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"DESIGNING AND TESTING OF SPINAL WELLNESS PROGRAM FOR HEALTHY INDIVIDUAL - AN INTERVENTIONAL STUDY"

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Abstract

Background: Human physical structure changes with age along with lifestyle. The changes are constant and irreversible to some extent. The spine is one of the most common structures which changes and leads to changes in other structures. Any kind of adverse changes in spinal structure compromises the proximal stability and mobility which further comprise the distal stability as well as mobility. Certain physical changes like tightness, stiffness, or weakness as well as functional limitations are not recognized until pain and discomfort overcome the ADLs. Spinal wellness should be taken into consideration from early aging with prediction, prevention, and personalization. Thus we would like to develop a comprehensive program for assessing and managing the normality of spinal structure under the spinal wellness program**. AIMS:** To find out the efficacy of the spinal Wellness Program on healthy individuals. **METHODOLOGY:**30 subjects were selected based on the physical assessment such as joint Range of Motion (ROMs), Manual Muscle Testing (MMT), the curvature of the spine, and v-sit & reach test and spine functional index under functional assessment. A subject-specific spinal wellness program was given for two weeks to assess the effect**. RESULT:** All the statistical analysis was done by SPSS 25. An intergroup analysis for comparing the difference between pre and post was done by using an independent sample t-test. In the pre-assessment, we found that normal subjects have a lack of range of motion and strength in the spine. after the program, we saw significant changes in the physical as well as functional outcomes. **CONCLUSION**: In context to result and discussion spinal wellness programs must be taken into consideration in the early age of life within the lifestyle modification to prevent spine-related disease and disorders such a comprehensive spinal wellness program can be prescribed to the community for health and wellness.

KEYWORDS: Spine Wellness, Stretching, Strengthening, Spine Deformity, Physiotherapy, Rehabilitation

INTRODUCTION

The human body is driven through physical and functional activity. Activity has an impact on lifestyle. Technological advances are increasing the number of three physically inactive lifestyles. Lack of exercise is considered a health risk factor and is often associated with the development of degenerative diseases such as hypertension, obesity, and spinal disease.

The present scenario on lifestyle is persons are doing fewer activities and using more gadgets its call sedentary lifestyle and sedentary lifestyle has an impact on person's postural health of the body and its give impact on the structure of the body like bones and muscles due to faulty adaptation of postures it gives more impact on the spinal health of the human body. The spine is an integral part of human mechanics because it has natural curvature that provides the body stability and mobility. Kyphosis is a condition in which the natural curves of the spine are unnaturally high. it can occur as a result of poor posture, while lordosis might develop as a result of an enlarged lumbar curve. A subject with enhanced lumbar lordosis has weak and stretched abdominal muscles, whereas the spine's erector muscles and hip flexor muscles should be shortened. During relaxed standing, these lumbopelvic imbalances should cause an increased lumbar lordosis and an enhanced anterior tilt of the pelvis.[1-3]

Malalignment of the spinal structure affects posture and causes a variety of spinal disorders such as back pain, neck pain, scoliosis, and kyphosis. Back pain and disability are associated with lack of exercise and affect about 80% of the adult population at some point in life. In some cases, this painful condition can be severe and chronic, so an exercise program as a non-pharmacological treatment to improve spinal stability and mobility, thereby reducing back pain and disability. [4-6]

Physical treatments aim to enhance function and stop disability from getting worse, Active strategies like exercise are associated with decreased disability. Passive methods (rest, medications) are related to worsening disability and aren't recommended. Public health programs should educate the general public on the prevention of low back pain and neck pain. The goal of this research is to help the community stay healthy and understand the value of back-related health and awareness activities. [14-23]

A spinal wellness program is a program to assess and maintain the physical and functional alignment of the spine among people without any pain, which incorporates stretching and strengthening to make sure normal structural stability and functional mobility. Wellness is a concept at the forefront of health promotion. The structure of this program is aimed at promoting health and identifying and correcting spinal problems.

