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Research Article

EFFECT OF REPETITIVE MCKENZIE LUMBAR SPINE EXERCISES ON CARDIOVASCULAR SYSTEM

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ABSTRACT

Background& Purpose:McKenzie exercises for the lumbar spine, which are done repeatedly, such as flexion in standing (FIS), extension in standing flexion in lying (FIL) & extension in lying (EIL) have been used in the management of low back pain for over three decades. The cardiovascular effects of exercises that involve postural stabilization, arm exercises and of exercises performed in lying are well known, but there are seldom studies performed to assess the cardiovascular effects of these commonly used McKenzie exercises. Therefore the study focused on evaluating the effects of 4 commonly used McKenzie exercises on the cardiovascular system.Methods: 80 subjects in the age group of 20-59 years were randomly assigned into 4 groups according to their age, such that such that each group comprised of an equal number of subjects & equal number of males & females. Each subject performed all the 4 exercises (FIS, EIS, FIL & EIL) for 10, 15 & 20 repetitions respectively. Heart rate, blood pressure & rate pressure product were recorded before & after each set of repetitions & after each type of exercise. Results: Repetitive McKenzie lumbar spine exercises had cardiovascular effects in apparently healthy subjects (both male & female). Exercises performed in lying were hemodynamically more demanding than that performed in standing, also exercises involving flexion of the lumbar spine elicited greater cardiovascular demand as compared to extension exercises i.e. FIL>EIL>FIS>EIS irrespective of the number of repetitions, 10, 15 or 20. The cardiovascular demand for a given subject increased as the number of repetitions increased, for all the 4 exercises. Conclusion: McKenzie exercises when done repetitively have cardiovascular effects in healthy subjects.

Keywords: McKenzie, low back pain, cardiovascular system

INTRODUCTION

Low back pain is a condition that continues to place a great deal of stress on the health care system of the industrialized societies. Low back pain affects approximately 80% of individuals in community[1]. It is the second most common cause for patient visits to physicians.[1] Globally whether viewed in terms of disability allowances, industrial injury claims, or frequency of patients visiting physician, low back pain is the most costly musculoskeletal condition.[2]

Low back pain can be extremely challenging to prevent, diagnose and treat since its etiology is diverse and cause often undetermined.[3] Patients suffering from low back pain as well as health care providers who treat them are often frustrated by the lack of progress realized during treatment & rehabilitation programs. One reason for this may be that treatment and rehabilitation recommendations for low back pain vary greatly across health care providers.[4] Additionally, many of the common treatment interventions prescribed to treat low back pain patients have little scientific validation of their efficacy.[5]

It has been suggested that several factors can predispose people to the development of low back

pain which includes; smoking, obesity, drug abuse, ageing, genetic predisposition, lack of physical conditioning, occupation involving excessive vibrating movements or positions that involve very little movement (i.e. sedentary occupations), occupations that involve lifting, bending and twisting. Also poor posture, frequency of forward bending and loss of low back extension are predisposing factors for low back pain.[6]

Many low back pain treatment and rehabilitation protocols throughout the mid and late twentieth century, primarily utilized passive modalities such as bed rest, ultrasound, electrical stimulation, hot packs and medication despite their being little validation of their efficacy. However, one of the current treatment interventions that utilize a more active approach to treating and rehabilitating low back pain is McKenzie therapy.[5]

Forthe last three decades, McKenzie lumbar spine exercises are being prescribed for the management of patients with low back pain. These comprise of repeated lumbar flexion and extension movements as a part of routine lumbar spine assessment and exercise program.[6, 7]

Moreover,less effort is made to explain about the cautions for increasing stress on the cardiovascular system because of these exercises. Thus, understanding the cardiovascular responses to McKenzie exercises can be useful for clinicians using these exercises fordiagnostic purpose and as an intervention.

