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"CARDIO-VASCULAR RESPONSES TO SELECTED DYNAMIC UPPER LIMB EXERCISES IN NORMAL SUBJECTS."

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ABSTRACT

Background and purpose: Cardiovascular responses to upper limb exercises differs from lower limb exercises. Although the muscle mass is smaller compared to the lower limb, the blood pressure and heart responses to upper limb exercise is more even to the low to moderate intensity exercises. Mechanical exercises with shoulder wheel and wall pulley exercise are often standard exercise in treating restricted range of motion (e.g. Frozen Shoulder) as well to regain strength in the upper extremity. However these low intensity exercises are given to patients without considering effect on cardiovascular system. Therefore, the purpose of this study was examining the cardiovascular effects to shoulder wheel and wall pulley arm exercises. **Subjects and method:** one hundred and twenty subjects without cardiovascular or cardiopulmonary disease between 31-60 years were randomly selected and assigned to the one of the age wise exercise group. The exercises were randomly allocated to each subject. All the subjects performed each exercise for three minutes. Blood Pressure, Heart Rate and Rate Pressure Product were recorded before and after each exercise. **Results:** The shoulder wheel and wall pulley exercises performed for three minutes were shown to have significant cardiovascular effects with respect to systolic blood pressure, diastolic blood pressure and heart rate ($P<0.05$). When comparison was made between shoulder wheel and wall pulley exercise, there was significant difference in cardiovascular response ($p<0.05$). Wall pulley arm exercise showed more cardiovascular response as compared to the shoulder wheel exercise. **Discussion and conclusion:** The selected dynamic upper limb exercises pose significant increase in the blood pressure and heart rate. Systolic blood pressure and diastolic blood pressure are considerably higher when work is performed with arms because of the smaller muscle mass and vasculature of the arms offer greater resistance to the blood flow. The above mentioned exercises can have cardiovascular effects in people with no cardiovascular or cardiopulmonary conditions. These effects may be important with respect to cardiac work. Hence, the selected dynamic upper limbs exercises if indicated for any subjects; they should have a cardiac and pulmonary risk factor assessment.

KEYWORDS Blood Pressure, Shoulder Wheel Exercises, Heart Rate.

Introduction;

Therapeutic exercise is the systemic and planned performance of bodily movements, postures or physical activities intended to provide a patient or client with the means to remediate or prevent impairments, improve physical function. [1, 2] In exercise lasting longer than a minute or two, a cardiac output and heart rate linearly increase, with peripheral oxygen uptake. The mean systemic arterial pressure increases and vascular resistance in active muscles fall, leading to large increase in blood flow to the muscle. [3]

In the study "Exercise Response through Wall Pulley against Bicycle Ergometer Work", the heart rate responses were greater for arm exercise than for leg exercise at comparable external work rates or energy cost levels. The systolic blood pressure values and myocardial oxygen rate were more for arm exercise at given external workloads, but not a comparable energy cost levels. [4]

The upper limbs have the smaller muscle mass and vasculature of the arm offer greater resistance to blood flow than the larger muscle mass and vasculature of legs. Blood flow to arms during exercise would be therefore requiring much larger systolic head of pressure. Clearly this form of exercise represents greater cardiovascular strain because the work of the heart increased considerably. For individuals who have cardiovascular dysfunction, these observations support the use of exercise that require large muscle groups, such as walking, bicycling, and running in contrast to unregulated exercises that engage a rather limited muscle mass such as shoveling, overhead hammering or even arm ergometry. [5]

Studies also show that, dynamic arm exercise results more rapid withdrawal of vagal modulation of HR than dynamic leg exercise. More pronounced and faster autonomic response to upper body exercise may explain the differences in hemodynamic responses to dynamic arm and leg physical work. [6] Blood pressure responses were inversely related to muscle mass employed at the source relative work load.

