Proceedings of the
XXXIst Annual International Occupational Ergonomics and Safety Conference
New Orleans, Louisiana, USA
June 12-13, 2019

Spine Compression Recovery as a Diagnostic for Chronic Back Pain

Uwe Reischl[1] and Ravindra S. Goonetilleke[2]

[1]Department of Community and Environmental Health, Boise State University, Boise, Idaho, USA

[2]Department of Integrative Systems and Design, Hong Kong University of Science and Technology, HONG KONG

Corresponding author's Email: ureischl@boisestate.edu

Author Note: Uwe Reischl is a professor in the Department of Community and Environmental Health. He is an occupational health physician with a research focus on healthcare ergonomics, human factors and international health. Ravindra Goonetilleke is a professor in the Department of Integrative Systems and Design with a research focus on user-centered design and product innovation.

Abstract: Back pain disorders are a leading cause of lost workdays and represent one of the most costly occupational health problems internationally. Reducing the risk of back-pain in the workplace continues to be an important goal for ergonomists and safety professionals. The aim of this study was to determine whether spine compression and recovery measurements can be used to differentiate symptomatic back-pain employees from asymptomatic employees. A case-control study was undertaken based on a convenience sample of 18 employees working at a regional medical center. Seven of the employees reported chronic back pain during the previous 6 months while eleven employees were asymptomatic. A portable precision stadiometer was used at the work-site to determine each employee's stature before and after an 8-hour shift and after a subsequent 15-minute resting recovery period. The symptomatic workers exhibited an average 8-hour stature compression of 8.1mm with a subsequent 15-minute recovery of 4.9 mm. The asymptomatic employees exhibited an average 8-hour stature compression of 3.4 mm with a subsequent 15-minute recovery of 4.4 mm. Back-pain employees exhibited a recovery of only 61%, the asymptomatic employees exhibited a recovery of 129% which differentiates the back pain employees from the asymptomatic employees. Using this data, a predictive diagnostic of 75% was obtained for the back-pain employees and a predictive value of 90% for the asymptomatic employees. Based on this finding, we suggest that spine compression recovery measurements can be applied as a method to identify employees at potential risk of back pain.

Keywords: Occupational Health, Chronic Back Pain Diagnostic, Spine Compression and Recovery

1. Background

Reducing chronic back-pain in the workplace continues to be an important goal for ergonomists and safety professionals. Factors contributing to this problem include heavy lifting, bending, twisting, carrying and pushing objects, inappropriate posture, and many more. Studies have shown that workers who experience chronic back-pain exhibit higher paraspinal muscle activity compared to asymptomatic workers performing the same tasks (Healey 2005, 2008). This increased paraspinal muscle activity results in greater stature compression during the day and leads to a delayed recovery afterwards (Lewis 2009, 2012, 2014). The aim of this study was to determine whether spine compression and recovery measurements can be used to differentiate symptomatic employees from asymptomatic employees.

2. Methods

A case-control study was undertaken based on a convenience sample of 18 employees (7 males and 11 females) who worked at a regional medical center. Seven of the employees reported chronic back pain during the previous 6 months while eleven employees were asymptomatic. A portable precision stadiometer was used at the work-site to determine each employee's stature at the height of the C-7 spinous process. Measurements were obtained before-and-after an 8-hour work shift, and before-and- after a 15-minute supine recovery period.

ISBN: 97819384965-7-8

2.1 Instrumentation

A lightweight portable precision stadiometer system described previously (Reischl 1995, 2014) was used in this study to document changes in stature over 8-hour work periods. Measurements were carried out in the standing position while the subjects leaned against a vertical reference frame equipped with a millimeter scale oriented towards a video camera. A landmark "dot" placed on the skin at the vertebra Prominens (C7) was used as the measurement reference point. This location is stable in response to head movement. To control a test subject's posture, four points of contact were maintained with the vertical frame: Contact of the occiput with an adjustable head-rest; contact of the mid-thoracic vertebra and the sacrum with the vertical frame; contact of the calcaneus with a heel reference block. Moving the video camera up or down, the image of the landmark reference "dot" on the skin of C7 could be centered on the crosshairs which were also projected onto the screen of the monitor. The position (i.e., height) of the reference "dot" was superimposed onto the reference millimeter scale. A measurement resolution of 0.01cm was achieved. A test subject's stature measurements were completed within 30 seconds.