Need of the study

physical changes like tightness, stiffness, or weakness as well as functional limitations are not recognized until pain and discomfort overcome the ADLs. Spinal wellness should be taken into consideration from early aging with prediction, prevention, and personalization. Thus we would like to develop a comprehensive program for assessing and managing the normality of spinal structure under the spinal wellness program

Materials and methodology - Materials to be used (a)bubble inclinometer, (b) goniometer (c) measure tape

Methodology

study design: an interventional study

study setting: community-dwelling,

study population: healthy individual

study sample: purposive sampling

Study duration:3 months

sample size: 30

venue for data collection: Rajkot city

CRITERIA FOR SELECTION

Inclusive criteria: age between 20 to 55 years**,** SF 36 health questionnaire **Exclusion criteria:** history of hospitalization in the last six months**,** history of the spinal implant**,** Presence of history of having severe pain

Intervention:

Mode: Stretching and Strengthening

Frequency:1 session/day, 6 days/week, 2 weeks.

Intensity: Stretching 30 sec hold, strengthening 40- 60% of 10RM

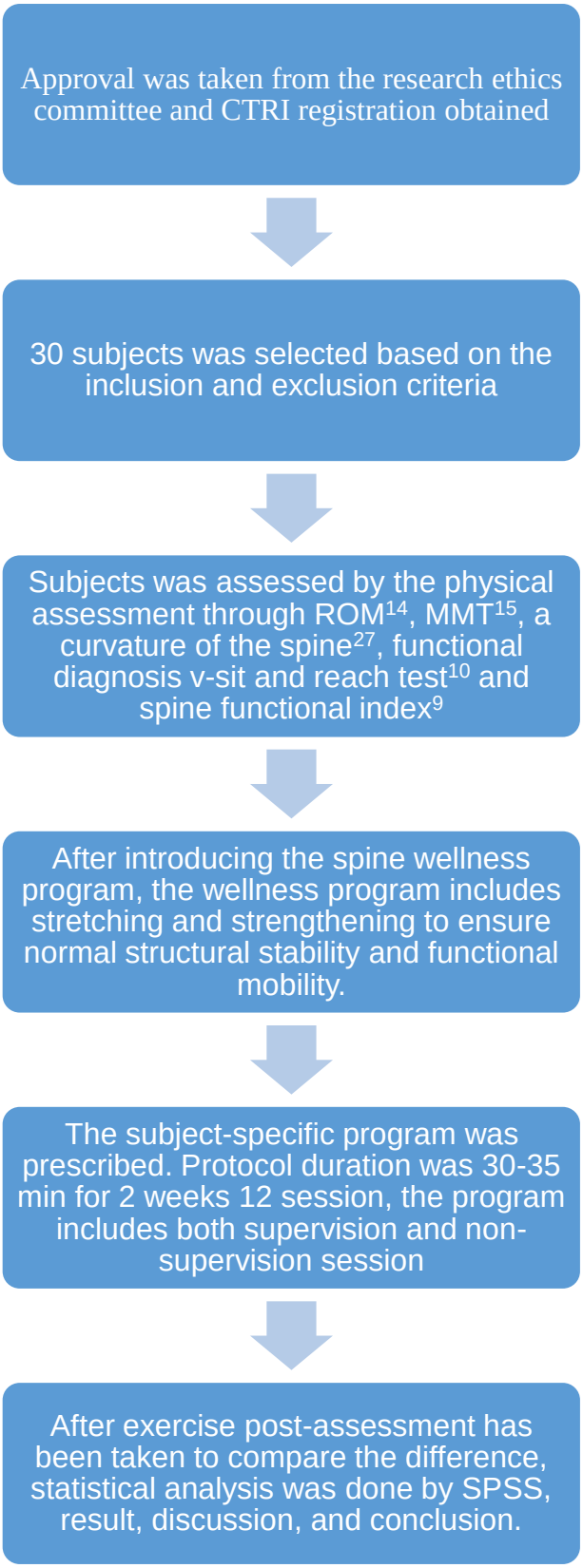
Type: Flexibility and mobility

Time : Each session 30-35 min.