Dynamic arm exercises assume increasingly important role in physiotherapy as they are used as both strengthening exercise as well mobility exercise for upper extremity. Mechanical exercises with shoulder wheel are often standard exercises advised by the Physical Therapist to the clients with the restricted shoulder range of motion (e.g.: Frozen Shoulder) as well to regain the strength in the upper extremity. [7] These are very commonly advised and easily performed exercises. However, many a times these exercises will be prescribed to the client without examining cardiovascular system. As per the best of our knowledge the effect of these exercise on cardiovascular system are not known.

Hence, the present study has been undertaken to evaluate the cardiovascular response (blood pressure and pulse rate) to shoulder wheel and wall pulley arm exercises in normal subjects.

Methodology

A total number of 120 non teaching staffs of S.D.M.College of Medical Sciences and Hospital including either sex were taken for the study.

In a total number of 700 subjects, 400 subjects were fulfilling the inclusion criteria and willing to participate in the study, in that 120 subjects were selected by simple random sampling. Ethical approval was granted by the Ethical Committee of S.D.M. College

of Medical Sciences and Hospital, Dharwad. Written informed consent was obtained from subjects prior to testing. Subjects attended two testing sessions. During the initial session they were familiarized with the testing procedure and screening by the physician. The cardiovascular responses to shoulder wheel and wall pulley arm exercise were measured during the second session.

The Inclusion criteria for this study; 120 subjects without any medical illness with full range of motion of bilateral upper limb, including men and women age group between 31 to 60 years.

Exclusion criteria: Hypertension (systolic blood pressure > 140mm Hg or diastolic blood pressure >90mm Hg), cardio respiratory disorders, subject unable to perform the prescribed exercise due to musculoskeletal and neurological conditions, participation in resistive or aerobic training program.

Procedure; With the subject seated, resting systolic blood pressure, and diastolic blood pressure and pulse were measured using a semi automated oscillometric monitor (Omron HEM-403C). The pre and post cardiovascular responses to two types of exercises shoulder wheel and wall pulley arm exercises where tested for all the subjects. The exercise sequence was randomly allocated for each subject. Each exercise was performed for three minutes separated by a minimum of four minutes of recovery period. Exercise was done in a cadence of 30/minute which was monitored by metronome. The first exercise was preceded by a 10 minutes period of baseline (resting) data collection during which subjects sat quietly with arms resting on their thighs. Subjects were guided and instructed to do the smooth and full range of motion. The cardiovascular parameters, systolic blood pressure, diastolic blood pressure and pulse rate were measured at rest and immediately after the exercise. The standard exercise protocol was followed for both the

Outcome measures; systolic blood pressure, diastolic blood pressure, heart rate and rate pressure product (systolic blood pressure multiplied by heart rate) .

Results - Table 1 Distribution of study subjects by age and sex

Age group	Male	%	Female	%	Totals
31-40	20	50.00	20	50.00	40
41-50	22	55.00	18	45.00	40
51-60	23	57.50	17	42.50	40
Totals	65	54.17	55	45.83	120
Chi-square=0.4700,df=2, >0.05, NS					

Table 2 Demographic information comparison of three age groups (31-40, 41-50, 51-60) by ANOVA test- Height (cm)

Variable	SV	SS	DF	MSS	F-value	P-value	Signi.
Height (cm)	Between groups	31	2	16	0.2937	0.7461	NS
	Within groups	6256	117	53		>0.05	
	Total	6287	119	69			
Weight (Kg)	Between groups	783	2	392	4.8894	0.0091	S
	Within groups	9372	117	80		<0.05	
	Total	10155	119	472			
BMI	Between groups	65	2	33	2.2847	0.1063	NS
	Within groups	1669	117	14		>0.05	
	Total	1734	119	47			

Table 3 SBP, DBP, HR and RPP responses to Shoulder wheel exercise.