Aim: The aim of this study was to examine the cardiovascular effects of four common McKenzie exercises – lumbar spinal flexion and extension in standing and lying, when these exercises are repeated 10, 15 and 20 times

Objectives:

- To study the cardiovascular effects of 4 common McKenzie exercises: Flexion in standing (FIS), extension in standing (EIS), flexion in lying (FIL)&extension in lying (EIL).
- To study the difference in the effects after 10, 15 and 20 repetitions of 4 McKenzie exercises.
- To compare the cardiovascular effects between different exercises i.e. FIS, EIS, FIL&EIL
- To compare the cardiovascular effects of these exercises between males and females

MATERIAL AND METHODS

Study design: The study commenced after obtaining permission from the head of the institution and the ethical committee of the college. The study is a cross sectional design, with the subject's parameters measured before and after the designed exercise protocol. The independent variables - 4 types of McKenzie exercises i.e. FIS, EIS, FIL and EIL; while the dependent variables - heart rate, blood pressure (both systolic and diastolic), rate pressure product.

Study setting: Out-patient department V.S.P.M. College of Physiotherapy

Subjects: Population of 80 subjects in the age group of 20-59 years was selected as participants for the study as per the inclusion criteria. Each participant performed the complete exercise protocol to examine the cardiovascular effects of 4 common McKenzie exercises as described earlier.

Sample size: Subjects were equally recruited maintaining an equal number of males and females. All the participants were subjected to the complete exercise protocol.

Inclusion criteria:Apparently healthy and asymptomatic subjects, age group – 20 to 59 years According to McKenzie this age range represents individuals at risk for pathology of the spine, specifically postural syndrome (30 years and younger), dysfunction syndrome (30 years and older) and derangement syndrome (20 to 55 years)[6].

Exclusion criteria: Cardiovascular conditions, pulmonary conditions, anemia, recent musculoskeletal injury, low back pain, intervertebral or facet joint pathology, metabolic disorders, smoking, any neurological deficit, cognitive disorders

Outcome measures:The main outcome measures used were heart rate in beats per minute, blood pressure both systolic and diastolic in mm of Hg and RPP

Pre-exercise protocol: The study purpose was informed to all the participants. They were made aware of the risks and their right to terminate participation at any time. All subjects acknowledged their understanding of the study and their willingness to participate by signing a written consent.

An interview was completed by positioning the subjects in a relaxed sitting position in a firm armchair for 5 minutes, which elicited information about the subject's activity and fitness levels. The activities of subjects were rated on a 3 point scale to establish whether the sample was homogenous concerning activity and fitness level. The resting HR

and BP were recorded in a relaxed sitting position in an armchair.[9,10]The arterial BP was obtained with an aneroid sphygmomanometer applied to the left arm in accordance with the American Heart Association Standards.[10]

The resting HR was determined by palpating the left radial arterial pulse. The pulse was counted for 30 seconds using a stop watch. The value was then multiplied by 2 to obtain a minute rate.[8]

Individuals were familiarized with the patterns of the exercises by verbal instructions, demonstration and practice. Care was taken to see that the practice session did not bring about any training effect to avoid biasing of the study.

Exercise procedure was, according to standard McKenzie protocol.[11]

Fig-1: McKenzie Lumbar spine exercises

Each subject performed all 4 types of above mentioned exercises for 10, 15 and 20 repetitions respectively in a single sitting. Subject was supposed to return to the resting position within 30 seconds.[8] The HR and BP of the subjects were then recorded. Care was taken that the parameters were recorded within 2 minutes.[10] The RPP (Rate pressure product) was calculated by multiplying the product of HR and Systolic BP by $10^{-2.}$

The subjects were instructed to perform the exercises in a continuous rhythm. The rhythm was dictated by the therapist such that on average, each subject could complete 20 repetitions in 1 minute.[8] On each movement, the subject reaches the maximum possible range for all the movements and maintains the position for one second before the next repetition. Breath holding was not allowed during the exercise**.** 15 minutes of rest period was allowed after each set of 10, 15 & 20 repetitions of each of the 4 exercises and also 15 minutes of gap betweenchange in the type of McKenzie exercise.

Data analysis : Descriptive statistics for the dependent measures, including means and standard deviations were calculated for each set of the 4 exercises i.e. Flexion in standing, extension in standing, flexion in lying and extension in lying and for each group i.e. 1, 2, 3, and 4.

Statistically the characteristics of the groups and the results were compared using One- way ANOVA and Paired and Unpaired t tests.

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A one-way analysis of variance (ANOVA) for repeated measures was used to compare the dependent measurements after performing all the four exercises for 10, 15 and 20 repetitions respectively. It was performed for both male and female subjects.

Paired t- test was used to analyze the difference in the mean values of RPP within four types of McKenzie exercises for 10, 15 and 20 repetitions in males.

