Influence of circadian variation on conservative management of spondylolisthesis

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ABSTRACT

Conservative management of spondylolisthesis is gaining acceptance over surgical corrections. The circadian timing system is known to control the majority of human performances. This study was carried out to investigate the effect of the circadian rhythms on the efficacy of a conservative rehabilitation program for patients with spondylolisthesis. Sixty volunteer patients were included in the study and randomly assigned to two groups. Both groups received the same program of treatment but at different times of the day and for three months. The range of trunk flexion, and the strength of the trunk flexors were measured for both groups before the program started and immediately after the application of the program. The fingertip-floor test and the isokinetic dynamometer were used for measurements. The results of the study showed that the range of trunk flexion and the strength of trunk flexors were improved in both groups. In-group one it was 30.20 ± 7.48 cm., and 48.40 ± 15.03 N-m. respectively and became 4.83 ± 6.97 cm., and 99.26 23.11 N-m. after the program was completed. In- group two the range of trunk flexion was 35.30 8.63 cm., and became 9.23 ± 6.51 cm., and isometric strength was 45.26 ± 13.98 N-m. and became 72.96 ± 17.80 N-m. The post treatment improvements were significantly higher in-group one trained in the afternoon. No differences were found when time of testing was switched. This means that the conservative management program is effective in treatment of spondylolisthesis, and the circadian rhythms had a significant influence upon the program efficacy.

Keywords: Spondylolisthesis, conservative treatment, circadian rhythm, trunk mobility, trunk strength.

INTRODUCTION

Spondylolisthesis is a common cause of low back dysfunction. It is common at the level of lumbosacral joint[9]. Forward slippage occurs when there are defective laminae and/or facets joints[18]. The main clinical symptoms are back pain and /or sciatica, increased lumbar lordosis, tight lumbar erector spinae and hip flexors, weak abdominal muscles, and in coordination of the lumbar-pelvic rhythm[5,14] The degree and progression of slippage are not necessarily associated with the clinical symptoms, or related to the severity of symptoms[27].

Conservative treatment of spondylolisthesis is focused on controlling and minimizing anterior shear stress in the lower

spine through stretching the tight structures and strengthening the abdominal muscles [5] Strengthening of the deep abdominal muscles provide dynamic stability and fine control to the lumbar spine[26].

Many physiological and endocrinal functions of the body are controlled through a circadian timing system[2], which is also related to performance of physical activities[8]. Physical activities performance was found to vary with time of day[16], and to improve during the afternoon and evening hours especially muscle strength and flexibility[11,12,13,15,23,24].

The purpose of this study was to assess the effect of a conservative exercise program for spondylolisthesis on increasing spinal stability as measured by trunk flexors strength, and trunk flexion range of motion. Also to find out the influence of circadian variation on the program.

MATERIALS AND METHODS

Subjects

Sixty subjects (14 males and 46 females) 35 to 52 years old (mean age, 44.13 years, standard deviation, 6.23 years) with confirmed first or second degree spondylolisthesis, voluntarily participated in the study. All subjects were from Kasr-El-Aini orthopaedic out patient clinic university hospitals and met the following criteria: (1) spondylolisthesis of L_{4-5} or L_5-S_1; (2) no associated back injuries, or general illness; (3) no fractures of the spine; and (4) no medication was used three months prior to the study or during the study. All subjects signed informed consent form. The subjects were assigned randomly into two equaled groups.

Instrumentation

a) Musculoskeletal Evaluation Rehabilitation And Conditioning (MERAC) isokinetic dynamometer with trunk attachment. Universal Gym Equipment, Inc., 72nd Avenue, SW, P.O. Box 1270, Cedar Rapids, Iowa, U.S.A.
b) Standard measuring tape. Tape has markings in both inches and centimeters; length is 6 ft. (180 cm).

