Effects of concentric vs eccentric loading on cardiovascular variables and ECG

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SUMMARY

There is a paucity of information concerning the cardiovascular responses and adaptations to strength training. Limited evidence suggest that which particular type of resistance exercise could be more tolerable as well as potentially safer for people with cardiac diseases or impairments. So, the aim of study was to determine and compare the effect of concentric and eccentric loading on cardiovascular variables and ECG.20 Young healthy students (mean age 20 ± 4 years) participated and were randomly divided into two groups- Experimental & Control. Pre & Post training readings were taken for following Parameters –*Heart Rate, Blood Pressure, Mean Arterial Pressure, Rate Pressure Product and ECG*. At first testing bout, participants performed concentric exercises (at 75% of 10 RM). Participants returned 10 days after the first session to perform exercises using the eccentric contraction type. Related't' test and one way ANOVA was applied for statistical analysis between groups. Cardiovascular measures collected from subjects were significantly lower during eccentric than during concentric bouts in all subjects (p<0.01) and ECG showed no significant changes after both training protocols (p>0.05). So, it can be concluded that since eccentric exercise produces less cardiopulmonary demands so are more suitable for persons with low exercise tolerance, who are at the risk of adverse cardiopulmonary events and for improving and maintaining cardiac fitness.

KEYWORDS: Eccentric Exercise, Concentric Exercise, ECG, Cardiopulmonary demands, Young population.

[Afr J Health Sci. 2010; 17:47-51]

Introduction

Resistance training has become a primary component of athletic conditioning, rehabilitation & general fitness programmes [1,3] and the notion that the sports specific resistance training should be an integral component for sport preparation by virtue of the direct enhancement of muscular strength is well established [4].

Although resistance training has long been accepted as a means for developing and maintaining muscular strength, power and muscle hypertrophy, its beneficial relationship to health factors and chronic disease has been recognized only recently. Resistance exercises can be carried out isotonically (with either concentric or eccentric muscle contractions), isokinetically, and isometrically. In all cases the ultimate goal is to improve functional performance & capabilities through the development of increased muscle strength, endurance or power [8].

However, the metabolic demands and safety of this type of strenuous exercise for a broader population of community dwelling older persons with age-related cardiopulmonary impairments and other illnesses such as hypertension, elevated cholesterol, diabetes, etc. are unknown. Several studies suggest that eccentric exercise can improve skeletal muscle performance, with a lower demand for oxygen compared with concentric exercise. However, these studies were largely conducted in young persons using cycle ergometry [12, 11], which is not an optimal means to augment skeletal muscle mass and strength and is also not available easily [15].

Similar to skeletal muscle, cardiac muscle also undergoes adaptations to resistance training. Adaptations & acute responses of Cardio Vascular System to resistance training are especially important when weight training is performed by some special populations such as seniors and individuals undergoing cardiac rehabilitation.

We hypothesized that eccentric resistance exercise would be less demanding on the cardiovascular system than concentric exercise. The purpose of the study was therefore to compare the effects of concentric and eccentric training on cardiovascular variables and ECG after 10 days of training in young adults.

Materials and methods

The present study was an experimental study with same subject design. The study was given approval by Medical Ethics Committee of the Guru Nanak Dev University, Amritsar.20 healthy university students aged between 20±4 years volunteered to participate in the study with no history of injury to upper and lower limb for past one year and who did not participate in any strength training program for past 6 months. The subjects were randomly divided into 2 groups.

Group I (Experimental Group) received concentric training for 10 days at 75% of 10 RM. After the first testing bout of concentric training for 10 days, the subjects were given eccentric training after a rest period of 10 days.

Group II (n=10) this group served as a control group who continued with their normal habitual activities, without any strength training.

The following parameters were evaluated on each subject of all the groups before and after the training (concentric and eccentric both).

