ELBOW FLEXOR MUSCLE FUNCTION AND UPPER ARM GIRTH FOLLOWING CONCURRENT STRENGTH AND ENDURANCE TRAINING IN NON RESISTANCE-TRAINED FEMALES

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The study investigated the effects of eight weeks of concurrent muscular strength and endurance resistance training of the non-dominant elbow flexors on muscular strength, endurance, and upper arm girths of previously non resistance-trained females. Subjects (n=12) were assigned to one of 3 training groups. These groups were Strength (S), Endurance (E), or Combined (C) with pre and post-training tests for arm girths, 1 RM preacher curl, maximal isometric torque, peak isokinetic torque at velocities of 30 and 90° s^{-1}, and total work during 25 continuous repetitions at 90° s^{-1}. Significant increases in pre-post strength and endurance occurred in both C and S groups, but not E, in the absence of any change in arm girth. Furthermore, C training produced equivalent gains in strength and endurance to the S and E groups, respectively.

KEY WORDS: resistance training, women, concurrent training, strength, endurance.

INTRODUCTION: Strength and endurance training are often carried out concurrently to improve either sports performance or general overall conditioning. Whilst it is universally recognised that strength training increases voluntary strength and endurance training increases endurance (Sale, MacDougall, Jacobs, & Garner, 1990a), it is questionable whether concurrent strength and endurance training results in equivalent gains compared to one mode of training. To date, the majority of research in this area has focused on the effects of endurance activity involving a large number of muscle groups (e.g., cycling or running) as opposed to local muscular resistance exercise. Furthermore, most studies have concentrated on training responses in males. It has been suggested that many women are reluctant to undertake resistance training programs due to the fear of a loss of femininity associated with large increases in limb circumference (Baechle, 1984). Therefore, the aims of this study were to evaluate: (1) Whether eight weeks of concurrent (combined) muscular strength and endurance resistance training of the non-dominant elbow flexors of non resistance-trained females results in similar strength and endurance gains to a strength only and endurance only program. (2) The effect of the three exercise modalities on upper arm girth.

METHODS: Twelve healthy non resistance-trained females aged 17-45 years were assigned to one of three training groups: Strength (S), Endurance (E), or Combined (C). Groups were chosen to be equivalent for age, body weight and 1 repetition maximum (RM). Subjects were tested prior to and following an eight week training program. The strength tests consisted of a 1 (RM) seated dumbbell preacher curl, maximal isometric torque at 90" of elbow flexion and peak isokinetic torque at velocities of 30 and 90" s^{-1}. Total work produced during 25 continuous repetitions at 90" s^{-1} was used to assess muscular endurance. 1 RM was measured on a seated preacher curl bench and isometric and isokinetic testing were conducted using a Cybex 6000 isokinetic dynamometer. Pre-test familiarisation sessions were conducted for all subjects in the two weeks prior to initial testing. Measurements of relaxed and flexed upper arm girths were also recorded. Subjects were instructed to refrain from any vigorous activity for a period of 48 hours prior to each testing session. All 3 groups. trained the non-dominant elbow flexors using seated dumbbell preacher bench curls for 3 sessions1week over 8 weeks with 48-72 hours recovery between sessions. The S group completed 5 sets of 6 repetitions at a cadence of 3 seconds concentric and 5 seconds eccentric per repetition with a resistance equal to 70-75% of their

1 RM. Recovery between sets was set at one minute. E training consisted of 5 sets of 25 repetitions at 45-50% of 1 RM at a cadence of 1 second for both concentric and eccentric phases. The C group alternated between S and E training so that in any one week they either performed 2 x S separated by 1 x E or 2 x E separated by 1 x S sessions. All training sessions were carried out under supervision in a gym environment to ensure correct technique and cadence. A series of 3 X 3 ANOVAs with repeated measures ($p < 0.05$) were used to ascertain the overall effects of the 3 training regimes on the arm girths, 1 RM, isometric and isokinetic torque, and total work measures.

RESULTS: The mean (± SEM) results of the subjects pre-test measures are presented in Table 1. There were no significant differences between the groups for any of the pre-test measures.

Table 1 Measures Prior to the Commencement of Training (mean ± SEM)

Training Groups	Relaxed Girth (cm)	Flexed Girth (cm)	1 RM (kg)	Isometric Peak Torque (Nm)	$30^{\circ}\,s^{-1}$ Peak Torque (Nm)	$90^{\circ}\,s^{-1}$ Peak Torque (Nm)	Total Work (J)
Strength (S)	25.651.9	27.2K2.0	7.0±1.1	29.3±4.7	21.354.0	17.5k3.3	590.35115.3
Endurance (E)	29.250.4	29.850.2	7.7±0.8	31.0K2.3	22.3k3.8	16.0±2.0	517.7k47.8
Combined (C)	27.1H.9	28.1k1.0	6.8H.6	26.3K2.7	17.8k0.6	14.8±1.7	457.0k44.5

There were no significant pre-post differences for any of the three training regimes with regard to relaxed and flexed upper arm girths. Figure 1 displays the mean percentage changes in pre-post measures following eight weeks of training (±SEM). Strength gains, as measured by 1 RM preacher bench curls, were apparent for all training regimes, although the only significant pre-post difference was that of the S group, being the only group to show a significant pre-post gain in isometric peak torque. However, significant increases in peak isokinetic torque at $30^{\circ}\,s^{-1}$ were demonstrated by both the S and C groups following training, whereas at $90^{\circ}\,s^{-1}$ significant increases were evident in only the C group. Total work increased in all groups, but the increase was significant only in the C group who performed 25% more work during 25 continuous repetitions at $90^{\circ}\,s^{-1}$ than achieved prior to training. There were, however, no significant differences on any of the measured variables between the three training regimes.