Sessions : Total 12 sessions, 6 Supervised and 6 Non supervised

Repetition: For stretching 3 reps/day, strengthening 10 reps/day

Procedure:



Intervention program

CERVICAL

CERVICAL	MOTION	SHORTENING	LENGTHENING	INTERVENTION	STRENGTHENING EXERCISE	STRETCHING EXERCISE
ROM RESTRICTED	extension	Neck flexors	Neck extensors	Strengthening followed by stretching	Prone kneeling head bending forward and backward, isometric neck exercise	Scalene muscle stretch
ROM RESTRICTED	flexors	Neck extensors	Neck flexors	Strengthening followed by stretching	High lying position head unsupported flexion, isometric neck exercise	Trapezius stretch, scalene and SCM stretch
ROM RESTRICTED	Side flexion	Contralateral Scalene and SCM	Ipsilateral Scalene and SCM	Strengthening followed by stretching	High side-lying head unsupported side flexion, isometric neck exercise	Scalene muscle stretch, trapezius muscle stretch
ROM RESTRICTED	rotation	Contralateral SCM	Ipsilateral SCM	Strengthening followed by stretching	High side-lying head unsupported head rotation, isometric neck exercise	SCM stretch, scalene stretch
CERVICAL	MOTION	LENGTHENING	SHORTENING	INTERVENTION	STRENGTHENING EXERCISE	STRETCHING EXERCISE
DECREASE STRENGTH	extension	Neck extensors	Neck flexors	Strengthening followed by stretching	Prone kneeling head bending forward and backward, isometric neck exercise	Scalene muscle stretch
DECREASE STRENGTH	flexors	Neck flexors	Neck extensors	Strengthening followed by stretching	High lying position head unsupported flexion, isometric neck exercise	Trapezius stretch, scalene and SCM stretch

DECREASE STRENGTH	Side flexion	Ipsilateral Scalene and SCM	Contralateral Scalene and SCM	Strengthening followed by stretching	High side-lying head unsupported side flexion, isometric neck exercise	Scalene muscle stretch, trapezius muscle stretch
DECREASE STRENGTH	rotation	Ipsilateral SCM	Contralateral SCM	Strengthening followed by stretching	High side-lying head unsupported head rotation, isometric neck exercise	SCM stretch, scalene stretch

THORACOLUMBAR

	MOTION	**SHORTENING**	**LENGTHENING**	**INTERVENTION**	**STRENGTHENING EXERCISE**	**STRETCHING EXERCISE**
ROM restricted	Flexion	extensors	flexors	Strengthening followed by stretching	Curl ups, bilateral leg raise	Erector spine stretch, child pose stretching
ROM restricted	Extension	flexors	extensor	Strengthening followed by stretching	Superman, Burd dog	Cobra stretch
ROM restricted	Side bending	Contralateral side flexors	Unilateral side flexors	Strengthening followed by stretching	Side plank hip lift exercise	Quadratus lumborum stretch
ROM restricted	rotation	Contralateral rotators	Unilateral rotators	Strengthening followed by stretching	Russian twist, Supine bicycling crunches, trunk rotation exercise	Oblique muscle stretch

	MOTION	LENGTHENING	SHORTENING	INTERVENTION	STRENGTHENING EXERCISE	STRETCHING EXERCISE
DECREASE STRENGTH	Flexion	flexors	extensors	Strengthening followed by stretching	Curl ups, bilateral leg raise	Erector spine stretch, child pose stretching
DECREASE STRENGTH	Extension	extensor	flexors	Strengthening followed by stretching	Superman, Burd dog	Cobra stretch
DECREASE STRENGTH	Side bending	Unilateral side flexors	Contralateral side flexors	Strengthening followed by stretching	Side plank hip lift exercise	Quadratus lumborum stretch
DECREASE STRENGTH	rotation	Unilateral rotators	Contralateral rotators	Strengthening followed by stretching	Russian twist, Supine bicycling crunches, trunk rotation exercise	Oblique muscle stretch

	shortening	lengthening	intervention	Strengthening exercise	Stretching exercise
Excessive lumbar lordosis	lumbar extensors	Hip flexors, abdominal muscles	Strengthening followed by stretching	Curl ups, bilateral leg raise, Russian twist	Erector spine stretch, child pose stretching
Decreased lumbar lordosis	Hamstrings, Abdominal muscles	iliopsoas muscle, lumbar extensor	Strengthening followed by stretching	Superman, Burd dog, SLR	Hamstring stretch, cobra stretch