Unpaired t- test was used to analyze the difference between the mean RPP values of males and females after performing four types of McKenzie exercises for 10, 15 and 20 repetitions.

The level of significance was set at 0.05 for all the comparisons.

RESULTS

Table 1: Mean & standard deviation for RPP

Exercise	Male			Female		
	10 Repetition	15 Repetition	20 Repetition	10 Repetition	15 Repetition	20 Repetition
FIL	116.94±6.90	123.95±6.10	131.34±8.45	105.16±6.48	112.07±6.22	112.07±6.22
EIL	109.86±5.04	116.15±7.23	123.27±7.71	98.01±1.20	102.92±5.32	102.92±5.32
FIS	104.53±5.69	111.55±6.9	117.14±7.79	93.32±7.52	97.46±6.89	97.46±6.89
EIS	100.26±5.50	104.43±6.43	110.35±8.25	86.14±6.24	88.89±7.57	88.89±7.57

Flexion in standing (FIS), extension in standing (EIS), flexion in lying (FIL)& extension in lying (EIL).

Table 2: Comparing for the effects of different exercises in males, after applying One-Way ANOVA

ANOVA Table for Males					
Variable	Source	df	F	p-value	Inference
RPP after 10 repetitions	Between Exercise Groups	3	31.1553	7.74e-16	Highlysignificant
	Within Exercise Groups	156			
RPP after 15 repetitions	Between Exercise Groups	3	(34.428) 37.1464	< 2.2e-16	Highlysignificant
	Within Exercise Groups	(156)155			
RPP after 20 repetitions	Between Exercise Groups	3	(38.0165) 41.5182	< 2.2e-16	Highlysignificant
	Within Exercise Groups	(156)154,			

The above Table shows that $p<0.05$, i.e. there is significant difference between the effects of different exercises on the mean values of RPP of males whatever may be the number of repetitions.

Table3: Comparing for the effects of different exercises in females, after applying One-Way ANOVA

ANOVA Table for Females					
Variable	Source	df	F	p-value	Inference
RPP after 10 repetitions	Between Exercise Groups	3	23.7331	1.044e-12	Highlysignificant
	Within Exercise Groups	156			
RPP after 15 repetitions	Between Exercise Groups	3	35.4009	< 2.2e-16	Highlysignificant
	Within Exercise Groups	156			
RPP after 20 repetitions	Between Exercise Groups	3	45.2708	< 2.2e-16	Highlysignificant
	Within Exercise Groups	156			

The above Table shows that $p<0.05$, i.e. there is significant difference between the effects of different exercises on the mean values of RPP of females whatever may be the number of repetitions.

Table 4: Comparison between the effects of exercises in females using paired t-test

Exercise	10 Repetition		15 Repetition		20 Repetition	
	t value	p value	t value	p value	t value	p value
EIS vs EIL	9.49	0.000	9.58	0.000	11.45	0.000
EIS vs FIS	5.57	0.000	7.06	0.000	7.74	0.000
EIS vs FIL	3.31	0.001	3.97	0.00015	5.44	0.000
EIL vs FIS	13.36	0.000	14.95	0.000	17.39	0.000
EIL vs FIL	8.90	0.000	9.29	0.000	11.92	0.000
FIS vs FIL	7.54	0.000	9.95	0.000	11.66	0.000

Flexion in standing (FIS), extension in standing (EIS), flexion in lying (FIL) & extension in lying (EIL).

Table 5: Comparison between the effects of exercises in males using paired t-test

Exercise	10 Repetition		15 Repetition		20 Repetition	
	t value	p value	t value	p value	t value	p value
EIS vs EIL	8.77	0.000	7.63	0.000	7.23	0.000
EIS vs FIS	6.06	0.000	5.24	0.000	4.46	0.000
EIS vs FIL	11.94	0.000	2.87	0.005	3.54	0.0007
EIL vs FIS	4.44	0.000	13.93	0.000	11.24	0.000
EIL vs FIL	5.23	0.000	7.22	0.000	6.92	0.000
FIS vs FIL	8.13	0.000	8.50	0.000	7.82	0.000

Flexion in standing (FIS), extension in standing (EIS), flexion in lying (FIL) & extension in lying (EIL).

