CONCURRENT ENDURANCE AND STRENGTH TRAINING IMPROVES NEUROMUSCULAR CHARACTERISTICS AND ENDURANCE PERFORMANCE BUT NOT RUNNING ECONOMY IN RECREATIONAL ENDURANCE RUNNERS

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INTRODUCTION

It has been shown that both explosive type and maximal strength training had positive influences on running performance and running economy (RE) due to improved neuromuscular characteristics in endurance athletes (Paavolainen et al. 1999, Millet et al. 2002). However, it has been suggested that concurrent endurance and strength training might interfere or inhibit strength and/or power development, at least, if the concurrent training period is too long and/or the training volume or intensity is too high (Leveritt et al. 1999). There is still a lack of data how the different types of strength training affects endurance characteristics in recreational endurance runners and what type of strength training is most effective to improve endurance performance. The present study compared the effects of different types of strength training on neuromuscular, aerobic and anaerobic performance in recreational endurance runners.

METHODS

Recreational men endurance runners (aiming to run marathon, n=27) were divided in three strength training groups: 1) M (maximal strength training, n=11, age 36±6 yrs, body mass 78.4±4.8 kg, height 179±5 cm), 2) E (explosive strength training, n=10, 36±6 yrs, 78.6±6.3 kg, 181±6 cm) and 3) C (muscle endurance training, "control", n=6, 34±9 yrs, 84.2±10.4 kg, 181±5 cm). The groups carried out an 8-week strength training program (table 1) as a supplement their normal low-intensity endurance training (mainly running). Group C was considered as a control group because their "strength" training was traditionally typical to endurance runners. Our total body strength training program included always at least 2 exercises for the leg extensors. Before the experimental period the subjects performed a 6-week preparatory pre-training period to familiarize themselves to strength training. The pre-training strength training sessions (carried out nine times) included the same exercises as during the intervention period. The loads, sets and reps during the 6-week preparatory period were 50-70% 1RM, 2-3 and 10 – 15, respectively.

Table 1. Training during the 8-week experimental period.

	Maximal strength group (M)	Explosive strength group (E)	Control group (C)
Strength training	2 times a week	2 times a week	2 times a week
Loads and action velocities	High loads (80 – 85% of 1RM), as fast as possible	Low loads (30 – 40% of 1RM), as fast as possible	Circuit training with body mass, low velocities
Leg extensor exercises	Leg press, squat (Smith-machine)	Leg press, squat (Smith-machine), squat jumps	Squat, lunges
sets / reps / exercise	3 x 4 - 6 RM	3 x 4 - 6	3 x 40 - 50 seconds
Endurance training (km / week)	Total: 43±20 Running: 27±11	Total: 42± 17 Running: 33±14	Total: 36± 11 Running: 29±8

The measurements were performed before and after the 8-week training period. A seated leg press machine was used to measure maximal bilateral concentric force (1RM). Surface EMG-activity of the concentric phase was recorded from the vastus lateralis (VL) of the right leg. Counter movement jump (CMJ, average of two highest jumps) was used to measure dynamic explosive force production of leg extensors. Maximal anaerobic running test (MART, 10 x 150 m with increasing speed / 100 s recovery) was performed on an indoor track to determine maximal velocity of MART (V_{MART}). Aerobic running test on a treadmill was used to determine maximal endurance performance (vVO_{2MAX}), maximal oxygen uptake (VO_{2MAX}) and RE (VO_2 at 10, 12, 14 km/h running speeds).

RESULTS

Changes in Body mass, fat% and fat free mass during the 8-week training period are presented in table 2. The 1RM increased in M and E by 3.6±4.5% ($p<0.05$) and by 3.6±2.7% ($p<0.01$), respectively (fig 1). These increases in 1RM were accompanied by increases in neural activation (EMG of VL) by 18.5±22.4% in M and by 9.0±4.4% in E. The changes in EMG of VL were significantly different between M and C ($p<0.05$) and between E and C ($p<0.01$). The changes in the EMG of VL correlated with the changes in 1RM in M ($r = 0.68$, $p<0.05$) (fig 2). All groups improved V_{MART} and CMJ but the improvements were significant ($p<0.05$) only in M (V_{MART}; 2.6±2.7% from 6.43±0.40 to 6.60±0.38 m/s, CMJ; 6.1±4.0%, from 28.4±4.2 to 30.1±3.9 cm). In the treadmill test, vVO_{2MAX} improved significantly in all groups (table 2) but the improvements in VO_{2MAX} did not reach statistical significance. However, the improvement (%) in vVO_{2MAX} was significantly greater ($p<0.01$) in C than M or E. RE did not change significantly in any group.