	SHORTENING	LENGTHENING	INTERVENTION	STRENGTHENING EXERCISE	STRETCHING EXERCISE
EXCESSIVE KYPHOSIS	pectoralis major, subclavius, and pectoralis minor	trapezius, rhomboids, and rotator cuff muscles	Strengthening followed by stretching	Blackburn exercise	Corner pec stretch

PELVIC

	SHORTENING	LENGTHENING	INTERVENTION	STRENGTHENING EXERCISE	STRETCHING EXERCISE
	iliopsoas, lumbar extensors	Abdominal muscles	strengthening, followed by stretching	Curl ups, bilateral leg raise, Russian twist	Erector spine stretch, child pose stretching
POSTERIOR PELVIC TILT	Hamstring, glutes, and lower abdominal muscles	Quadriceps, lower back muscles	strengthening, followed by stretching	Superman, squat, high sitting knee extension	Cobra pose, hamstring stretch
LATERAL PELVIC TILT	Opposite side abductors and erector spine	Same side erectors spine and abductors	Strengthening followed by stretching	Superman, Burd dog, side SLR	Erector spine stretch, child pose stretching, piriformis stretch

HIP

	MOTION	LENGTHENING	SHORTENING	INTERVENTION	STRENGTHENING EXERCISE	STRETCHING EXERCISE
ROM RESTRICTED	Flexion	Iliopsoas, rectus femoris	Hamstring, gluteus Maximus	Strengthening followed by stretching	Supine SLR, squatting	Hamstring stretch, unilateral knee to chest
ROM RESTRICTED	Extension	Hamstring, gluteus Maximus	Iliopsoas, rectus femoris	Strengthening followed by stretching	Squatting, standing hamstring curl	Iliopsoas and quadriceps stretch
ROM RESTRICTED	abduction	Piriformis, gluteus medias, gluteus-minimus	Adductors longus, brevis	Strengthening followed by stretching	Side SLR, squat to hip abduction	Butterfly stretch, sumo squat
ROM RESTRICTED	adduction	Adductors longus, brevis	Piriformis, gluteus medias, gluteus-minimus	Strengthening followed by stretching	Side lying hip adduction	Piriformis stretch, sumo squat

ROM RESTRICTED	Medial rotation	anterior fibres of gluteus medius and minimus, tensor fascia latae	biceps femoris, gluteus maximus, piriformis	Strengthening followed by stretching	Squat to hip abduction, side lying abduction	Unilateral knee to chest, piriformis stretch, hamstring stretch
ROM RESTRICTED	Lateral rotation	biceps femoris, gluteus maximus, piriformis	anterior fibres of gluteus medius and minimus, tensor fascia latae	Strengthening followed by stretching	Hamstring curl, Squat to hip abduction, side SLR	TFL stretch, sumo squat

	MOTION	**SHORTENING**	**LENGTHENING**	**INTERVENTION**	**STRENGTHENING EXERCISE**	**STRETCHING EXERCISE**
DECREASE STRENGTH	Flexion	Hamstring, gluteus Maximus	Iliopsoas, rectus femoris	Strengthening followed by stretching	Supine SLR, squatting	Hamstring stretch, unilateral knee to chest
DECREASE STRENGTH	Extension	Iliopsoas, rectus femoris	Hamstring, gluteus Maximus	Strengthening followed by stretching	Squatting, standing hamstring curl	Iliopsoas and quadriceps stretch
DECREASE STRENGTH	abduction	Adductors longus, brevis	Piriformis, gluteus medias, gluteus-minimus	Strengthening followed by stretching	Side SLR, squat to hip abduction	Butterfly stretch, sumo squat
DECREASE STRENGTH	adduction	Piriformis, gluteus medias, gluteus-minimus	Adductors longus, brevis	Strengthening followed by stretching	Side-lying hip adduction	Piriformis stretch, sumo squat
DECREASE STRENGTH	Medial rotation	biceps femoris, gluteus maximus, piriformis	anterior fibers of gluteus medius and minimus, tensor fascia lata	Strengthening followed by stretching	Squat to hip abduction, side-lying abduction	Unilateral knee to chest, piriformis stretch, hamstring stretch

