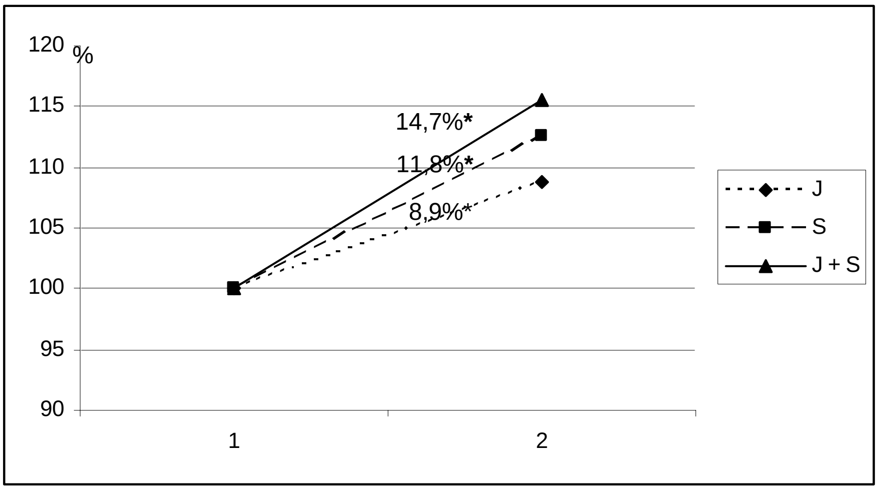

Figure 2: Mean percentage gains in counter-movement-jump of the three experimental groups

DISCUSSION: The results of the three experimental groups show that the power of the leg extension chain, tested with the CMJ and the SJ, was significantly more increased by doing the parallel squat in combination with CMJ than by doing CMJ alone. Like other studies this investigation shows a superiority of combining strength training with jumps in opposite of performing strength training or jumps alone, without finding a significant difference between S and S + J (Adams et al. 1992; Baker 1996; Fatouros 2000). This should be recognized as an evidence for increasing maximal strength as a major part of the training for enhancing power output. Looking at other investigations this has proven to be valid (Adams et al. 1992; Anderst / Eksten / Koceja 1994; Butcher et al 2001; Fagan / Doyle-Baker 2000; Fatouros et al. 2000; Ford et al. 1983; Fry et al 1991; Häkkinen / Komi 1985; Hoff / Berdahl 2000; Shimp-Bowerman 2000; Trzaskoma / Trzaskoma 2000; Venable et al. 1991).
Looking at this one has to take into consideration the moderate training status of the persons into consideration which means that in not well trained people small stimuli are sufficient to produce positive adaptations (Hasegawa et al. 2002; Kraemer / Newton 1994).
The next part of this study will be focused at squats (jump squats) with 30% and 60% of maximal strength to analyse the combination of a faster movement velocity with a moderate strength stimulus on power output.

Practical recommendations for training of the slow and the fast stretch-shortening-cycle (SSC):

All SSC training methods aim primarily at adaptation of the nervous system. Therefore, they should be performed in a rested state only.
Before starting a SSC training period a preparatory training is recommended. This can consist of weight training: for example half squats (3 sets with 5 repetitions each, 5 minutes rest interval and 3 workouts per week) till the subject is able to lift twice of body weight.
Easier methods such as single or double leg-hopping or alternate-step-hopping are suitable for novices. One should be careful with drop jumps (DJ) for beginners because the potential for injury is much higher. A drop jump from a height of 40 cm produces a force peak of about 8 times body weight. This is one reason why the use of additional loading even through relatively small weights is inexpedient. The other reason is the risk of the appearance of inhibition by increasing the load.
A training of reactive movements most commonly is started with hopping:
hopping with both legs at personal rhythm or with maximal frequency (maximal number of ground contacts possible) or with maximal height. In all tree types, 30 repetitions are performed with rest intervals of 5 min between sets. All three types can be combined in a workout, since they can be quickly and easily performed and require no apparatus. In single-

leg hopping the number of repetitions per set is reduced to 10 jumps. This training method can be exercised every second day at the beginning and later on daily.
A classification of reactive training methods leads to a destination between horizontal and vertical jumps on one hand and between fast and slow SSCs (CMJ) on the other hand.
Horizontal jumps are practised as alternate step-hopping for 3 sets, with in each case 20 repetitions (1o per leg) performed with 5 min of rest. Other possibilities are „triple“ or „pentajumps“ for 5 sets of 5 – 10 repetitions. Depending of the aim of the training the number of repetitions are 5 if it is power orientated and 10 if it is strength endurance typed. The rest interval in the power training is 10 min between sets, in strength endurance training 2 – 5 min. These jumps can also be used as tests. The distance reached is used as a measure of training adaptation.
Vertical jumps can be divided in slow SSCs (CMJ) and in short SSCs (DJ). Slow SSCs have comparable normativa for the organisation of training like the fast SSCs.The most important method in fast SSC are drop jumps. A set consists of 10 jumps from an individual falling height detected at the diagnosis. Between the jumps a rest of 6 – 8 sec avoids fatigue. If the interval between the jumps is shorter lactate accumulation increases over 4 mmol/l till the end of the second set and the excitability of the nervous system is also reduced. Between sets the rest interval should be 10 min. Longer rest interval reduces the potentiating effects, shorter rest intervals increases fatigue. The number of workouts per week should not exceed three. The risk of injury increases dramatically when more than three workouts are exercised. This is also true for high level young athletes. Usually the rest interval between workouts should be 72 hours. Drop-jump-training is integrated in the periodization of training in a four week block.
Mostly the falling heights are lower compared to the jumping heights, i.e. the vertical rise of the COG. Therefore one assumes that main parts of the physical and physiological work are due to jumping and not to the climb up process. In order to hold the physical work in the SSCs constant and to eliminate climb up work a special measurement device was developed. The vertical jumping height (COG) was limited by a soft floor mat which could be mounted in a variable position. For the elimination of concentric work a seesaw was used. The results show clearly that the work done in climbing up in a physical sense is not comparable to the work done in a physiological sense. Lactate accumulation is two to three time higher in climbing work compared to purely SSC. The better results in SSCs seems to come from the exploitation of the SRES combined with the reflex contribution that lead to a more profitable storage of elasticity. Therefore the training is more profitable when training forms without climbing work are used.
The effect of drop-jump-training is doubtful if the contact phase with the ground lasts too short or too long a time. Most apparatus like machines or sledges that should be used for SSC training are ineffective because the contact times are much too long. The athlete must consciously pretend that she or he will be landing on a hot plate and therefore contact as fast as possible to reach a maximal jumping height of COG. For this reason the landing surfaces should be the same compliance as they are used in competition.
Macrocycles of reactive training methods are arranged as last part of the preparation period or as microcycles during the competition period.

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