ORIGINAL ARTICLES

Learning Spinal Manipulation
*A Comparison of Two Teaching Models**

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Purpose: The goal of the present study was to quantify the high-velocity, low-amplitude spinal manipulation biomechanical parameters in two cohorts of students from different teaching institutions. The first cohort of students was taught chiropractic techniques in a patient–doctor positioning practice setting, while the second cohort of students was taught in a "complete practice" manipulation setting, thus performing spinal manipulation skills on fellow student colleagues. It was hypothesized that the students exposed to complete practice would perform the standardized spinal manipulation with better biomechanical parameters. **Methods:** Participants (n = 88) were students enrolled in two distinct chiropractic programs. Thoracic spine manipulation skills were assessed using an instrumented manikin, which allowed the measurement of applied force. Dependent variables included peak force, time to peak force, rate of force production, peak force variability, and global coordination. **Results:** The results revealed that students exposed to complete practice demonstrated lower time to peak force values, higher peak force, and a steeper rate of force production compared with students in the patient–doctor positioning scenario. A significant group by gender interaction was also noted for the time to peak force and rate of force production variables. **Conclusion:** The results of the present study confirm the importance of chiropractic technique curriculum and perhaps gender in spinal manipulation skill learning. It also stresses the importance of integrating spinal manipulation skills practice early in training to maximize the number and the quality of significant learner–instructor interactions. (J Chiropr Educ 2011;25(2):125—131)

Key Indexing Terms: Chiropractic; Education; Manipulation, Spinal; Motor Skills

INTRODUCTION

High-velocity, low-amplitude (HVLA) spinal manipulation has been frequently described and studied using a motor control or learning paradigm.[1–4] Recent studies clearly highlight the similarities between the learning processes involved in this particular psychomotor task and the skills encountered in sports and leisure activities.[1–4] These studies also identified some specific conditions that enable a faster and more efficient learning process and systematically suggest that skilled spinal manipulation performance is promoted through guided rehearsal and experience and that measurable improvement in observed performance can be reached when qualitative or quantitative feedback related to force time parameters is provided.[2, 3, 5]

Despite this growing body of evidence indicating that, from a motor learning perspective, HVLA spinal manipulation may be regarded as another psychomotor skill, motor learning principles are rarely fully integrated in chiropractic curricula. Learning HVLA spinal manipulation within the chiropractic educational realm involves complex issues related to tradition, safety, and effectiveness in the application

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of such treatment procedures. [6, 7] These particular issues may also explain why implementation and integration of motor learning principles in chiropractic training greatly diverge from one teaching institution to another. Traditionally, teaching HVLA spinal manipulation has been a fundamental aspect of chiropractic training. The usual teaching procedure involves starting with the theoretical aspects of HVLA spinal manipulation, followed by instructors demonstrating a specific spinal manipulation and students imitating the instructed procedure. As they carry out the task, they mimic the patient's and the clinician's positions, hand placement, direction of force, and the amount and control of force imparted during performance of the technique. Students acquire this skill partially or completely, according to their training level. Although most chiropractic colleges and teaching institutions have partially implemented motor learning principles and procedures in their technique curriculum, some have maintained a more traditional approach to HVLA spinal manipulation teaching. The available evidence to guide colleges in the development of their technique curriculum is growing but uncertainties remain.[8]

To study the effect of two separate technique curricula from independent training programs, Triano et al.[9] compared groups of students exposed to different ratios of laboratory and didactic technique teaching. Laboratory sessions in the group with more hours devoted to practical training were characterized by systematic rehearsal of patient transfer and positioning as well as nonmanipulative soft tissue manual procedures. Results showed that the group of students exposed to higher levels of laboratory training performed significantly better on biomechanical parameters in a standardized L4 mammillary push HVLA manipulation procedure in a lateral recumbent position. However, this study did not specifically compare the traditional patient–doctor positioning curricular practices versus complete practice of manipulation (including the thrust).

The goal of the present study was therefore to quantify the HVLA spinal manipulation biomechanical parameters of two cohorts of students in two different teaching institutions. The first cohort of students was taught chiropractic techniques in a patient–doctor positioning practice setting (group 1) and the second cohort of students was taught in a "complete practice" manipulation setting, thus performing spinal manipulation skills on student colleagues (group 2). It was hypothesized that the students exposed to complete practice would perform the standardized HVLA spinal manipulation procedure with greater speed and rate of force production than the group exposed to only traditional patient–doctor positioning training.

METHODS

Participants

Forty-five students enrolled in a chiropractic program using a patient–doctor positioning model and 43 students enrolled in a chiropractic program favoring complete practice of spinal manipulation skills voluntarily participated in the current study. All students gave their informed written consent according to the protocol approved by the local ethics committees. Students from both teaching institutions were tested a few weeks before or after their entry in their respective outpatient clinics and had cumulated similar amounts of formal laboratory training in chiropractic technique classes.