DECREASE STRENGTH	Lateral rotation	anterior fibres of gluteus medius and minimus, tensor fascia latae	biceps femoris, gluteus maximus, piriformis	Strengthening followed by stretching	Hamstring curl, Squat to hip abduction, side SLR	TFL stretch, sumo squat

SCAPULA AND SHOULDER

	Present	**lengthening**	**shortening**	**intervention**	**Strengthening exercise**	**Stretching exercise**
protraction	Yes, or no	trapezius, rhomboids, and latissimus dorsi muscles	serratus anterior, pectoralis major, and pectoralis minor muscles	Strengthening followed by stretching	Black burn ex's	Corner pec stretch
retraction	Yes, or no	serratus anterior, pectoralis major, and pectoralis minor muscles	trapezius, rhomboids, and latissimus dorsi muscles	Strengthening followed by stretching	Wall pushups	Trapezius stretch, Last stretch
Elevation	Yes, or no	Upper trapezius, serratus anterior, levator scapulae	trapezius, rhomboid muscles	Strengthening followed by stretching	Shoulder shrug, Prone on elbow	Rhomboid stretch, treps stretch
depression	Yes, or no	Trapezius, rhomboid muscles	Upper trapezius, serratus anterior, levator scapulae	Strengthening followed by stretching	Black burn ex's	Trapezius stretch, lats stretch, levator scapulae stretch

Statistical analysis

Statistical analysis was done using SPSS version 25 was used to generate graphs and tables.

Variable was assessed for normality. For that value of skewness, kurtosis, histogram, and Shapiro-Wilk test was used.

For the normal distribution, the value of skewness and kurtosis should be between -1.96 to +1.96 and the value for the Shapiro-Wilk test should be greater than 0.05.

Data were normally distributed so the paired T-test (parametric) was used.

The level of significance was considered less than 0.05, the confidence interval was kept at 95%

Result:

Table 1: Range of Motion of Cervical Spine Test Analysis

		Mean	SD	T value	P-value
Left side rotation	Pre	14.57	1.524	4.894	0.000
	Post	13.17	0.699		
Right side rotation	pre	14.70	1.442	6.073	0.000
	Post	13.17	0.699		
Left side flexion	Pre	14.87	1.408	7.549	0.000
	Post	13.13	0.681		
Right side flexion	Pre	14.83	1.416	7.369	0.000
	Post	13.13	0.681		

Interpretation: Paired T-Test of Range of Motion was done. As per the data analysed, the p-value (probability value) of all ROM is 0.000 which is less than 0.05 (standard value). This shows there is a significant difference between Pre ROM score and Post ROM score. Moreover, there is also improvement seen in the mean Post ROM value

Table 2: Analysis of The Range of Motion Thoracolumbar Spine

		Mean	SD	T value	P value
Flexion	Pre	8.13	1.456	-6.326	0.000
	Post	9.70	0.535		
Extension	pre	8.17	1.440	-5.049	0.000
	Post	9.50	0.861		
Lt lateral flexion	Pre	35.17	7.159	8.732	0.000
	Post	27.33	4.088		
Rt lateral flexion	Pre	35.53	7.286	8.733	0.000
	Post	27.53	4.208		

Interpretation: Paired T-Test of Range of Motion of thoracolumbar spine was done. As per the data analyzed, the p-value (probability value) of all ROM is 0.000 which is less than 0.05 (standard value). This shows there is a significant difference between Pre ROM score and Post ROM score. Moreover, there is also improvement seen in the mean Post ROM value.

Table 3: Analysis of The Range of Motion Lumbar Spine

		Mean	SD	T value	P-value
Flexion	pre	7.00	1.414	-7.047	0.000
	post	7.77	0.935		
extension	Pre	3.07	1.461	-7.449	0.000
	post	3.80	1.064		

Interpretation: Paired T-Test of Range of Motion of the lumbar spine was done. As per the data analysed, the p-value (probability value) of all ROM is 0.000 which is less than 0.05 (standard value). This shows there is a significant difference between Pre ROM score and Post ROM score. Moreover, there is also improvement seen in the mean Post ROM value.

