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Original article

EFFECT OF CONCURRENT TRAINING ON CD34+/CD45 STEM CELLS, VO_2 MAX, CERTAIN PHYSICAL VARIABLES AND RECORD LEVEL OF 2000_M ROWING.

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Abstract

*Purpose.*Concurrent training is term used to characterize the method whereby aerobic and strength training exercises are performed in the same training session. That strategy was chosen because energy expenditure could be maximized both during and after the training through increased oxygen consumption after exercise .the aim of this study was to determine the effect of effect of concurrent training on cd34+/cd45 stem cells , vo_2 max, certain physical variables and record level of 2000m rowing.

Methods. Twenty five young male rowers. Divided into three experimental groups,Concurrent (CG, n = 8), strength (SG, n = 8), and aerobic training group (EG, n = 9). Each group trained 3 times a week for 8 weeks, strength training, aerobic training, or both types of training in the same session. Parameters assessed the high,weight, power,strength; training age, vo_2 max (Astrand Treadmill Test was used to determine the vo_2max) and Blood Sample were collected from an antecubital vein into vacuum tubes to measure the Cd34+/Cd45 Stem Cells. All subjects were free of any disorders known to affect performance, such as bone fractures, osteoporosis, diabetes and cardiovascular disease. The participants did not report use of any anti-seizure drugs, alcohol and cortoon consumption, neither smoking cigarette. And all participants were fully informed about the aims of the study, and gave their voluntary consent before participation. The measurement procedures were in agreement with the ethical human experimentation.

*Results.*The results indicated that increased significantly between the pre and post measures for the three experimental groups in accounting of cd34+/cd45 stem cells , power , strength , vo_2 max and record level of 2000m rowing for concurrent group(CG, n = 8) .

*Conclusions.*The results indicate that two months of concurrent training program can improve physicaland record level of 2000m rowing and stem cells among young rowers.

*Key words:*Concurrenttraining – Cd34+/Cd45 Stem Cells, 1500M Running

Introduction

Sports' training is done for improving sports performance. The sports performance, as any other type of human performance, is not the product of on single system or aspect of human personality. On the contrary, it is the product of the total personality of the sports person. The personality of a person has several dimensions e.g., physical, physiological, social and psychic. In order to improve sports performance the social and psychic capacities of the sports person also have to be improved in addition to the physical and physiological ones. In other words the total personality of a sportsman has to be improved in order to improve his performance. Sports' training, therefore, directly and indirectly aims at improving the personality of the sportsman. No wonder, therefore, sports training is a pedagogical process.

So as to have the utmost efficiency, consistent improvement and balanced abilities, a sportsperson must participate in year round conditioning programs. For that they must put their bodies under a certain amount of stress to increase physical capabilities. Physical exercise is extremely important for maintaining physical fitness including healthy weight; building and maintaining healthy bones, muscles, and joints; promoting physiological well-being; and strengthening the immune system. To improve or maintain a desired level of physical fitness, there is a need to constantly administer an adequate training intensity while exercising. Different training modalities are used for the development of different features of physical fitness, as each sportsperson requires a different types and levels of physical composure.

The concomitant integration of endurance and resistance training in a regular training plan is termed concurrent training.

In 1980, (Hickson, 1980) first provided evidence for the existence of an "interference phenomenon" between resistance and endurance training by demonstrating that strength gains were hindered when the two types of training were performed concurrently (concurrent training).

Since that time until now, the combination of resistance training (RT) and endurance training (ET) is frequently used in athletic.

This term is used to characterize the method whereby aerobic and strength training exercises are performed in the same training session (Bell, et al. 2000; Dantas, et al. 2008). That strategy was chosen because energy expenditure could be maximized both

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during and after the training through increased oxygen consumption after exercise 18. Some authors mention concurrent training in their publications (McCarthy, et al. 2002; Izquierdo, et al. 2005; Davis, et al. 2008).

The specificity of training principle states that the nature of tissue adaptation after training is dependent on the specific type of training practiced (Baechle, 1994; Brooks, 2000; Nieman, 2003).

As a corollary to this principle, combining two types of training (e.g., resistance and endurance training) may interfere with the training response induced by either type of training alone. Reasonable physiologic and metabolic evidence exists to support this principle.