Chiropractic Technique Curricula

Students in group 1 were exclusively exposed to a patient–doctor positioning model characterized by an overly prescriptive organization of practice. In such a model, emphasis is directed to countless parameters preceding the thrust component of manipulation. Thrust is not permitted and therefore the student's attention is never guided toward the goal of the action.[10] Students in group 2 were exposed to spinal manipulation with thrust early on in their training (1st year). In this model, instructors and proprioceptive feedback are rapidly included in the decision-making process related to spinal manipulation execution. This allows a large variability in movement experiences and enhances the development of general rules of skill execution.[11] Participants' demographics and curricula descriptions are presented in Table 1.

Procedure

Participants were instructed to complete 10 consecutive thoracic spine manipulations on an instrumented manikin using a right-handed pisiformis contact. The maneuver, identified as a prone unilateral hypothenar transverse push adjustment, was performed with a posterior to anterior force vector (relative to the manikin) using either a left or right

Table 1. Participants' demographics and curricula descriptions

	Group 1 (n = 44) 33F; 11M Mean (SD)	Group 2 (n = 43) 17F; 26M Mean (SD)	p Values
Demographics			
Age (y)	26.28 (6.87)	30.19 (7.92)	< .0001[a]
Weight (kg)	63.61 (10.44)	85.12 (21.75)	< .0001
Height (cm)	168.39 (7.70)	174.37 (11.63)	.006
Curricula characteristics			
Total hours	330	330	-
Laboratory hours	250	225	-
Didactic hours	65[b]	75	-
Soft tissue mobilization hours	15[c]	30	-

[a] Mann-Whitney U test.

[b] Technique classes are set up as full laboratory training but include approximately 65 h of didactic training.

[c] Soft tissue mobilization hours are taught within technique training hours.

contact. All participants were asked to complete the 10 thoracic spine manipulations with the minimum force required to obtain simulated audible release. No feedback regarding their performance was provided. While performing spinal manipulation (SM), they were also instructed to place one foot on a force plate (FP-BTA, Vernier, Beaverton, OR) and use the body positioning of their choice. All participants completed up to five practice trials to gauge the level of resistance offered by the manikin. These specific task requirements and all instructions provided to the participants were identical during all experimental sessions in both teaching institutions.

Apparatus

A manikin for teaching cardiopulmonary resuscitation was modified and instrumented with a spring to emulate the resistance offered by a thoracic spine. A strain gauge (model UL 400, Statham, Oxnard, CA) was installed at the top of a spring to replicate movement and resistance of the thoracic spine and rib cage. The strain gauge allowed the recording of vertical forces applied by participants over the contact point. To simulate typical absolute movement of the thoracic vertebrae undergoing SM, the manikin was modified to limit posterior to anterior movement to approximately 5 mm. This was done by mounting an electromagnet at the base of the spring. The electromagnet was controlled by a variable current, which allowed the experimenter to modulate the level of maximal resistance offered by the spring. For the five experimental sessions, resistive force was set approximately to 450 N. Once the specified force level (450 N, measured on the strain gauge) was achieved by the participant performing SM, the electromagnet switched off while force was recorded continuously. As a result, unloading of the spring and movement of the manikin torso surface simulated articular release characterizing vertebral joint cavitation.

Data Analysis

Strain gauge and force plate data were recorded at a sampling rate of 500 Hz for 4 s with a 12-bit A/D converter (PCI 6024E, National Instruments, Austin, TX). LabView (National Instruments, Austin, TX) was used for data collection and data processing was performed using Matlab (MathWorks, Natick, MA). Force applied to the manikin and vertical force plate signals were filtered with a fifth-order Butterworth filter (10-Hz low-pass cutoff frequency). These signals were analyzed to determine the following force-time parameters: onset of force, peak force applied (absolute peak force and peak force normalized to body weight), preload force, and onset of unloading (vertical force) measured from the force plate. All parameters were analyzed for each trial and each participant and for all experimental sessions with a customized software. The data were then used to calculate time to peak force, rate of force production, and peak force variability. A global coordination index was obtained by calculating temporal lag between the onset of the force plate unloading and the onset of peak force production.

Statistical Analyses

Group differences in participants' demographics were tested using a *t* test for independent groups. Outcome measures were subjected to a test of normal distribution (Shapiro-Wilk test). Only the normally distributed variables were submitted to the Student *t* test. Statistical significance was set at $p < .05$.