Table 4: V Sit and Reach Test

		Mean	SD	T value	P-value
V sit and reach test	pre	21.43	2.254	-5.215	0.000
	post	22.37	2.008		

Interpretation: Paired T-Test of v sit and reach test was done. As per the data analysed, the p-value (probability value) of all v sit and reach tests is 0.000 which is less than 0.05 (standard value). This shows there is a significant difference between Pre v sit and reach test score and Post v sit and reach test score. Moreover, there is also improvement seen in the mean Post v sit and reach test value.

Table 5: Spine Functional Index

		Mean	SD	T value	P-value
Spine functional index	Pre	94.13	3.636	8.363	0.000
	Post	99.47	1.383		

Interpretation: Paired T-Test of spine functional index was done. As per the data analysed, the p-value (probability value) of all ROM is 0.000 which is less than 0.05 (standard value). This shows there is a significant difference between the Pre SPI score and the Post SPI score. Moreover, there is also improvement seen in the mean Post SPI value.

Table 6: Manual Muscle Testing of the Spine

		Mean	SD	t value	P value
Flexion	Pre	4.07	0.740	-7.047	0.000
	Post	4.90	0.305		
Extension	Pre	3.87	0.730	-7.449	0.000
	Post	4.77	0.504		
rotation	Pre	4.07	0.740	-7.047	0.000
	Post	4.90	0.305		
t/extension	Pre	3.87	0.730	-7.449	0.000
	Post	4.77	0.504		

Interpretation: Paired T-Test manual muscle test was done. As per the data analysed, the p-value (probability value) of all MMT is 0.000 which is less than 0.05 (standard value). This shows there is a significant difference between the Pre MMT

score and Post MMT score. Moreover, there is also improvement seen in the mean Post MMT value.

Table 7: Curvature of The Spine

		Mean	SD	T value	P value
T1-T2	Pre	21.67	7.112	5.693	0.012
	Post	20.67	5.979		
T11-T12	pre	21.83	6.884	2.971	0.006
	Post	20.67	5.683		
L1-L2	Pre	11.00	5.931	-2.971	0.006
	Post	12.17	5.032		
L4-L5	Pre	11.17	6.254	-2.971	0.006
	Post	12.33	5.371		

Interpretation: Paired T-Test of curvature of the spine was done. As per the data analysed, the p-value (probability value) of all curvatures of the spine is 0.000 which is less than 0.05 (standard value). This shows there is a significant difference between Pre curvature of the spine score and Post curvature of the spine score. Moreover, there is also improvement seen in the mean Post curvature of the spine value.

Discussion:

Above study demonstrated that stretching exercises targeting the neck muscles trapezius, scalene, sternocleidomastoid significantly improve neck range of motion and increase neck functions among healthy individuals. When you stretch a muscle, your body responds by increasing blood flow to that area. The blood vessels around the targeted muscle widen to allow more blood to flow through, and your heart starts pumping more blood. Our results were in line with previous studies showing the benefit of stretching exercise for the neck condition.

the current study was to evaluate the effectiveness of stretching on thoracolumbar range of motion (ROM), functional limitation in a healthy individual. Erector spine stretch, child pose stretching, cobra stretch, quadratus lumborum stretch, oblique muscle stretch one can demonstrate improvement on thoracolumbar ROM.

the current study was to evaluate the effectiveness of stretching on lumbar range of motion (ROM), functional limitation in a healthy individual. Erector spine stretch, child pose stretching, cobra stretch, quadratus lumborum stretch, oblique muscle stretch one can demonstrate improvement on lumbar ROM. When you stretch a muscle, your body responds by increasing blood flow to that area. The blood vessels around the targeted muscle widen to allow more blood to flow through, and your heart starts pumping more blood. Our results were in line with previous studies showing the benefit of stretching exercise for the back condition.

v sit and reach test is one of the linear flexibility tests which helps to measure the extensibility of the hamstrings and lower back. In the post mean we can find the improvement in the flexibility in the hamstring and lower back. Because we did the back flexibility and strengthening exercise which helps in the back flexibility and mobility.

we find out to increase spine functional index score after this program, because our program is target the whole spine, and our program includes stretching and strengthening exercises which help in the improvement in spinal stability and mobility.

above study demonstrated that strengthening exercise targeting the back and core muscles and exercise we done curl-ups, bilateral leg raise, superman, burd dog, side plank leg lift, Russian twist significantly improve back range of motion and increased back functions among healthy individuals. In the pre mean we find out lumbar flexion strength is more than lumbar extension, which causes muscle imbalance. And this is one of the reasons for back pain, so in this wellness program, we fix it.

in the measurement of the curvature of the spine we find the subject is affected by poor posture that's why they have kyphosis, increase lumbar

lordosis, and some have a flat back syndrome. When the person's lumbar lordosis is increase so they have tightness in the back and weakness the abdominal muscle, the body's posture affects by the kinetic chain, and time our comprehensive program helps in the improvement in the spinal stability and mobility, after the program, we have seen a significant change in the curvature of the spine.