However, Athletes are expecting to experience the benefits that these two different types of training have to offer. A number of studies have shown that performing these two types of training simultaneously can be detrimental to the gains that might be made in performing one type of training alone (Hickson, 1980; Dudley, Djamil, 1985; Craig, 1991; Bell, et al. 1997). In contrast, numerous studies have reported that there is no interference in performance gains with concurrent training when compared to resistance or endurance training alone (Sale, et al. 1990; Bell, et al. 1991; Abernethy, Quigley. 1993; Gravelle, Blessing. 2000).

Hence, the aim of this study was to determine the effect of effect of concurrent training on cd34+/cd45 stem cells, vo_2 max, certain physical variables and record level of 2000m rowing among younger's.

Method

Twenty five young male rowers divided into three experimental groups, concurrent (CG, n = 8), strength (SG, n = 8), and aerobic training group (EG, n = 9). Each group trained 3 times a week for 8 weeks, strength training, aerobic training, or both types of training in the same session.

Parameters assessed the high,weight ,power , strength , training age , vo_2 max (Astrand Treadmill Test was used to determine the vo_2 max) and Blood Sample were collected from an antecubital vein into vacuum tubes to measure the Cd34/Cd45 Stem Cells. All subjects were free of any disorders known to affect performance, such as bone fractures, osteoporosis, diabetes and cardiovascular disease. The participants did not report use of any anti-seizure drugs, alcohol and cortoon consumption, neither smoking cigarette. And all participants were fully informed about the aims of the study, and gave their voluntary consent before participation. The measurement procedures were in agreement with the ethical human experimentation.

Testing Procedures

Subjects were assessed before and after an 8-week training program Tests followed a general warm-up that consisted of running, calisthenics, and stretching

Astrand Treadmill Test(ATT)

To monitor the development of the athlete's general endurance (VO2max).

To undertake this test you will require:

- Treadmill
- Stopwatch
- Assistant

This test requires the athlete to run as long as possible on a treadmill whose slope increments at timed intervals

- The athlete warms up for 10 minutes
- The assistant sets up the treadmill with a speed of 8.05km/hr (5 mph) and an incline of 0%
- The assistant gives the command "GO", starts the stopwatch and the athlete commences the test
- The assistant, after 3 minutes into the test, adjusts the treadmill incline to 2.5% and then every 2 minutes thereafter increases the incline by 2.5%
- The assistant stops the stopwatch and records the time when the athlete is unable to continue
- From the total running time an estimate of the athlete's VO2max can be calculated as follows:
- VO2max mls/kg/min=(Time × 1.444) + 14.99

Where "Time" is the recorded test time expressed in minutes and fractions of a minute.

Static strength test (LS)(BS)

A back dynamometer was used to measure the static leg strength. The subjects stood on the dynamometer platform and crouched to the desired leg bend position, while strapped around the waist to the dynamometer. At a prescribed time they exerted a maximum force straight upward by extending their legs. They kept their backs straight, head erect and chest high. 3 trials were allowed to the subjects and the best score was taken. Subjects had a rest between the trials.

Standing Long Jump Test (SLJ):

The subject stands behind a line marked on the ground with feet slightly apart. A two foot take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backwards. Three attempts are allowed.

Seated Medicine Ball Throw (SMBT):

The subject stands with their back to a wall, on a mat facing the area to which the ball is to be thrown, and with the feet extended and slightly apart. The ball is held with the hands (two hands) on the side and slightly behind the center. The ball is brought to the chest, and then thrown vigorously out as far as possible. The back should remain in contact with the wall at all times. Three attempts are allowed. The

distance from the wall to where the ball lands are recorded. The measurement is recorded to the nearest 10 cm. The best result of three throws is used.

Push Up Test (PUT)

The push-up fitness test (also called the press up test) measures upper body strength and endurance. There are many variations of the test, such as different placement of the hands, how far to dip, the length of the test and the method of counting.

A standard push up begins with the hands and toes touching the floor, the body and legs in a straight line, feet slightly apart, the arms at shoulder width apart, extended and at a right angles to the body. Keeping the back and knees straight, the subject lowers the body to a predetermined point, to touch some other object, or until there is a 90-degree angle at the elbows, then returns back to the starting position with the arms extended. This action is repeated, and test continues until exhaustion, or until they can do no more in rhythm or have reached the target number of push-ups. Record the number of correctly completed push-ups.