Procedures

A) Evaluation

Patients were subjected to initial physical therapy evaluation including measurement of active range of motion of trunk flexion, and the maximum pain free voluntary isometric contraction of the trunk flexors.

The active range of movement of the trunk was measured from standing position[22]. The patient was instructed to bend forward as far as he could and to try to touch his toes. The patient was asked to keep his knees straight during bending forward. The distance from his fingertips to the floor was measured three times and the average was recorded for each patient.

The maximal pain free isometric contraction of the trunk flexors was measured by the use of the MERAC dynamometer, fitted with trunk attachment, using a standard testing protocol from modified sitting position[20,28]. The stop points were met at 30 and 60 degrees[17]. The mean of three successive measurements was calculated and recorded. The interrater reliability for the dynamometer has been reported to be excellent with an ICCs of 0.93 to 0.98 for trunk muscles performance measurement[25].

The measurement procedures were conducted immediately after the conclusion of the treatment program; once at the same time of the day the group used to receive the treatment program, and once at the time of the

day the other group used to receive the program.

B) Treatment

The exercise program included the following: (1) Lower back muscles stretching from hook lying position, (2) Lower back muscles, hamstrings, and gastrocnemius muscles stretching from long sitting position with both feet supported on the wall and a belt to keep both knees extended; (3) Iliopsoas muscle stretching from supine lying position with both lower limbs outside the lower end of the treatment table, the therapist kept one lower limb flexed and supported with his hand, the other hand was used to stretch the iliopsoas of the opposite hip; (4) strengthening of the abdominal muscles from crock lying position and raising the head; the exercise was repeated raising the head and shoulders as a graduation; and to a sitting position as a further graduation.

All the stretching exercises were performed for thirty seconds and a rest period of thirty seconds and for three repetitions[3,4]. The abdominal strengthening exercises were performed to the target position, then to hold for count of ten, relaxation for equal amount of time, and were repeated for ten times each during the first three weeks, then the repetitions was increased to 20 times for the rest of the program. The strengthening abdominal exercises were performed gradually; the first exercise during the first week of the program, the second one was added during the second week, and the third one during the third week. The program was performed three times a week for three months. The first group performed the program at 15:00-17:00 Pm, the second group performed the program at 8:00-10:00 Am.

RESULTS

Group one consisted of thirty subjects (6 males ad 24 females) mean age was 46.58 6.91 years. Group two consisted of thirty subjects (8 males and 22 females) mean age was 41.68 ± 5.23 years.

The mean of pretreatment and post treatment measurements of trunk active range of flexion motion; and the maximum pain free voluntary isometric contraction of the trunk flexors were compared using the paired t-test for each group, differences were considered significant at $P \leq .05$ (tables 1 and 2, Figs 1 and 2).

Table (1): Comparison between the pre and post treatment measurements of trunk flexion and trunk flexors strength in group one.

	Range of motion (cm.)*		Strength (N-M)**	
	Pre treatment	Post treatment	Pre treatment	Post treatment
Range				
minimum	15	0	25	66
maximum	45	25	90	160
Mean	30.20	4.83	48.40	99.26
St. deviation	7.48	6.97	15.03	23.11
St. error	1.36	1.27	2.74	4.21
t-value	16.4254		-13.06211	
2-Tail probability	0.0000***		0.0000***	

*centimeter. ** Newton/meters. ***significant.