Conclusion

In context to result and discussion spinal wellness program must be taken into consideration in the early age of life within the lifestyle modification to prevent spine-related disease and disorder such comprehensive spinal wellness program can be prescribed to the community for health and wellness.

However, further study is needed to evaluate the efficacy of the present spinal wellness program with available therapeutic plans for understanding changes between the groups.

Reference:

1. Chaurasia BD. BD Chaurasia's Human Anatomy. CBS Publishers & Distributors Pvt Ltd.; 2010.
2. Bogduk N. Functional anatomy of the spine. Handb Clin Neurol. 2016;136:675-88. PMID: 27430435. doi: 10.1016/B978-0-444-53486-6.00032-6.
3. Sadler SG, Spink MJ, Ho A, De Carvalho DE. Restriction in lateral bending range of motion, lumbar lordosis, and hamstring flexibility predicts the development of low back pain: a systematic review of prospective cohort studies. BMC Musculoskelet Disord. 2017 Mar 7;18(1):179. PMID: 28264687. doi: 10.1186/s12891-017-1529-6.
4. Youdas JW, Garrett TR, Egan KS, Therneau TM. Lumbar lordosis and pelvic inclination in adults with chronic low back pain. Phys Ther. 2000 Mar;80(3):261-75. PMID: 10696121.
5. Manchikanti L, Singh V, Falco FJ, Benyamin RM, Hirsch JA. Epidemiology of low back pain in adults. Neuromodulation. 2014 Oct;17 Suppl 2:3-10. PMID: 25395112. doi: 10.1111/ner.12214.
6. Andersson GB. Epidemiological features of chronic low-back pain. Lancet. 1999 Aug 14;354(9178):581-5. PMID: 10470716.
7. Henchoz Y, Kai-Lik So A. Exercise and nonspecific low back pain: a literature review. Joint Bone Spine. 2008 Oct;75(5):533-9. PMID: 18940772. doi: 10.1016/j.jbspin.2008.01.019.
8. Didia BC, Jaja BN, Abere EI, Agi CE. Measurement of spinal curvature: a comparison of two manual methods. Eur J Gen Med. 2011;8(3):189-93. doi: 10.29333/ejgm/82570.
9. Gabel CP, Melloh M, Burkett B, Michener LA. The Spine Functional Index: development and clinimetric validation of a new whole-spine functional outcome measure. Spine J. 2019 Feb;19(2):e19-e27. PMID: 30189311. doi: 10.1016/j.spinee.2018.08.006.
10. López-Miñarro PA, Alacid F, Rodríguez-García PL. A comparison of the sit-and-reach test and the back-saver sit-and-reach test in university students. J Sports Sci Med. 2009 Mar 1;8(1):116-22. PMID: 24149754.
11. Magee DJ. Orthopedic physical assessment-E-Book. Elsevier Health Sciences; 2014 Mar 25.
12. Joshua A.et al, ''Examination of a Clinical Prediction Rule to Identify Patients With Neck Pain Likely to Benefit From Thoracic Spine Thrust Manipulation and a General Cervical Range of Motion Exercise: Multi-Center Randomized Clinical Trial", *Physical Therapy*, Volume 90, Issue 9, 1 September 2010.
13. Kisner C,et al, Therapeutic exercise: foundations and techniques. Fa Davis; 2017 Oct 18.
14. Norkin CC, White DJ. Measurement of joint motion: a guide to goniometry. FA Davis; 2016 Nov 18
15. Hislop H, Avers D, et al,Daniels and Worthingham's muscle Testing-E-Book: Techniques of manual examination and