Wall Sit Test (WST)

To measure the strength endurance of the lower body, particularly the quadriceps muscle group. equipment required: smooth wall and a stopwatch

Stand comfortably with feet approximately shoulder width apart, with your back against a smooth vertical wall. Slowly slide your back down the wall to assume a position with both your knees and hips at a 90° angle. The timing starts when one foot is lifted off the ground and is stopped when the subject cannot maintain the position and the foot are returned to the ground. After a period of rest, the other leg is tested.

The total time in seconds that the position was held for each leg is recorded

Blood Samples:

In the rest period, blood drawn by venipuncture and used the Flow cytometer for counting and examining microscopic particles, such as CD34/CD45

Statistical analysis

All statistical analyses were calculated by the SPSS statistical package. the results are reported as means and standard deviations (sd). Differences between three groups were reported as mean difference ±95% confidence intervals (meandiff ± 95%). One way ANOVA for samples was used to determine the differences in the parameters between the three groups. And Pearson correlations between all variables was used, the $p<0.05$ was considered as statistically significant.

Results:

Table 1. ANOVA for VO_2MAX, physical variables and Blood CD34/CD45 Count and Record level of 1500m run

CD34/CD45	Sum of Squares	Df.	Mean Square	F	Sig.
Between Groups	17.607	2	8.804	40.884	.000
Within Groups	4.737	22	.215		
Total	22.345	24			
VO_2 MAX					
Between Groups	14.184	2	7.092	29.343	.000
Within Groups	5.317	22	.242		
Total	19.502	24			
LS					
Between Groups	512.651	2	256.326	23.168	.000
Within Groups	243.402	22	11.064		
Total	756.053	24			
BS					
Between Groups	777.760	2	388.880	23.504	.000
Within Groups	364.000	22	16.545		
Total	1141.760	24			
SLJ					
Between Groups	1133.569	2	566.785	27.561	.000
Within Groups	452.431	22	20.565		
Total	1586.000	24			
SMBT					
Between Groups	2.094	2	1.047	6.349	.007
Within Groups	3.628	22	.165		
Total	5.722	24			
PUT					
Between Groups	110.463	2	55.231	11.901	.000
Within Groups	102.097	22	4.641		

Total	212.560	24			
WST					
Between Groups	743.403	2	371.701	22.932	.000
Within Groups	356.597	22	16.209		
Total	1100.000	24			
Record level 1500m					
Between Groups	.042	2	.021	9.462	.001
Within Groups	.049	22	.002		
Total	.090	24			

Table 1.show that significant differences between three groups in all variables except variable of SMBT

Table 2. LCD for VO_2MAX, physical variables and Blood CD34/CD45 Count and Record level of 1500m run

Dependent Variable	(I) GROUPS	(J) GROUPS	Mean Difference (I-J)	Sig.
CD34/CD45	**Strength group**	**endurance group**	**1.43917***	**.000**
		concurrent group	**-.51250***	**.038**
	endurance group	**concurrent group**	**-1.95167***	**.000**
vo_2max	**Strength group**	**endurance group**	**-1.817069***	**.000**
		concurrent group	**-1.154000***	**.000**
	endurance group	**concurrent group**	**.663069***	**.011**
LS	**Strength group**	**endurance group**	**9.051528***	**.000**
		concurrent group	**-.726250-**	**.667**
	endurance group	**concurrent group**	**-9.777778***	**.000**
BS	**Strength group**	**endurance group**	**12.500000***	**.000**
		concurrent group	**2.000000**	**.336**
	endurance group	**concurrent group**	**-10.500000***	**.000**
SLJ	**Strength group**	**endurance group**	**15.347222***	**.000**
		concurrent group	**3.125000**	**.182**
	endurance group	**concurrent group**	**-12.222222***	**.000**
PUT	**Strength group**	**endurance group**	**4.55556***	**.000**
		concurrent group	**.37500**	**.731**
	endurance group	**concurrent group**	**-4.18056***	**.001**
WST	**Strength group**	**endurance group**	**1.80556**	**.366**
		concurrent group	**-10.62500***	**.000**
	endurance group	**concurrent group**	**-12.43056***	**.000**
RL1500M	**Strength group**	**endurance group**	**-.01681-**	**.470**
		concurrent group	**.07750***	**.003**
	endurance group	**concurrent group**	**.09431***	**.000**

***. The mean difference is significant at the 0.05 level.**

Table 2.Show that.