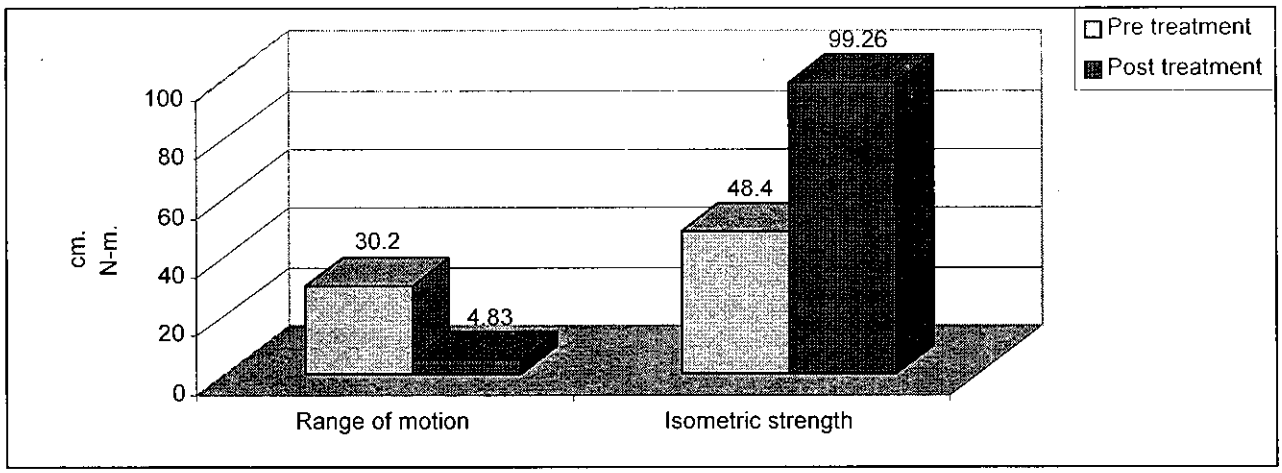

Fig. (1): Pretreatment and post treatment trunk range of motion and isometric strength for group one.

Table (2): Comparison between pre and post treatment measurements of trunk flexion and trunk flexors strength in group two.

	Range of motion (cm.)*		Strength (N-m)**	
	Pre Treatment	Post treatment	Pre Treatment	Post treatment
Range				
minimum	15	0	30	40
maximum	51	25	90	111
Mean	35.30	9.23	45.26	72.96
St. deviation	8.63	6.51	13.98	17.80
St. error	1.57	1.18	2.55	3.25
t-value	18.57191		-10.60072	
2-tail probability	0.0000***		0.0000***	

*centimeter. ** Newton/meters. ***significant.

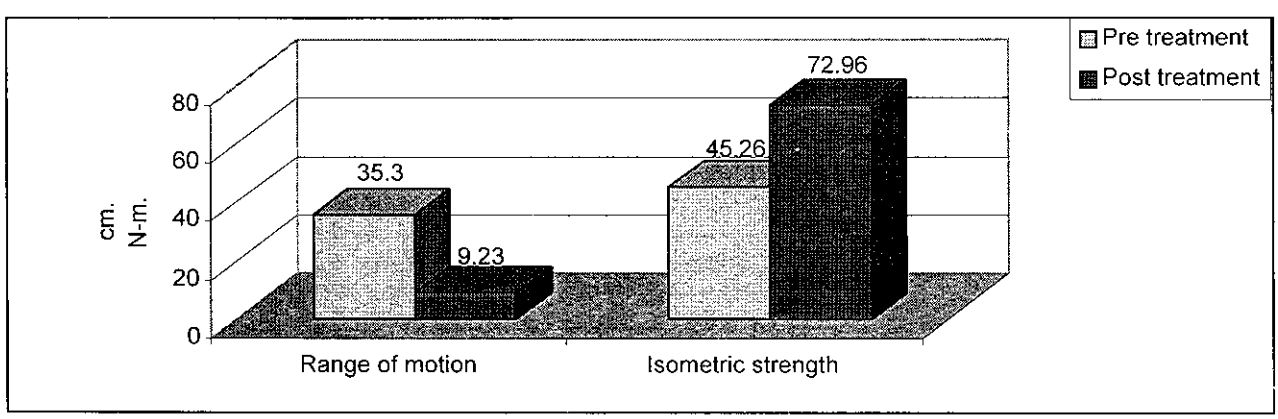

Fig. (2): Pretreatment and post treatment trunk range of motion and isometric strength for group two.