Variable		Mean	SD	Mean Diff.	SD Diff.	Paired t	p-value	Significance
SBP	Resting	127.0042	7.1554	-10.0875	4.6053	-23.9948	<0.05	S
	After 3 min	137.0917	8.2879				0.0000	
DBP	Resting	80.4125	5.1293	-5.4292	3.1942	-18.6192	<0.05	S
	After 3 min	85.8417	5.1872				0.0000	
HR	Resting	75.5417	9.2805	-8.9500	9.3702	-10.4632	<0.05	S
	After 3 min	84.4917	8.8175				0.0000	
RPP	Resting	96.0402	13.6557	-19.9413	13.5300	-16.1452	<0.05	S
	After 3 min	115.9815	15.1571				0.0000	

Table 4 SBP, DBP, HR and RPP responses to wall pulley arm exercise.

Variable		Mean	SD	Mean Diff.	SD Diff.	Paired t	p-value	Signi.
SBP	Resting	126.5542	7.1628	-14.6458	6.8790	-23.3226	<0.05	S
	After 3 min	141.2000	9.2069				0.0000	
DBP	Resting	80.1375	4.9701	-6.5792	3.1429	-22.9311	<0.05	S
	After 3 min	86.7167	5.6199				0.0000	
HR	Resting	76.0000	6.6866	-12.9917	5.0096	-28.4085	<0.05	S
	After 3 min	88.9917	8.0058				0.0000	
RPP	Resting	96.3033	10.8993	-29.5808	10.3261	-31.3808	<0.05	S
	After 3 min	125.8841	15.9260				0.0000	

Table 5 Comparison of Shoulder Wheel and wall pulley exercises with respect to SBP, DBP, HR and RPP values.

Variable	Period of time	Exercise	Mean	SD	t-value	p-value	Significance
SBP	Resting	SW	127.0042	7.1554	0.4869	0.6268	
		WP	126.5542	7.1628		>0.05	NS
	After 3 min	SW	137.0917	8.2879	-3.6330	0.0003	
		WP	141.2000	9.2069		<0.05	S
DBP	Resting	SW	80.4125	5.1293	0.4218	0.6736	
		WP	80.1375	4.9701		>0.05	NS
	After 3 min	SW	85.8417	5.1872	-1.2533	0.2113	
		WP	86.7167	5.6199		>0.05	NS
HR	Resting	SW	75.5417	9.2805	-0.4389	0.6611	
		WP	76.0000	6.6866		>0.05	NS

	After 3 min	SW	84.4917	8.8175	-4.1391	0.0000	
		WP	88.9917	8.0058		<0.05	S
RPP	Resting	SW	96.0402	13.6557	-0.1650	0.8691	
		WP	96.3033	10.8993		>0.05	NS
	After 3 min	SW	115.9815	15.1571	-4.9340	0.0000	
		WP	125.8841	15.9260		<0.05	S

Discussion

The present study is to find cardiovascular responses to selected dynamic upper limb exercises in normal subjects. The data obtained was subjected to statistical analysis and results showed significant cardiovascular responses to the selected dynamic upper limb exercises.

The table-1 shows the distribution of study subjects by age and sex. Many patients with autonomic-cardiovascular disorder are middle aged and older. Hence, subjects between 31-60 yrs were taken for the study.

In table 3 & 4, shows there is highly significant cardiovascular response i.e., systolic blood pressure, diastolic blood pressure, heart rate and rate pressure product, when compared with resting and immediately after 3 minutes of exercise values.

In normal adult subjects, the systolic pressure rises with increase levels of workload and diastolic pressure increases slightly (less than 10mm Hg), remains same or drops slightly (less than 10mm Hg).[8]

Systolic blood pressure rises during exercise because the increase in cardiac output is greater than the decrease in peripheral vascular resistance. (9) The normal physiological response to exercise is dramatic redistribution blood flow away from non-working muscles. (8) The immediate response of the cardiovascular system to exercise is an increase in heart rate due to a decrease in vagal tone. This increase is followed by rise in sympathetic outpouring to the heart and systemic blood vessels. During dynamic exercise, heart rate increases linearly with work load and (Latin capital V with dot above) O2.[10]