- Significant differences in CD34/CD45 between Strength group and endurance group for Strength group.
- Significant differences in CD34/CD45 between Strength group and concurrent group for concurrent group.
- Significant differences in CD34/CD45 between endurance group and concurrent group for concurrent group.
- Significant differences in vo_2max between Strength group and endurance group for endurance group.
- Significant differences in vo_2max between Strength group and concurrent group for concurrent group.
- Significant differences in vo_2max between endurance group and concurrent group for endurance group.

- Significant differences in LS between Strength group and endurance group for Strength group.
- No significant differences in LS between Strength group and concurrent group .
- Significant differences in LS between endurance group and concurrent group for concurrent group.
- Significant differences in BS between Strength group and endurance group for Strength group.
- No significant differences in BS between Strength group and concurrent group .
- Significant differences in BS between endurance group and concurrent group for concurrent group.
- Significant differences in SLJ between Strength group and endurance group for Strength group.
- No significant differences in SLJ between Strength group and concurrent group .
- Significant differences in SLJ between endurance group and concurrent group for concurrent group.
- Significant differences in PUT between Strength group and endurance group for Strength group.
- No significant differences in PUT between Strength group and concurrent group .
- Significant differences in PUT between endurance group and concurrent group for concurrent group.
- No significant differences in WST between Strength group and endurance group.
- Significant differences in WST between Strength group and concurrent group for concurrent group.
- Significant differences in WST between endurance group and concurrent group for concurrent group.
- No significant differences in RL1500M between Strength group and endurance group.
- Significant differences in RL1500M between Strength group and concurrent group for concurrent group.
- Significant differences in RL1500M between endurance group and concurrent group for concurrent group.

Discussion

The purpose of this study was to determine if Concurrent training can enhance (vo2max) (LS), (BS), (SLJ), (SMBT), (WST) (PUT) (RL1500M) and CD34/CD45 among young rowers

The main findings from this study were the significant Improvements in the physical variables, Record level of 1500m run and counting of CD34/CD45 stem cells. This proved the concurrent training efficacy.

(Kraemer, et al. 1995) reported that concurrent training interfered with leg press and double leg extension strength development. This study also showed that only the resistance trained group improved in peak and mean power during the Wingate anaerobic test. (Bell, et al. 1997) reported interference in strength gains in the subjects of the concurrent group who were female, but not in the male subjects. Another study by (Bell, et al. 1991) found the resistance training group to make larger gains in knee extension one repetition maximum (1 RM), but not leg press 1 RM when compared to the concurrent group. A very recent study conducted by (Balabinis, et al. 2003) showed that the resistance training group made greater gains in leg press and bench press 1 RM compared to the concurrent group.

However, interestingly the concurrent group in this study showed greater improvements in many of the other performance tests conducted. It should also be noted that in all but one of the above studies changes in V02max were the same for the concurrent and endurance only groups.

Based on the findings of the studies discussed in the two previous paragraphs it seems rather convincing that endurance training interferes with strength development.

However, several studies have been conducted showing no interference in strength development by concurrent training (Hickson, 1980; Dudley, Djamil. 1985; Craig, 1991; Bell, et al. 1997). (Sale, et al. 1990) found no interference in strength or endurance development with concurrent training. This study actually showed that the concurrent group improved the most in the number of repetitions performed at 80% of leg press 1 RM. These results may have been due to the hybrid nature of the training program (endurance training = 3 minute bouts at 90-100% VO2max and resistance training = sets of 15-20 repetitions) used in this study.

(Abernethy, Quigley, 1993) performed a study solely examining concurrent training in elbow extensor muscles. Their study also showed no interference in strength development. Four other studies have also reported no difference in the strength gains of the concurrent and resistance training only groups.

(Balabinis, et al. 2003) actually found the concurrent group to improve more than the resistance training group in Wingate power. It is interesting to note that in this study the resistance only group out-performed the concurrent group in 1 RM leg press and bench press, but the concurrent group showed greater improvements in 1 RM squat, vertical jump, and Wingate power. As previously stated, (Crameri, et al. 2007) showed interference in vertical jump performance when comparing untrained subjects who concurrently trained to those who only resistance trained. However, they failed to show any interference when a group of trained rowers who began resistance training was compared to the untrained group who only resistance trained. A recent study conducted by (McCarthy, et al. 2002) also reported no strength impairments with concurrent training.