The mean of post treatment measurements of trunk active range of flexion motion; and the maximum pain free voluntary isometric contraction of the trunk flexors were compared in the two groups using the unpaired t-test, differences considered significant at $P \leq .05$ (Table 3, and Fig. 3).

Table (3): Comparison between the post treatment measurements of trunk flexion and trunk flexors strength in the two groups.

	Range of motion (cm.)*		Strength (N-m)**	
	Group one post treatment	Group two post treatment	Group one post treatment	Group two post treatment
Range				
minimum	0	0	66	40
maximum	25	25	160	111
Mean	4.83	9.23	99.26	72.96
St. deviation	6.97	6.51	23.11	17.80
St. error	1.27	1.18	4.21	3.25
t-value	-2.525133		4.937423	
2-tail probability	0.0143***		0.0000***	

*centimeter. ** Newton/meters. ***significant.

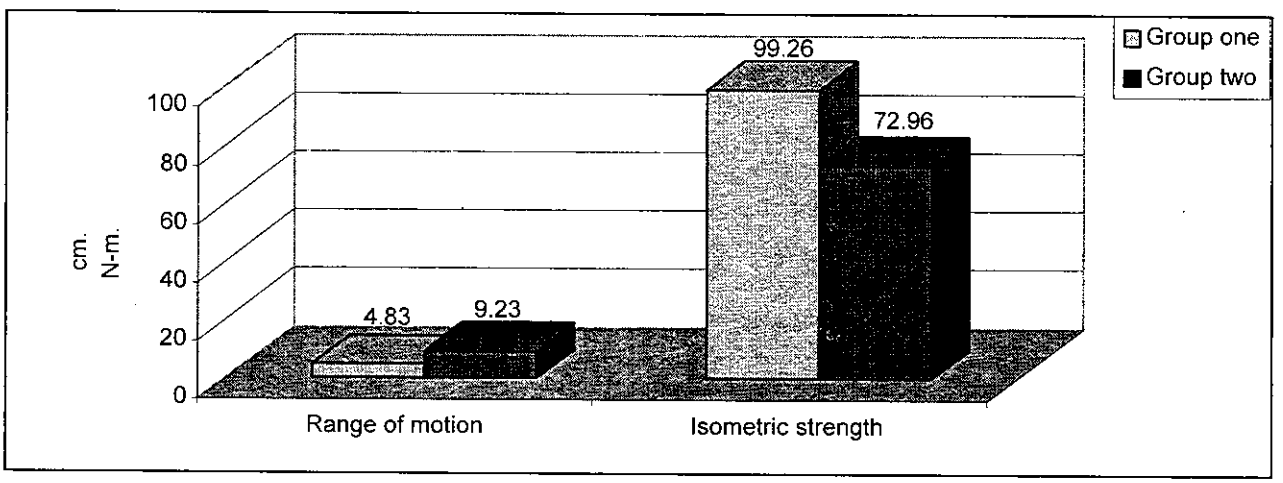

Fig. (3): The mean values of the post treatment measurements of range of trunk motion and isometric strength of trunk flexors of both groups.

Comparison of the same measurements taken for both groups post treatment but at the time of the day that the other group used for treatment showed no significant differences ($P>.05$) from the measurements taken at the regular treatment time of the day for both groups.

DISCUSSION

Spondylolisthesis leads to segmental instability[6]. The mechanical imbalance of the muscles leads to hyperlordotic posture of the lumbosacral region[5], kyphotic deformity in the sagittal plane of the sacrum[1], incoordination of the lumbar-pelvic rhythm[14], and restriction of forward bending which is a combined lumbar

and hip motion[19]. Forward trunk bending restriction was related to limitation of lumbar-pelvic movement and to shortening of hamstring muscles[21].