Table 6: Comparison between mean RPP values of males and females using unpaired t-test

Exercise	Repetitions	t-value	p value
	10	0.0669	0.47

FIS	15	1.3468	0.09
	20	1.9517	**0.02***
EIS	10	1.4104	0.08
	15	1.9002	**0.03***
	20	2.3787	**0.009***
FIL	10	0.3629	0.35
	15	0.4224	0.33
	20	0.8806	0.19
EIL	10	0.4028	0.34
	15	0.6745	0.25
	20	0.8833	0.19

The Table shows that p values are significant i.e. $p<0.05$ only in 3 cases. Therefore it can be concluded that mean values of RPP does not differ significantly between males and females except when EIS is repeated 15 or 20 times and when FIS is repeated 20 times.

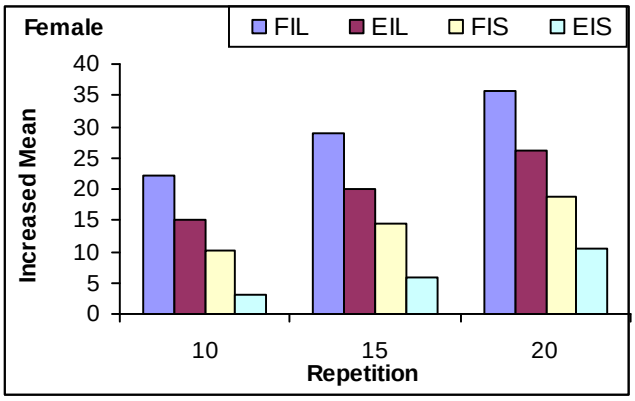

Fig 2:Mean RPP increases such that FIL>EIL>FIS>EIS in females after any number of repetitions.

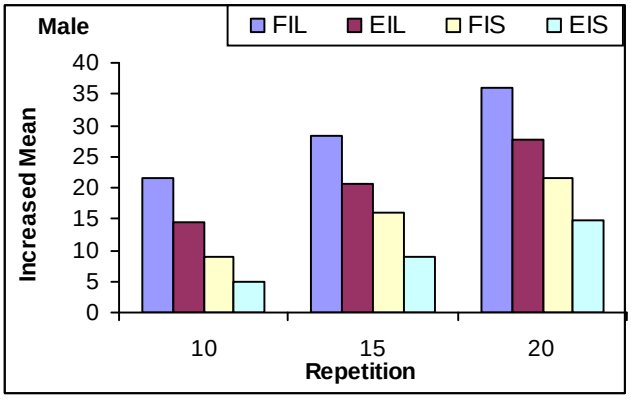

Fig 3: Mean RPP increases such that FIL>EIL>FIS>EIS in males whatever may be the number of repetitions.

DISCUSSION

As a result of data analysis repetitive McKenzie exercises for the lumbar spine elicit significant hemodynamic stress in healthy subjects both males and females. [$p<0.001$] These exercises increase the work of the heart in people with no known spinal impairments and no cardiovascular or cardiopulmonary insufficiencies. It was found that the cardiovascular demand increased as the number of repetitions for a given type of exercise increased.

Richardson D, stated that the magnitude and frequency of active muscular contractions also affect the blood flow. The muscle metabolism increases in response to voluntary contractions, and therefore blood flow to the active musculature.[12]

Claire P. Kispert, proposed that RPP has been shown to be a valid predictor of myocardial VO2 for measurements performed at rest and during exercise. The measurements of RPP is useful in clinical settings because both HR and SBP are easily obtained as noninvasive measurements.[13]

Gobel FL, Nordstom LA, et al concluded in their study that heart rate and rate pressure product, both are easily measured hemodynamic variables andgood predictors of mixed venous oxygen saturation (MVO2) during exercise in ischemic heart disease patients with normal blood pressure.[14]

The results strongly support the idea that these McKenzie exercises performed within 1 minute represents a risk for a patient with underlying cardiovascular dysfunction. The degree to which an increase in RPP is an index of cardiovascular stress, represents cardiovascular strain depends on the underlying path physiology. Thus a given absolute increase of RPP may be inconsequential in a person without cardiovascular or pulmonary pathology; however, it may constitute marked hemodynamic strain in an individual with such pathology.[13]

It was found that mean RPP values were greater after 20 repetitions of each of the 4 exercises when compared to mean RPP values after 10 and 15 repetitions. The mean RPP values were also greater during the exercises which were performed in lying position than in upright position both in male and female subjects (FIL>EIL>FIS>EIS) . This finding is consistent with known physiology.[15]

Tommy Boonestated that cardiac output increases when lying down versus standing [16] which is consistent with the results of the study.