- Heart Rate (Polar Heart Rate Monitor)
- Blood Pressure (Sphygmomanometer)
- Rate Pressure Product [Calculated RPP=HR*SBP]
- Mean Arterial Pressure [Calculated MAP=DBP+1/3(SBP-DBP)]
- ECG (Cardio fax 3R)

Exercise protocol

Prior to the exercise test bouts, maximal voluntary force (10-repetition maximum) was determined to determine the workload for the testing sessions. At the first testing bout (2-3days after the last 10-repetition maximum testing session), participants performed concentric exercises for 4 muscle groups: Biceps, Deltoid, Quadriceps, Hip Abductors using weights, dumbbells and Quadriceps Table (three sets of 10 repetitions with 1minute rest between each set) at 75% of the 10-repetition maximum by random assignment. Participants returned 10 days after the first exercise trial to perform an exercise bout using the eccentric contraction type.

Statistical analysis

The arithmetic mean, standard deviation and standard error were used to prepare summary of the statistics. Analysis of covariance (ANOVA) was used to compare mean differences of cardiovascular measures statistically between eccentric and concentric groups. Data in the text and tables are presented as means and SD. The data was analyzed for statistical significance using statistical package for social sciences (SPSS 14.0) software. Related't' test was applied for comparison within the groups and one way ANOVA was applied for comparison between concentric, eccentric and control groups.

Results

The results of the study showed significant rise in cardiac variables in both concentric and eccentric training groups, when the post training variables were compared with the pre training cardiac variables. Whereas in the control group, no significant differences were found between the pre training and post training values.

In the intergroup comparison, no statistically significant differences were found between eccentric and concentric groups but clinically in terms of percentage rise, concentric group showed much higher increase in cardiac variables as compared to eccentric group.

The results of the study have shown no significant changes in ECG intervals after both eccentric and concentric training.

Table. Exhibits the multiple comparisons using the Scheffe test for Heart Rate and Rate pressure product alteration in Pre and Post training values between

Intragroup comparison of cardiovascular parameters for concentric Training group.

	Pre-training Mean	SD	Post training Mean	SD	t-value
HR	82.3	11.662	88.9	11.450	10.104***
SBP	111.00	4.546	120.00	4.714	9.925***
DBP	69.20	11.163	80.00	12.220	7.521***
RPP	9171.40	1606.592	10703.4	1629.312	22.306***
MAP	90.10	6.983	100.00	7.57	9.350***

*** p<0.001, **p<0.01,*p<0.05

Intragroup comparison of cardiovascular variables for Eccentric training group.

	Pre-training Mean	SD	Post training Mean	SD	t-value
HR	78.20	8.482	80.80	8.456	4.801**
SBP	111.00	5.981	114.80	6.268	10.585***
DBP	67.40	9.094	70.40	9.697	5.582***
RPP	8716.40	1368.277	9315.80	1. 1439.220	2. 7.078***
MAP	89.20	7.192	92.60	3. 7.604	4. 8.500***

Multiple comparisons using Schefee Test for Heart Rate and Rate Pressure Product Alteration in Pre training and Post training.

Dependent Variable	(I)Group	(J) Group	Mean Diff. (I-I)	Standard Error	Sig.
HR Pre	Concentric	Eccentric	4.10000	4.28140	.637
		Control	11.20000	4.28140	0.047
	Eccentric	Concentric	-4.10000	4.28140	.637
		Control	7.10000	4.28140	.270
	Control	Concentric	-11.20000	4.28140	.047
		Control	-7.10000	4.28140	.270
HR Post	Concentric	Eccentric	8.10000	3.99166	.147
		Control	17.40000*	3.99166	.001
	Eccentric	Concentric	-8.10000	3.99166	.147
		Control	9.30000	3.99166	.084
	Control	Concentric	-17.40000*	3.99166	.001
		Control	-9.30000	3.99166	.084
RPP Pre	Concentric	Eccentric	455.0000	698.04395	.810
		Control	828.0000	698.04395	.504
	Eccentric	Concentric	-455.0000	698.04395	.810
		Control	373.0000	698.04395	.868
	Control	Concentric	-828.0000	698.04395	.504
		Control	-373.0000	698.04395	.868
RPP Post	Concentric	Eccentric	1387.60000	659.47214	.129
		Control	2376.60000	659.47214	.005
	Eccentric	Concentric	1387.60000	659.47214	.129
		Control	2376.60000*	659.47214	.340
	Control	Concentric	-2376.60000*	659.47214	.005
		Control	-989.0000	659.47214	.340

** The mean difference is significant at the .05 level.*

Concentric, Eccentric and Control Group. In post training HR and RPP, statistically significant differences were observed between concentric and Control Group.

