Original articles

The effects of smoking on intersegmental motion in the upper thoracic spine[☆]

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Abstract

Objective: The aim of this study was to determine if smoking has an effect on intersegmental motion in the upper thoracic spine.

Methods: Fifty participants (25 smokers and 25 nonsmokers) who met the inclusion criteria were enrolled into the study. Both groups were scanned by the ProAdjuster (Pittsburg, PA) system 3 times for 3 days in the upper thoracic spine to determine the fixation, mobility, frequency, and motoricity of each segment.

Results: The results revealed an overall higher rate of fixation in both the smoker and nonsmoker groups at all 3 vertebral levels. However, there was a higher rate of fixation within the smoker group than the nonsmoker group ($P < .05$). The results showed that participants who smoked had a higher fixation rate, which is energy needed to overcome inertia in the T1 spinal region. The mobility was higher in the nonsmoking group ($P < .05$). Frequency and motoricity showed no significant differences between the 2 groups ($P > .05$).

Conclusion: According to the data that have been compiled, there is significantly greater fixation in the smoking participants at T1/T2 and T2/T3 spinal regions when compared with the nonsmoking participants, although both groups had a higher-than-normal fixation rate. The nonsmoking participants demonstrated higher mobility compared with the smoking group.

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Introduction

According to the “A Somatic Component to Myocardial Infarction” (1985),¹ there is a relationship between myocardial infarction and its related somatic components. This study showed changes specifically in

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the paravertebral soft tissues. Christensen et al² reported that patients with stable angina pectoris might benefit from manual therapy. Research studies and reviews suggested that smoking might play a role in certain type of low back pain.³⁻⁵ In somatovisceral reflex theory, an initial stimulus or insult to the nervous system from a somatic receptor, as in a spinal joint, will cause an efferent reflexive manifestation or response to be expressed in the visceral tissue or organ.⁶ The 1992 publication "The Reflex Effects of Spinal Somatic Nerve Stimulation on Visceral Function"⁷ discussed a correlation between somatic stimuli and various viscera throughout the body.

Sato and Swenson⁸ showed that heart rate, blood pressure, and renal and adrenal sympathetic nerve activity could be altered by applying mechanical pressure to the spine. The study "A Living History—A Quantitative Study of Experienced Chiropractors Treating Visceral Conditions"⁹ showed that chiropractors treated visceral conditions in the same fashion as neuromusculoskeletal conditions. The doctors reported that visceral complaints showed up as pain, spinal subluxations, and nerve conduction problems, which were responsible for referred pain in organ dysfunction. They explained how many visceral conditions like gastrointestinal, abdominal, and dysmenorrheal problems can be helped with spinal adjustments.⁹ The body has receptors in muscles, skin, and organs that develop together in the embryo and grow from the spinal cord. Signals from these areas go through neurons and then come together in the spinal cord. They then take 1 of 3 pathways to the thalamus. Information then goes to the hypothalamus gland and the postcentral gyrus, where the body decides on its response. The response is then carried by the reticulospinal tract back to the skin, muscles, and organs.¹⁰ The study "An Investigation into the Effect of Organ Irritation on Muscle Strength and Spinal Mobility"¹¹ showed that environmental irritants that cause an irritation to the organs caused somatic muscles to weaken and new spinal fixations. These organs included the ears, eyes, lungs, and stomach. The somatoautonomic dysfunction theory states that viscera, somites, and psychic factors are all connected. If there is a visceral bombardment of the dorsal horn, it can alter somatic function. Smoking is known to affect fatigue resistance in muscles,¹² increase skin conduction,¹³ and lower the immune system response, all while increasing the risk for infection by increasing the release of neutrophils and interleukin-8.¹⁴

The purpose of this investigation was to determine the differences of the intersegmental motion in the first, second, and third thoracic vertebrae in smokers and

nonsmokers. In this study, the ProAdjuster (Pittsburg, PA) system was used so that computerized tracking could be used to calculate specific spinal movement.¹⁵ The hypothesis was that smoking would not affect the spinal intersegmental motion.

Methods

Subjects were obtained through in-classroom announcements at a chiropractic college. The sample consisted of students and faculty currently living in a metropolitan area. There was no discrimination based on sex, age, socioeconomic level, activity level, or previous treatment. All subjects had to meet the following criteria to be included in this study: exhibit no presence of scoliosis; no lung-related conditions (ie, asthma, emphysema, chronic obstructive pulmonary disease, etc); and no known fractures, malignancies, or terminal illnesses as obtained by the questionnaire. The inclusion criteria for each nonsmoker included a history of no cigarette use in the past 10 years. To be classified as a smoker, the subject must have had a history of regular cigarette use of 1 to 5 packs per week for 6 months or more. All participants must not have received an adjustment in the thoracic spine 24 hours before the study. All subjects must sign a consent form approved by the Institutional Review Board of Logan College of Chiropractic.

Students who were trained to use the ProAdjuster system for analysis procedures performed all clinical procedures under the supervision of a licensed chiropractor who was trained in ProAdjuster system. The students who performed the analysis were higher-trimester students who had completed most of their chiropractic courses. In addition, they completed the ProAdjuster training on and off campus. The ProAdjuster system (donated to the chiropractic college by ProAdjuster) was used to increase the specificity and sensitivity of the examination. It works by using a piezoelectric sensor that sends an impulse through each spinal level to determine the motion dynamics of that level. The examiner scanning the subjects was unaware of whether or not the subject was a smoker. The T1 was determined by palpation. Each subject was assigned a number and placed in a group based on whether or not they smoked.