The work of a large muscle mass of the upper and lower extremities, theabdominal muscles, and the trunk muscles are involved in flexion in lying.[11]

Christensen EH, Astrand PO, in their work concluded that volume of oxygen consumed during physical exercise is necessarily dependent upon the load on the muscles and also on the mass of the muscles at work. Work with legs can bring the metabolism to a higher level than can exercise performed by the arms.[17] All these researches confirm that there is increased oxygen demand by the contracting muscleswhich in turn increases the HR, BP, cardiac output and stroke volume.[11]

On the other hand, EILis an exercise that involves the workof upper extremity muscles while raising the upper trunk against gravity.[11]

Several studies by Bevgard S, Freyschuss V, Strandell T, Stenberg J, Astrand P O, Astrand I, Asit G, John W; in their study concluded that arm exercise in comparison with leg exercise is accompanied by a large rise in heart rate, blood pressure, pulmonary ventilation, and arterial lactate concentration and this difference are attributed to more dominating sympathetic vasoconstriction tone during arm exercise. [18]

Flexion in lying, however is additionally associated with inadvertent holding of breath and increased intrathoracic pressure, leading to increased resistance to blood returning to the heart and thus there is a reflex increase in the HR and BP.[11] Thus there is increased workload on the heart during FIL as compared to EIL, which is also in accordance with the results of this study.

The range of motion during back extension is less than during flexion, therefore there is presumably less muscle work, and therefore, less work of the heart in extension compared with flexion, in both standing and lying positions. This fact was also confirmed by the results of the current study. (EIS<FIS)

When the mean RPPs of males and females were compared, it was found that RPP for females were smaller than their counterpart males except in a few cases. However, significant differences were found only when EIS was repeated 15 or 20 times and when FIS was repeated 20 times.

Bengstsson C[19],stated that several studies from industrialized countries have reported age associated changes in both systolic (SBP) and diastolic (DBP) blood pressures. These changes in blood pressures seem to be different for SBP and DBP and have also been reported to be different in male and female subjects.Claire P. Kispert[13] in his article stated that, in general BP is lower for women younger than 40 to 50 years in comparison with men of this age group which also supports the findings of the present study.

The study indicates that before administering McKenzie exercises to any patient having spinal problem cardiovascular status should be examined. This study recommends that, ruling out cardiovascular and pulmonary disease by history taking alone isnot sufficient and cardiac and pulmonary risk factor assessment should be done before prescribing McKenzieexercises. The results of the study suggest that baseline heart rate and blood pressure should be recorded routinely**.** Cardiovascular monitoringshould also be taught to the patient themselves so that cardiovascular monitoring can be performed when repetitive McKenzie exercises for the lumbar spine are performed as a home exercise program. Also whenpatients are following McKenzie protocol as home exercise program care should be taken those they don't exceed the prescribed number of repetitions. It is also suggested that when prescribing FIL which was found to have highest cardiovascular demand, physical therapist should closely monitor the patient. Patients should discourage for breath holding or straining during the exercise**.** Patients should be taught to self monitor their cardiovascular parameters who are knownto have risk factors for cardiovascular disease.

However till date there are seldom studies documented on the adverse cardiovascular effects of McKenzie exercises; therefore awareness of their effects is important for the judicious prescription of designed exercise protocol.

CONCLUSION

McKenzie exercises for the lumbar spine i.e. FIS, EIS, FIL, and EIL performed repetitively i.e. for 10, 15 & 20 repetitions at are routinely used in the assessment & management of low back pain. This study found that these exercises have cardiovascular effects in otherwise healthy individuals & who are within age group of 20-59 years.FIL>EIL>FIS>EISin males as well as females and this effect is accentuated with increasing number of repetitions.Further research is needed to elucidate factors that increase the risk for a given patient. Electrocardiographic

studies would help establish the effects of these exercises on cardiac rhythm and provide a guide for proper prescription of McKenzie exercises.

Limitation:Only non invasive outcome measures were used for cardiovascular evaluation

Conflict of interest: Nil

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