Systolic and diastolic blood pressures are considerably higher when work is performed with the arms because of the smaller muscle mass and vasculature of the arms offer greater resistance to the blood flow. Blood flow to the arms during exercise would therefore require larger systolic head of pressure. In similar studies stated by McArdle W.D. and Marino, it has found at a given percentage of the maximal oxygen consumption systolic and diastolic blood pressures were considerably higher, when work was performed with the arms than with the legs, presumably because muscle mass is smaller and the total peripheral vascular resistance is higher with arm exercise .[5,10]

At normal and sub maximal levels of exercise, cardiac output and heart rate responses increase linearly as the work load and VO2 demand increases. (9) At near maximum and maximum level of exertion, however, the heart rate responses become less linear and increases disproportionately to work load imposed. If the work load is applied using arm work exclusively, heart rate and blood pressure responses are significantly higher for any given work load.[8]

Simple non-invasive measures of cardiovascular responses can be obtained with heart rate, systolic blood pressure and the rate pressure product (RPP). The RPP is the product of heart rate and systolic blood pressure multiplied by 10-2. The RPP is considered on excellent index of myocardial oxygen demand and, therefore, work of heart. [11,12]

In our study as both the systolic blood pressure and heart rate increased significantly, hence the RPP. As for the results the systolic blood pressure, diastolic blood pressure, heart rate and rate pressure product increased for both shoulder wheel and wall pulley arm exercise in all the study subjects (i.e., 31-60 years). The result of our study strongly support the idea that, these selected dynamic upper limb exercises, typically performed for 3 minutes have significant cardiovascular response, and hence might pose risk for a patient with underlying cardiovascular dysfunction.

Comparison between shoulder wheel and wall pulley exercise was done with respect to SBP, DBP, HR and RPP values. The wall pulley arm exercise showed significant cardiovascular response (SBP, HR and RPP values), the only parameter that did not show significant difference was DBP. No significance difference was found at resting parameters (SBP, DBP, HR and RPP), which was checked before performing each exercise.

When we analyzed the biomechanics of both the exercise, we found that;

1) Shoulder wheel exercise was done in standing, whereas wall pulley exercise was done in sitting position.

2) Only one upper extremity was used to perform the exercise with shoulder wheel, where as bilateral upper extremities were used in wall pulley arm exercise.

3) Both exercises were in the form of isotonic and isometric contraction of upper limb muscles, though in wall pulley arm exercise isometric component was more because bilateral upper limbs were used in the exercise.

4) Both the exercises had overhead upper limb activities. The amount of over head activity was more during the wall pulley exercise as compared to the shoulder wheel exercise.

A lower mechanical efficiency in arm exercise owing static muscular contractions in the form of work (which do not contribute to the external work accomplished). Sympathetic outflow will be more due to static contraction of small muscle groups in the arm exercise. (13) Both the exercises in our study had an isometric component because of lower mechanical efficiency, and in the form gripping the handle while performing the exercise. In a study, standards for exercise testing and training; states that, isometric exercise force larger pressure than volume load on the left ventricle in relation to the body's ability to supply oxygen. (14) Hence, both the exercises in our study were having isometric component, though the wall pulley arm exercise had a greater isometric component as compared to the shoulder wheel exercise, because both upper limbs were used in wall pulley arm exercise.

It has been reported that blood flow and by implication, oxygen delivery to the exercising muscles is reduced when gravitational assistance is attenuated, for example, during arm exercise performed above the level of heart. [15]

The higher heart rate in exercise, where arms were used above the level of heart was the expression of larger static and postural component. [16]

In both exercises overhead component was there comparatively more in case of wall pulley than the shoulder wheel exercise.

The diastolic blood pressure response was statistically not significant, when compared to shoulder wheel and wall pulley arm exercise. As the diastolic blood pressure may increase normally within 10mm Hg to any exercise, and the variation to the diastolic blood pressure to any dynamic exercise is not much. [8]

Conclusion;

Selected dynamic upper limb exercises (shoulder wheel and wall pulley arm exercise) has significant effect on cardiovascular parameters of study subjects. We recommend that, patients for whom these exercises are prescribed require a cardiac risk factor assessment to establish whether HR and BP should monitor.

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