performance testing. Elsevier Health Sciences; 2013 Sep 27.
16. Kim B, Yim J. Core Stability and Hip Exercises Improve Physical Function and Activity in Patients with Non-Specific Low Back Pain: A Randomized Controlled Trial. Tohoku J Exp Med. 2020 Jul;251(3):193-206. doi: 10.1620/tjem.251.193. PMID: 32669487.
17. Kim D, et al "Effect of an exercise program for posture correction on musculoskeletal pain." J Phys Ther Sci. 2015 Jun;27(6):1791-4,Epub 2015 Jun 30.
18. Cho HY, Kim EH, Kim J. Effects of the CORE Exercise Program on Pain and Active Range of Motion in Patients with Chronic Low Back Pain. J Phys Ther Sci. 2014 Aug;26(8):1237-40. doi: 10.1589/jpts.26.1237. Epub 2014 Aug 30. PMID: 25202188; PMCID: PMC4155227
19. Gram B, Andersen C, Zebis MK, Bredahl T, Pedersen MT, Mortensen OS, Jensen RH, Andersen LL, Sjøgaard G. Effect of training supervision on effectiveness of strength training for reducing neck/shoulder pain and headache in office workers: cluster randomized controlled trial. Biomed Res Int. 2014;2014:693013. doi: 10.1155/2014/693013. Epub 2014 Feb
20. Dettori JR, et al,The effects of spinal flexion and extension exercises and their associated postures in patients with acute low back pain. Spine (Phila Pa 1976). 1995 Nov 1;20(21):2303-12. doi: 10.1097/00007632-199511000-00008.
21. Youdas JW,et al,Lumbar lordosis and pelvic inclination in adults with chronic low back pain. Phys Ther. 2000 Mar;80(3):261-75.
22. Sheikhhoseini R, Shahrbanian S, Sayyadi P, O'Sullivan K. Effectiveness of Therapeutic Exercise on Forward Head Posture: A Systematic Review and Meta-analysis. J Manipulative Physiol Ther. 2018 Jul-Aug;41(6):530-539. Epub 2018 Aug 11.
23. Gatti R, et al, "Efficacy of trunk balance exercises for individuals with chronic low back pain: a randomized clinical trial." J Orthop Sports Phys Ther. 2011 Aug;41(8):542-52. Jun 7 2011
24. Cleland JA, Mintken PE, Carpenter K, Fritz JM, Glynn P, Whitman J, Childs JD. Examination of a clinical prediction rule to identify patients with neck pain likely to benefit from thoracic spine thrust manipulation and a general cervical range of motion exercise: multi-center randomized clinical trial. Phys Ther. 2010 Sep;90(9):1239-50. Jul 15 ,2010
25. Cho HY, et al,Effects of the CORE Exercise Program on Pain and Active Range of Motion in Patients with Chronic Low Back Pain. J Phys Ther Sci. 2014 Aug;26(8):1237-40.
26. Lima VP, de Alkmim Moreira Nunes R, da Silva JB, Paz GA, Jesus M, de Castro JBP, Dantas EHM, de Souza Vale RG. Pain perception and low back pain functional disability after a 10-week core and mobility training program: A pilot study. J Back Musculoskelet Rehabil. 2018;31(4):637-643. doi: 10.3233/BMR-169739. PMID: 29526837.
27. Cho HY, Kim EH, Kim J. "Effects of the CORE Exercise Program on Pain and Active Range of Motion in Patients with Chronic Low Back Pain. J Phys Ther Sci. 2014 Aug;26(8):1237-40. doi: 10.1589/jpts.26.1237. Epub 2014 Aug 30. PMID: 25202188; PMCID: PMC4155227.
28. Rainville J, Hartigan C, Martinez E, Limke J, Jouve C, Finno M. Exercise as a treatment for chronic low back pain. Spine J. 2004 Jan-Feb;4(1):106-15.
29. Devaney L,et al, "Description and clinimetric properties. Physiother Theory Pract." 2017 Oct;33(10):797-804.Epub 2017 Aug 4.
30. Malik, et al,"Normative Values of Modified-Modified Schober Test in Measuring Lumbar Flexion and Extension: A Cross-Sectional Study." International Journal of Health Science and Research. 6. 1