2.2 Subjects

Eighteen persons employed at a regional medical center participated in this study as volunteer subjects. They were recruited through an inter-departmental memorandum describing the goal and scope of the study. Seven of the volunteer subjects who were selected for this study had previously reported experiencing chronic back pain. Eleven of the subjects reported being symptom free. The symptomatic or asymptomatic status was determined based on a standardized medical questionnaire, a standardized pain questionnaire, and a physical exam conducted by the occupational health nurse. All subjects were healthy, i.e., free of any disability or disease. The characteristics of the "pain-free" group are summarized in Table I. the characteristics of the back-pain group are summarized in Table II. The two groups were similar in height, age, and weight. The average age of the symptom-free group was 48.4 years, the average height was 67.1 inches, and the average weight was 179.1 lbs. The average age of the "back-pain" group was 47.5 years, average height was 66.0 inches, and the average weight was 165.7 lbs. There were eight females and three males in the "pain free" group. There were eight females and no males in the "back pain" group. Both groups included a combination of administrators, nurses and technicians.

Table 1. Characteristics of volunteer subjects without back pain symptoms

ID Number	Pain (Yes / No)	Gender (M / F)	Age (years)	Height (in)	Weight (lbs.)	Job Classification
207	No	F	30	63	120	Admin
210	No	F	52	68	194	Admin
216	No	F	31	65	197	Admin
217	No	M	52	68	225	Tech
218	No	M	54	72	230	Tech
219	No	M	64	69	150	Admin
221	No	F	55	63	155	Nurse
222	No	F	35	63	98	Nurse
223	No	F	46	62	148	Admin
224	No	F	48	67	168	Nurse
232	No	F	56	66	138	Nurse
Average			47.5	66.0	165.7	

Table 2. Characteristics of volunteer subjects exhibiting back-pain symptoms

ID Number	Pain (Yes / No)	Gender (M / F)	Age (Years)	Height (in)	Weight (lbs.)	Job Classification
203	Yes	M	48	70	183	Admin
205	Yes	F	50	67	150	Admin
211	Yes	M	52	72	245	Tech
212	Yes	M	58	66	180	Pharm
225	Yes	F	49	64	140	Admin
226	Yes	F	53	66	170	Nurse
227	Yes	F	29	65	186	Admin
228	Yes	M	52	71	231	Tech
Average			43.2	67.6	185.6	

2.3 Measurements

Each subject was measured three times during an 8-hour work period. The first measurement was obtained prior to shift begin (0730hr), the second measurement was taken at the end of the work shift (1630hr), and the third measurement was taken immediately after completing a 15-minute rest period.

3. Results

The symptomatic workers exhibited an average 8-hour stature compression of 8.1(±4.1) mm with a subsequent 15-minute recovery of 4.9 (±1.7) mm. The asymptomatic employees exhibited an average 8-hour stature compression of 3.4 (± 1.5) mm with a subsequent 15-minute recovery of 4.4 (± 1.4) mm. While back-pain employees exhibited a recovery of only 61%, the asymptomatic employees exhibited a recovery of 129%. This difference in stature recovery differentiates the back pain employees from the asymptomatic employees. Using a 100%+ recovery value as an outcome measure, a 2x2 predictive diagnostic of 75% is seen for the back-pain employees and a predictive value of 90% for the asymptomatic employees. Based on the results of this study, we suggest that assessment of spine compression recovery can serve as an objective method to identify employees at risk of back pain, allowing employers to implement appropriate ergonomic interventions.

Table III summarizes the stature compression and subsequent 15-minute recovery values obtained for the eleven pain-free volunteer subjects. Table IV summarizes the stature compression and subsequent 15-minute stature recovery values obtained for the seven back-pain volunteer subjects.