Mean value was used to represent changes in the 2 groups. An analysis of variance (ANOVA) test was used to assess the differences of the ProAdjuster analysis. Significance was determined at *P* less than or equal to .05. SigmaStat 3.5 (Systat Software Inc, San Jose, CA) statistical software was used for the data analysis.

Results

Fifty chiropractic students were recruited, with 25 in the smoker group. There were 14 men and 11 women in the smoker group, with an average age of 29.9 ± 11.9 years. The nonsmoker group had 9 men and 16 women, with an average age of 24.8 ± 3.4 years. No subjects dropped out of the study. Each participant was scanned a total of 6 times: 2 scans per visit for 3 visits. The data for fixation, mobility, frequency, and motoricity for the first, second, and third thoracic vertebrae were recorded and then averaged. This became the baseline value for each participant. The baseline readings for all the smokers and nonsmokers were averaged to obtain the data in Table 1 and Fig 1.

The results revealed an overall higher rate of fixation in both smokers and nonsmokers at all 3 vertebral levels compared with the average value in the database. However, there was a higher rate of fixation within the smoker group than the nonsmoker group. The ANOVA on the 3 tests showed a significant change in the no-smoke group ($P = .001$), but there was no significant change in the smoking group.

The mobility measurements were decreased at all levels in both groups. The results revealed higher mobility at the first thoracic vertebra in the smoker group and at the second and third thoracic vertebrae in the nonsmoker group. No statistically significant changes were found in both the smoking and no-smoke groups for mobility ($P = .150$).

Overall, the frequency values collected were the closest to the ideal range, with higher values being recorded at the first thoracic vertebra in the smoker group and at the second and third thoracic vertebrae in the nonsmoker group. The ANOVA on the 3 tests showed a significant change in the no-smoke group ($P = .005$), but there was no significant change in the smoking group.

The motoricity results were similar to the frequency results, with higher values for the first thoracic vertebra in the smoker group and higher values for the second and third thoracic vertebrae in the

Fig 1. Measurement values for T1 showed an increased fixation in smokers.

nonsmokers. No statistically significant changes were found in both the smoking and no-smoke groups for motoricity ($P = .111$).

Overall, the data for both groups were close to one another, with minimal differences noted. The fixation and mobility values revealed that both groups were hypomobile in the first, second, and third thoracic vertebrae. The smoking group had higher values, which indicated increased hypomobility. The readings for both frequency and motoricity were less than the ideal values, with the smoker group recording values closest to ideal for the first thoracic vertebra and the nonsmoker group recording values closest to ideal for the second and third thoracic vertebrae.

Discussion

There are several different methods of determining the intersegmental motion in each spinal level. These include static palpation, active motion, and motion palpation. The problem with static spinal palpation is that it lacks research on its reliability as shown in the writings of Russell¹⁶ and Simmonds et al.¹⁷ They showed that static palpation is not a reliable source because of the variability in force applied to the segments and the overestimation of motion by the practitioner.

There could have been discrepancies in our data due to factors that we did not take into consideration including anterior head carriage, stress levels, types of

Table 1 Averaged measurements of participants

		Fixation	Mobility	Frequency	Motoricity
Smokers	T1-S	29.85	37.88	44.58	43.19
	T2-S	26.84	38.42	45.10	42.77
	T3-S	26.48	38.97	43.84	43.24
Nonsmokers	T1-NS	25.64	37.87	44.01	42.19
	T2-NS	25.52	39.02	45.14	43.25
	T3-NS	26.13	40.26	44.45	44.05

smoking, amount of smoking, and level of physical activity. Anterior head carriage, increased levels of stress, increased amount of smoking, and high levels of physical activity in the upper extremity area could cause intersegmental motion in T1/T2 and T2/T3 to be decreased. We do not know how the types of smoking would affect intersegmental motion in T1/T2 and T2/T3; but in a future study, keeping those factors constant would help with the results.

Another point of view to this discussion on decreased intersegmental motion or fixation and the relationship to smoking can include the relationship of cellular changes in the tissues. The spinal intersegmental motion segment is considered a joint complex that is composed of the intervertebral disk, contiguous vertebra, and other connective tissues that unite them. Akmal et al¹⁸ demonstrated in their results a significant effect of nicotine on nucleus pulposus cells, and this effect varies depending on the dose of nicotine exposure. This supports the existence of nicotine sensitivity of nucleus pulposus cells and may provide an explanation for the detrimental effects of smoking on disk degeneration.¹⁸ Hadley and Reddy¹⁹ stated that nicotine, the best-studied toxin in cigarettes, has a direct injurious effect on osteoblastic cells. Aside from its detrimental effects on bone mineral density, bone blood supply, and blood flow, nicotine has been documented to decrease osteoblast cellular proliferation, interrupt collagen synthesis, and inhibit osteoblastic cellular metabolism.¹⁹ Glassman et al²⁰ stated that cigarette smoking has been identified as an important risk factor for both nonunion and poor clinical outcome in lumbar spine fusion surgery. In particular, smoking has been shown to markedly diminish fusion rate for the challenging healing environment associated with posterolateral spine fusion procedures.²⁰

One of the limitations of the study was inter- and intraexaminer reliability. During testing, we realized that the different members used the ProAdjuster differently, which may have skewed the data. The initial subjects had more skewed results as compared with the later subjects because more experience was obtained as more tests were performed. The small sample size was another limitation of the study. Based on the findings of the current study, further research in this area with larger sample size may be needed.

Conclusion

There was significantly greater fixation in the smoking participants at T1/T2 and T2/T3 spinal

regions when compared with the nonsmoking participants, although both groups had a higher-than-normal fixation rate. The nonsmoking participants demonstrated higher thoracic spinal mobility compared with the smoking group.

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