The conservative approach used in this study was directed to solve the above mentioned problems through stretching of the tight structures and strengthening of the abdominal muscles to address the mechanical instability and the muscle imbalances. The findings of the study supported the claim that stretching of the tight structures improve lumbopelvic posture and lumbar and hip motion during forward bending of the trunk[21]. Abdominal strengthening exercises would help to reduce the anterior shear stresses across the lumbosacral junction through balancing the muscular forces and stresses in the lower spine. The improved strength of the abdominal muscles accompanied by increased intra-abdominal pressure could have increased the anterior support of the spinal column and prevented further slipping of the vertebrae[7,10].

The recorded measurements for pre and post treatment trunk bending range of motion and trunk flexors isometric strength were significantly different in both groups.

The improvements of the post treatment measurements of the first group, trained between 15:00 to 17:00 Pm hours, were significantly higher than that of the second group, trained between 8:00 to 10:00 Am hours. It was proposed that muscle strength and flexibility would improve during the afternoon and early evening hours[11,12,13,23,24] The results of the present study support that proposal.

To eliminate the possibility that the improvements were time dependant, or related to habitual behavior, switching the time of testing procedures for both groups revealed no significant differences in the performance of both groups at either testing time.

Based on the findings of the study, it is therefore suggested that tight structures stretching and weak abdominal muscles strengthening should be included in all conservative rehabilitation programs for spondylolisthesis. The program is recommended to be performed in the afternoon or early evening.

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الملخص العربي

تأثير تغير الإيقاع الحيوي على برنامج علاج تحفظي للانزلاق الفقاري الأمامي

العلاج التحفظي للانزلاق الفقاري الأمامي يحظى بالقبول عن التدخلات الجراحية ، إنه من المعروف أن نظام الإيقاع الحيوي يتحكم في غالبية الأداء الإنساني .

يهدف هذا البحث لدراسة تأثير تغير الإيقاع الحيوي على فاعلية برنامج علاج تحفظي لمرضى الانزلاق الفقاري الأمامي . اشترك في الدراسة ستون مريضاً متطوعاً تم تقسيمهم عشوائياً على مجموعتين متساويتين . اتبعت المجموعتان نفس برنامج العلاج لمدة ثلاثة شهور ولكن كل مجموعة تلقت البرنامج في وقت مختلف من اليوم . المدى الحركي لثني الجذع والقوة المتساوية للعضلات الثانية للجذع تم قياسهم للمجموعتين قبل بدء البرنامج ومرة أخرى بعد نهاية البرنامج .

أشارت نتائج البحث إلى وجود فروق معنوية في قياسات المدى الحركي والقوة العضلية للمجموعتين بعد تنفيذ البرنامج مقارنة بالقياسات قبل بدء البرنامج . المجموعة الأولى كان المدى الحركي 30.20 ± 7.48 سم والقوة العضلية 48.40 ± 15.03 نيوتن/متر وأصبحت بعد تنفيذ البرنامج 4.83 6.97 سم و 99.26 ± 23.11 نيوتن/متر على التوالي . في المجموعة الثانية كان المدى الحركي 35.30 8.63 سم وأصبح 9.23 ± 6.51 سم ، وكانت القوة العضلية 45.26 ± 13.98 وأصبحت 72.96 ± 17.80 نيوتن/متر بعد تنفيذ البرنامج . كذلك أظهرت النتائج فروقاً معنوية في النتائج البعدية للمجموعتين لصالح المجموعة الأولى التي تلقت البرنامج في فترة ما بعد الظهر .

لم تظهر النتائج أي فروق معنوية عند تغيير موعد القياسات النهائية لكل مجموعة من موعد تلقيها للبرنامج إلى الموعد الذي كانت المجموعة الأخرى تتلقى فيه البرنامج . وبذلك أظهرت النتائج فاعلية برنامج العلاج التحفظي للانزلاق الفقاري الأمامي وكذلك تأثير الإيقاع الحيوي على فاعلية البرنامج .