The average 8-hour stature compression value for the eleven pain-free subjects was 0.34 centimeter while the average15-minute recovery value was 0.44 centimeter. This 15-minute recovery value represents a recovery level of 129%. The average 8-hour stature compression value for the seven back-pain subjects was 0.80 centimeter while the average 15-minute recovery value was 0.49 centimeter. The 15-minute recovery for this group, therefore, represents a recovery level of only 61%.

Table 3. 8-hour spine compression and 15-minute recovery values for subjects without back pain symptoms

ISBN: 97819384965-7-8

ID Number	Pain Yes / No	8-hour Compression (cm)	15-minute Recovery (cm)	100% Recovery (+ / -)
207	No	0.45	0.49	+
210	No	0.32	0.40	+
216	No	0.36	0.30	-
217	No	0.28	0.31	+
218	No	0.22	0.55	+
219	No	0.41	0.45	+
221	No	0.50	0.46	-
222	No	0.17	0.47	+
223	No	0.60	0.65	+
224	No	0.38	0.50	+
232	No	0.06	0.21	+
Average		0.34 (cm)	0.44 (cm)	129 (%)

Table 4. 8-hour spine compression and 15-minute recovery values for subjects with back-pain symptoms

ID Number	Pain Yes / No	8-hours Compression (cm)	15-minute Recovery (cm)	100% Recovery (+ / -)
203	Yes	0.62	0.41	-
205	Yes	0.60	0.58	-
211	Yes	1.61	0.34	-
212	Yes	0.28	0.62	+
225	Yes	0.90	0.69	-
226	Yes	0.94	0.58	-
227	Yes	0.73	0.20	-
Average		0.80 (cm)	0.49 (cm)	61 (%)

4. Analysis

The inter-vertebral disc appears to be the most likely tissue to be undergoing sufficient height change to produce the stature changes observed in this study. Whether this occurs because of annular fiber strain, volume change, i.e. fluid loss, or a combination of both, is not known. The overall range of stature compression measured for the eighteen volunteer subjects are consistent with values reported in previous studies of athletes and nurses (Beynon 2001, Garbutt 1990). The significantly

greater stature compression observed for the subjects who suffer back pain, in comparison to the asymptomatic subjects, suggests that additional spinal loading occurred during the work shift. Since relevant variables such as gender, age, height, weight, work load, work rate, and work environment were similar for both groups; it can be assumed that additional spinal loading may be intrinsic to back pain. Persons with back pain may guard against additional pain by using more muscles than they need to (Marras 2001). Also, the increased spine compression may also be explained by the increased static muscle tension that is often associated with the chronic back pain syndrome (Floor 1989, 1990). It is important to note that spine compression and recovery is an on-going, non-linear, process that occurs over a 24-hour period. Therefore, obtaining the stature measurements for all of the subjects at the same time period during the day, i.e., 0730hr, 1630hr, and 1645hr, was able to control for this non-linear diurnal pattern.

As shown in Tables III and IV, the average spine compression and recovery values for the back-pain group were higher than the spine compression observed for the pain-free group, i.e. 0.80 cm vs. .034 cm. These values illustrate a substantial difference between the two groups. The values for the individual subjects were highly variable and no two subjects in either group exhibited the same values. Therefore, it was necessary to "standardize" these values in order to allow for a comparison. This can be achieved using each subject's 15-minute recovery value as a reference. Dividing the 15-minute recovery by the 8-hour compression value results in a subject relative recovery status. As shown in Tables III and IV, the pain-free group exhibited a recovery of 129% while the back- pain group exhibited a recovery of 61%.

By using the 15-minute recovery data to "normalize" each subject's 8-hour compression value, it is possible to compare the back-pain group with the pain-free group. For example, using a 100% recovery value as a "reference" criteria, the data summarized in Table III shows that 9 out of 11 subjects in the pain-free group exceeded this reference value. However, Table IV shows that only 1 back-pain subject out of 7 met or exceeded the same reference value. A "diagnostic" table is now possible as illustrated in Table V.

Using the data obtained from the 19 volunteer test subjects and applying the relative recovery criteria outlined above, a positive predictive value of 75% and a negative predictive value of 90% is observed. This suggests that if the spine compression and recovery test were applied to a similar group of employees, 75% of the employees suffering back pain would be diagnosed correctly while 90% of the asymptomatic employees would be identified correctly.