A small number of other studies have examined whether or not adding resistance training to the training regimen of endurance-trained athletes could improve their endurance performance. The results of these

studies are also inconsistent. (Bishop, et al. 1999) showed that resistance training of endurance-trained cyclists did not improve their performance. In this study the resistance trained subjects did improve in the strength test, but showed no difference from the control group in average power output during a 1-h cycle test, lactate threshold, or V02max. Nelson, et al. (1990) reported that after 11 weeks concurrent training actually interfered with gains in V02max as compared to endurance training alone. Here the authors speculated that as a result of hypertrophy a dilution in mitochondrial volume of the type IIa fibers might have occurred in the concurrent group.

(Häkkinen, et al. 2005) performed a study showing just the opposite of Nelson's findings. They found that subjects who had resistance trained showed greater improvements in short and long-term endurance compared to those who only endurance trained. Short-term endurance was 5-8 min to exhaustion and long term was maximal cycling time to exhaustion at 80% VO2max. It was hypothesized that resistance training increased short-term endurance performance by increasing high-energy phosphate and glycogen stores. Short-term endurance may have also been improved by increases in the fast twitch to slow twitch fiber area ratio. Long-term endurance performance was believed to have increased due to a delay in the recruitment of fast twitch fibers as a result of resistance training increasing maximum strength Nelson, et al. (1990). It has also been suggested that long-term endurance performance can benefit from resistance training not only by reducing large motor unit recruitment, but also by improving running or cycling economy. Similar to Hickson's findings (1980), (Balabinis, et al. 2003) recently reported that those who concurrently trained made greater gains in VO2max than those who only endurance trained.

Another important result of our study is the significant reduction in the CD34/CD45 stem cells secretions after the training program; these findings show the quality of the training program design.

Several mechanisms may contribute to increaseof CD34/CD45 stem cells followed 8- weeks of the training programs. Concerning the adaptations to strength and power training, (Ferrauti, et al. 2001) main factors are referred to in the literature: neural and hypertrophic. (Ransford, 1982) and resistance training is more likely to be associated with increases in fiber cross-sectional area.

A number of studies have shown that exercise improves the function and regeneration of the cardiovascular system and skeletal muscle by activating and mobilizing organ-resident stem cells (Crameri, et al. 2007; Petrella, et al. 2006) or by recruiting blood-circulating stem or progenitor cells (Adams, et al. 2004; Sandri, et al. 2005).

(Kadi, Thornell, 2000) suggest that physical exercise can exert powerful effects on different stem cell niches by altering their microenvironment. Currently, the mechanisms behind the maintenance of a quiescent state within each stem cell niche as well as the exact signals leading to the proliferation of stem cells following exercise are not fully understood.

Practical Applications

Two months of concurrent training program (endurance and resistance training) could improve physical and record level of 2000m rowing and stem cells among young rowers.

References

Abernethy, P., Quigley, B., 1993, Concurrent Strength and Endurance Training of the Elbow Extensors. J Strength and Conditioning Research 7: 234-240.

Adams, V., Lenk, K., Linke, A et al., 2004, Increase of circulating endothelial progenitor cells in patients with coronary artery disease after exercise-induced ischemia. ArteriosclerThrombVasc Biol. 24:684–90.

Baechle, T.R., 1994, Essentials of Strength Training and Conditioning. Champaign, IL: Human Kinetics, pp. 57–71, 137–166, 287–290, 314.

Balabinis, C., Psarakis, H., Charalampos, M. et al., 2003, Early Phase Changes by Concurrent Endurance and Strength Training. J Strength and Conditioning Research 17(2): 393-401.

Bell, G., Syrotuik, T., Socha, I. et al., 1997, Effects of Strength Training and Concurrent Strength and Endurance Training on Strength, Testosterone, and Cortisol. J Strength and Conditioning Research 11(1): 57-64.

Bell, G., Peterson, J., Wessel, K. et al., 1991, Physiological Adaptations to Concurrent Endurance Training and Low Velocity Resistance Training.Int J Sports Med 12(4): 384-390.