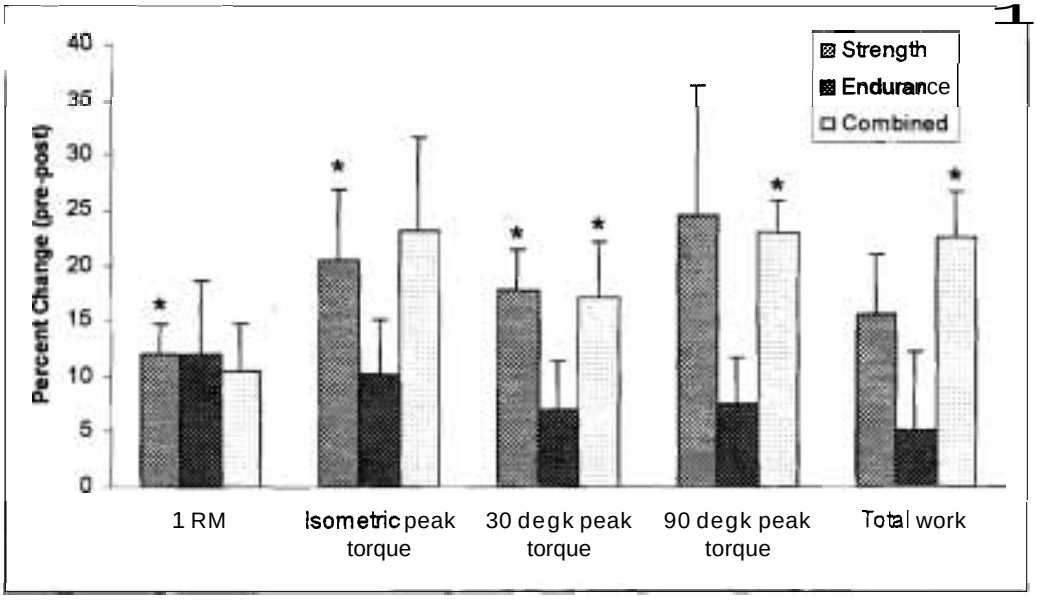

Figure 1 - Percentage change in pre-post measures following 8 weeks of training Mean (± SEM). * p< 0.05 for pre-post values

DISCUSSION: The finding of significantly increased isometric peak torque following training in the S group may be explained by the slow contraction velocity of the S sessions (3 second concentric and 5 second eccentric phases). During training the C group followed the S protocol only twice per week (once on alternating weeks). This may not have constituted a sufficiently intense stimulus, explaining the smaller improvement in isometric peak torque. This reasoning would also account for the 1 RM findings, since only the S group produced significant pre-post gains. The significant increases in peak isokinetic torque at both 30 and 90" s^{-1} in the C group may reflect the fact that the alternating training velocities were similar to the testing velocities. Sale (1992, p. 255) reports that velocity specificity in strength training is reflected in greater increases in high velocity, as opposed to low velocity strength following training at high velocities, and vice versa. Although the velocities of testing at 90" s^{-1} and training in the low intensity1 high volume protocol were similar, training was submaximal whilst the endurance test required repeated maximal efforts. This may explain the fact that the E group did not produce significant increases in endurance. A number of studies have reported that concurrent strength and endurance training does not compromise strength or endurance when compared to strength or endurance only programs (Hennessy, L.C., and Watson, A.W.S. 1994; Sale et al., 1990a; Volpe, S.L., Walberg-Rarıkin, J., Rodman, K.W., and Sebolt, D.R. 1993). Those results are supported by our study that also found no significant difference between the three training regimens for all of the measured variables. There are, however, some studies (Dudley, G.A., & Djamil, R. 1985; Hickson, 1980; Sale, D.G., Jacobs, I., MacDougall, J.D., and Gamer, S. 1990) which report compromises in strength, but not endurance, when following a concurrent strength and endurance training program as compared to a strength only program. Two of these three studies (Hickson, 1980; Sale et al., 1990) differed from both our study and those that reported no differences between groups in the respect that the concurrent strength and endurance training was completed on the same versus different days. Sale et al (1990, p. 355) reported that same day versus different day concurrent strength and endurance training may impede strength development. The results of our study suggest some interaction between the alternating training intensities and volumes of the C group resulting in significant increases in isokinetic strength and endurance capacity. The fact that previously non resistance-trained females following an eight week concurrent strength and endurance resistance training program can gain 23%, 17% and 22% increases in isometric and isokinetic (30 and 90" s^{-1}) strength respectively, without significant increase in upper arm girth, is important because it adds support to dispelling the myth that resistance training in females, leading to strength gains, is always associated with circumference increases. The Staron, et al. (1994) study also reported increases in strength, without accompanying significant girth increases, following an eight week progressive resistance training program in men and women. The findings of the present study have implications for novice female athletes who wish to embark on a resistance training program to improve their strength and endurance but fear increases in limb circumference that they perceive will accompany the other desired physiological gains.

CONCLUSION: Significant gains in isokinetic strength and muscular endurance can be made by previously non-resistance trained females in response to eight weeks of alternating concurrent moderate intensity1 low volume (strength) and low intensity/moderate volume (endurance) resistance training. These increases in both strength and endurance were realised without concomitant increases in relaxed and flexed upper arm girth. The findings have relevance to novice female athletes seeking to improve muscular strength and endurance while minimising limb girths.

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