Table 5. Summary of symptomatic and asymptomatic subjects in relation to their 15-minute recovery values (Diagnostic Table)

	Pain-Free Diagnosis 15-minute Recovery More than 100%	**Back-Pain Diagnosis** 15-minute Recovery Less than 100%	Total
Subjects with Back Pain	1	6	7
Subjects without Back Pain	9	2	11
Total	10	8	18

Back-pain predictive value = 6/8 = 75%
Symptom-free predictive value = 9/10 = 90%

5. Conclusions

The results of this pilot study suggest that it is now possible to develop an objective diagnostic strategy to help identify employees at increased risk of work related back-pain. The measurement system used in this study provides a tool for occupational health professionals to conduct evaluations of work associated chronic back pain and to test the efficacy of ergonomic interventions in reducing such symptoms.

ISBN: 97819384965-7-8

6. References

Beynon, C; Reilly, T. (2001). Spinal Shrinkage during a seated break and standing break during simulated nursing tasks, *Applied Ergonomics,* 32: 617-622

Eklund, J.A.E.; Corlett, N., (1984). Shrinkage as a measure of the effect of load on the spine, *Spine,* 9: 189-194

Flor, H.; Turk, D.C. (1989). Psychophysiology of chronic pain: Do chronic pain patients exhibit symptom - specific psychophysiological responses? *Psychological Bulletin,* 105: 215-259

Flor, H.; Birbaumer, N.: Turk, D.C. (1990). The physiology of chronic pain, *Advanced Behavior Research Therapy,* 12: 47-84

Fowler, N.E., Rodacki, C.L., Roacki, A. L., (2005), Spinal shrinkage and recovery in women with and without low back pain. *Arch Phys Me Rehabil*, 86: 505-511.

Garbutt, G.; Boocock, M.G.; Reilly, T., (1990). Running speed and spinal shrinkage in runners with and without low back pain, *Med. Sci. Sports Exercises,* 22: 769-772

Healey, E.L, Fowler, N.E., Burden, A.M., McEwan, I.M., (2005). The influence of different unloading positions upon stature recovery and paraspinal muscle activity. *Clinical Biomechanics*, 365-371

Healey, E.L, Fowler, N.E., Burden, A.M., McEwan, I.M., (2005). Raised paraspinal muscle activity reduces rate of stature recovery after loaded exercise in individuals with chronic low back pain. *Arch Phys Med Rehabil*, 86: 710-715.

Healey, E.L., Burden, A.B., Mc Ewan, I.M., Fowler, N.E. (2008). The impact of increasing paraspinal muscle activity on stature recovery in asymptomatic people. *Arch Phys Me Rehabil*, 89: 749-753.

Lewis, S.E., Fowler, N.E., (2009). Changes in intervertebral disk dimensions after a loading task and the relationship with stature change measurements. *Arch Phys Me Rehabil*, 90: 1795-1799.

Lewis, S., Holmes, P, Woby, S., Hinle, J., Fowler, N., (2012). The relationships between measures of stature recovery, muscle activity an psychological factors in patients with chronic low back pain. *Manual Therapy*, 17: 27-33.

Lewis, S., Holmes, P, Woby, S., Hinle, J., Fowler, N., (2014). Changes in muscle activity and stature recovery after active rehabilitation for chronic low back pain. *Manual Therapy*, 19: 178-183

Marras, W.S.; Davis, K.G. (2001). Ferguson, S.A.: Lucas, B.R.; Gupta, P.: Spine loading characteristics of patients with sow back pain compared with asymptomatic individuals, *Spine,* 26: 2566-2577

Reischl, U., Weinsheimer, W. (1995). Back-pain prevention - spinal recovery characteristics. Proceedings of the 35th Congress of the German Occupational and Environmental Medicine Association, R. Schiele, Editor, 381-385. (In German)

Reischl, U, Weinsheimer, W. (2004). Work-related spinal compression and recovery profiles for healthcare and industrial employees. Proceedings of the 2nd International Ergonomics Conference. Zagreb, Croatia. Budimir Mijovic, Editor. 9-15

ISBN: 97819384965-7-8