Discussion

Resistance training can affect virtually all major aspects of cardiovascular functions. Changes in Cardiac morphology, systolic and diastolic function, heart rate, blood pressure and the lipid profile indicate both cardiovascular functions and health, and cardiovascular risk.

Studies done in the past have focused on the information concerning the CV responses and adaptations to resistance training. These responses and adaptations of cardiovascular system to resistance training are especially important when weight training is performed by some special populations such as elderly people and individuals undergoing Cardiac rehabilitation.

However, in these studies only metabolic demands were concentrated and not an effect of any particular type of resistance training on ECG was taken into account. So, the present study was aimed at bridging this gap.

This is the first study to compare the metabolic effects of eccentric and concentric resistance exercise at sub maximal workload (75% of the 10-Repetition maximum) previously shown to produce skeletal muscle hypertrophy and to augment strength during chronic training. The results demonstrated that peak cardiovascular and pulmonary responses of Heart Rate, Systolic Blood Pressure, Rate Pressure Product and Mean Arterial Pressure during intense bouts of eccentric resistance exercise at these workloads were significantly less compared with bouts of concentric exercise for young adults. Overend et al. also showed that maximum heart rate and mean arterial pressure were less with eccentric than concentric resistance exercise in older subjects, which further corroborates our findings [6].

Studies indicate that muscle adaptations (strength and hypertrophy) are superior with eccentric resistance exercise training compared with standard concentric based resistance training modes [9, 10]. Because sub maximal workloads have produced significant increases in muscle mass, strength and power [14, 5], eccentric exercise at the workload evaluated in this study should, therefore, produce skeletal muscle benefits when used with longitudinal training. Finally, because of the greater stresses placed on the cardiopulmonary system with concentric exercise, it is possible that some older patients with more severe cardiopulmonary limitations may not be able to tolerate concentric exercise programmes even at sub maximal intensities approximating 65%.

The results of the present study suggest that repetitive sub maximal strength exercise (eccentric or concentric) is associated with a transient and marked increase in heart rate, systolic blood pressure, diastolic blood pressure mean arterial pressure and rate pressure product. The mechanisms responsible for the strength-mediated rise in heart rate and arterial pressure are related to:

• Firstly, a transient increase in total systemic vascular resistance associated with performing maximal muscular contractions.

• As a result of increase in intrathoracic pressure associated with performing a brief (2 to 3 second) valsalva maneuver (a forced expiration against a closed glottis) and

• And lastly because of Neural-mediated mechanisms that stimulate the cardiovascular control centre in the ventro lateral medulla [7, 2].

No significant change was found in ECG parameters after 10 days of eccentric or concentric training. It may be due to inefficient overloading of the cardiac muscles during training or the intensity or duration of training might not be enough to cause Left Ventricular or cardiac muscle hypertrophy, both of which are depicted in form of ECG interval changes. The resistance training is based upon overload and specificity principle. According to the specificity principle, the specific exercise elicits specific adaptations creating specific training effects [13].

Conclusion

At the end, we speculate that eccentric resistance exercise produces less cardiopulmonary demands as compared to concentric exercises. So, may be better suited for persons with low exercise tolerance and who are at the risk of adverse cardiopulmonary events as well as for improving or maintaining cardiovascular fitness.

Based on our findings, future studies should evaluate whether eccentric training at sub maximal intensities produces greater or at least comparable gains in muscle mass, strength, power and physical function for population with low exercise tolerance (i.e. from ageing or catabolic illness such as cancer or AIDS) or those who have cardiopulmonary limitations due to chronic lung disease or heart failure.

Acknowledgement

We are grateful for the loyal participation of all study participants and to Dr Jaspal Singh Sandhu and Mrs. Sarika for their helpful suggestions.

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