Table 2. Changes in selected anthropometric and endurance characteristics.

	Maximal strength group (M)		Explosive strength group (E)		Control group (C)	
	Before	After	Before	After	Before	After
Body mass (kg)	78.4 ± 5.9	77.4 ± 5.9*	78.6 ± 6.3	76.9 ± 5.4*	84.2 ± 10.4	82.2 ± 10.3**
Fat% (skinfold)	17.2 ± 4.0	16.7 ± 4.3	16.0 ± 6.1	15.4 ± 5.7*	20.4 ± 5.9	19.1 ± 5.5*
Fat-free mass (kg)	64.9 ± 5.8	64.5 ± 5.8	65.8 ± 5.0	64.9 ± 4.3	66.7 ± 6.7	66.2 ± 6.6
vVO_{2MAX} (km/h)	15.1 ± 1.2	15.3 ± 1.1**	15.3 ± 1.0	15.6 ± 1.0*	14.5 ± 0.9	15.2 ± 1.0**
VO_{2MAX} (ml/kg/min)	51.5 ± 3.7	52.1 ± 4.7	50.6 ± 5.2	51.6 ± 3.8	47.7 ± 5.8	51.6 ± 6.4

* = significantly different than before value, $p<0.05$, ** = significantly different than before value, $p<0.01$.

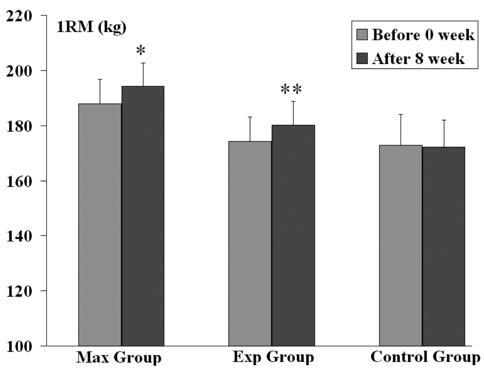

Fig 1. 1RM during the 8-week training period.

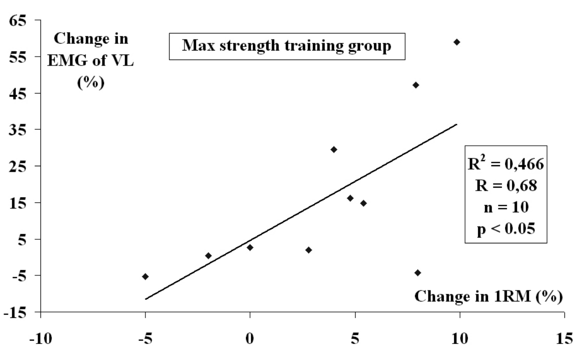

Fig 2. A correlation between the relative changes in EMG of VL and 1RM in M.

DISCUSSION

The present 8-week concurrent maximal or explosive strength and endurance training improved aerobic and selective neuromuscular performance. The data indicate that the neuromuscular improvements in runners could be explained primarily by neural adaptations. However, it is notable that control group improved aerobic performance even more than M and E without significant neuromuscular improvements. None of these training groups improved RE, which is contrary to other studies in athletes (Paavolainen et al. 1999, Millet et al. 2002). Possible reasons for this might be the different training backgrounds of the subjects between the studies and the small improvements observed in neuromuscular characteristics which did not produce improvements in RE. Interestingly, M improved anaerobic performance capacity which might give some advantage to real competitive performance, especially for sprinting actions at the end of the race.

CONCLUSIONS

Recreational endurance runners should include also strength training in their training programs to improve their endurance performance. All the strength training modes used in the present study can be effective to improve endurance performance in recreational endurance runners who have no systematic long-term experience in strength training.

REFERENCES

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