Bell, G., Syrotuik, D., Martin, T. et al., 2000, Effect of concurrent strength and endurance training on skeletal muscle properties and hormone concentrations in humans", European journal of applied physiology, vol. 81, no. 5, pp. 418-427.

Bishop, D., Jenkins, L. Mackinnon, M. et al., 1999, The Effects of Strength Training on Endurance Performance and Muscle Characteristics. Med Science in Sports Exercise 31: 886-891.

Brooks, G., 2000, Exercise Physiology: Human Bioenergetics and Its Applications. Mountain View, CA: Mayfield Publishing Company, pp. 401–419, 669.

Craig, B., Lucas, R., Pohlman, H. et al., 1991, The Effects of Running, Weightlifting and a Combination of Both on Growth Hormone Release. J Strength and Conditioning Research 5: 198-203.

Crameri, R., Aagaard, P., Qvortrup, K. et al., 2007, Myofibre damage in human skeletal muscle:

effects of electrical stimulation versus voluntary contraction. J Physiol.583:365–80.

Dantas, E., Viana, M., Cader, S. et al., 2008, Effects of a programme for yearsenderers physical force on the muscle and body composition of adults. Sport Sci Health; 4: 15-19.

Davis, W.J., Wood, D.T., Andrews, R.G., et al. 2008, Concurrent training enhances athletes strength, muscle endurance, and other measures. J Strength Cond Res ; 22(5): 1487-1502.

Dudley, G., Djamil, R., 1985, Incompatibility of Endurance- and Strength-Training Modes of Exercise. J ApplPhysiol 59: 1446-1451.

Ferrauti, A., Neumann, G., Weber, K. et al., 2001, Urine catecholamine concentrations and psychophysical stress in elite tennis under practice and tournament conditions. J Sports Med Phys Fitness; 41:269–74.

Gravelle, B., Blessing, D., 2000, Physiological Adaptation in Women Concurrently Training for Strength and Endurance. J Strength and Conditioning Research 14: 5-13.

Häkkinen, A., Pakarinen, A., Hannonen, P. et al., 2005, Effects of prolonged combined strength and endurance training on physical fitness, body composition and serum hormones in women with rheumatoid arthritis and in healthy controls", Clinical and experimental rheumatology, vol. 23, no. 4, pp. 505-512.

Hickson, R., 1980, Interference of Strength Development by Simultaneously Training for Strength and Endurance. EurJ.ApplPhysiol, 255-263.

Izquierdo, M., Häkkinen, K., Ibáñez, J. et al., 2005, Effects of combined resistance and cardiovascular training on strength, power, muscle cross-sectional area, and endurance markers in middle-aged men. Eur J ApplPhysiol ; 94: 70-75.

Kadi, F., Thornell, L., 2000, Concomitant increases in myonuclear and satellite cell content in female trapezius muscle following strength training. Histochem. Cell Biol. 113:99 –103

Kraemer, W., Patton, S. Gordon, E. et al., 1995, Compatibility of high-intensity strength and endurance training on hormonal and skeletal muscle adaptations. J. Appl. Physiol. 78: 976–989.

Mccarthy, J.P., Pozniak, M., Agre, J., 2002, Neuromuscular adaptations to concurrent strength and endurance training. Med Sci Sports Exerc ; 34(3): 511-519.

Nelson, A., Arnall, S., Loy, L. et al., 1990, Consequences of Combining Strength and Endurance Training Regimens. Physical Therapy 70: 287-294.

Nieman, D., 2003, Exercise Testing and Prescription: A Health-Related Approach. New York: McGraw-Hill, 2003, pp. 79–110.

Petrella, J.K., Kim, J.S., Cross, J.M. et al., 2006, Efficacy of myonuclear addition may explain differential myofiber growth among resistance-trained young and older men and women. Am J Physiol. 291:E937–46.

Ransford, C., 1982, A role for amines in the antidepressant effect of exercise: a review. Med Sci Sport Exerc ;4:1–10.

Sale, D., MacDougall, I., Jacobs, and S. Garner. 1990, Interaction Between Concurrent Strength and Endurance Training. J ApplPhysiol 68: 260-270.

Sandri, M., Adams, V., Gielen, S. et al., 2005, Effects of exercise and ischemia on mobilization and functional activation of blood-derived progenitor cells in patients with ischemic syndromes: results of 3 randomized studies. Circulation. 111:3391–9.