RESULTS

Statistical analyses revealed significant between - group differences in weight, height, and age. The only variable distributed normally was the peak force, which was therefore submitted to a *t* test for independent group analysis. All other variables were tested using nonparametric analyses (Mann-Whitney U test). Because significant between-group differences were observed for age, weight, height, and gender, these covariables were included in an analysis of covariance (ANCOVA) model to test whether they had an effect on each outcome variable.

Statistical analyses comparing both cohorts of students revealed significant differences in peak force, time to peak force, and rate of force application variables. Mean and standard deviation values and statistics are presented in Table 2. In brief, students exposed to complete practice (group 2) demonstrated lower time to peak force values, higher peak forces, and a steeper rate of force production. Preload values were also higher for this group, although the difference did not reach statistical significance. Figure 1 illustrates typical mean and standard deviation of spinal manipulation force-time curves for one typical participant of each group.

The results of the ANCOVA showed a significant group-by-gender interaction effect for time to peak force [F (1, 80) = 6.132, p = .015] and rate of force application [F (1, 80) = 5.156, p = .026). Post-hoc analysis using the Tukey HSD test revealed that the males in group 2 showed significantly lower time to peak force than females in groups 2 and 1. Moreover, the post-hoc analysis revealed that the males in group 2 showed a significantly higher rate of force application compared with all other groups of males and females (see Fig. 2). Despite the inclusion of gender, height, and age in the ANCOVA, significant group differences in peak force, normalized peak force, and preload force could be observed.

DISCUSSION

The aim of this study was to compare spinal manipulation skill performances in two cohorts of students exposed to different procedural teaching approaches. The results of the present study confirm the importance of chiropractic technique curriculum in spinal manipulation skill learning while raising interesting gender differences at a specific stage of learning. Males exposed to complete practice of SM skills performed better than females in several biomechanical parameters. These results also stress the importance of integrating spinal manipulation skills practice early in training to maximize the number and the quality of significant learner–instructor interactions.

Table 2. Mean and standard deviation of dependent variables for both cohorts of students

Variable	Group 1	Group 2	p Values
Peak force (N)	425.9 (67.5)	481.2 (58.3)	< .0001[a]
Peak force normalized to body weight (%)	0.70 (0.14)	0.61 (0.16)	.009[a]
Peak force variability (N)	31.2 (12.0)	34.7 (21.7)	NS[b]
Preload (N)	131.5 (21.6)	155.3 (55.6)	.055[b]
Time to peak force (ms)	112 (25)	101 (35)	.02[b]
Force production rate (N/s)	2960.4 (1016.8)	3840.3 (1496.9)	< .004[b]
Coordination index (ms)	49 (31)	56 (29)	NS[b]

[a] *t* test for independent samples.
[b] Mann-Whitney U test. NS = not significant.

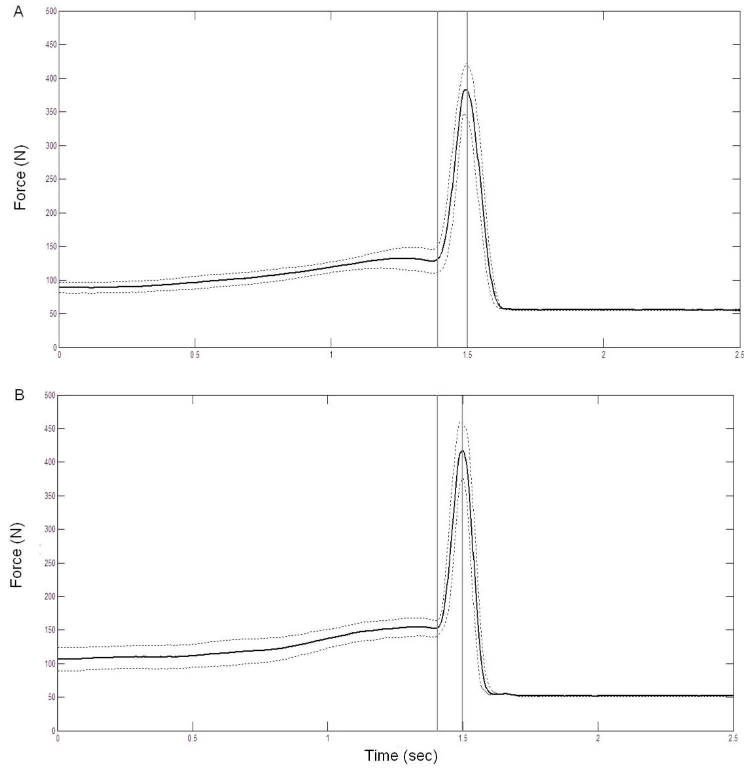

Figure 1. Typical mean time curve for (A) participants from group 1 and (B) participants from group 2. The time curves illustrate the mean (solid line) and standard deviation (dotted lines) of 10 trials.

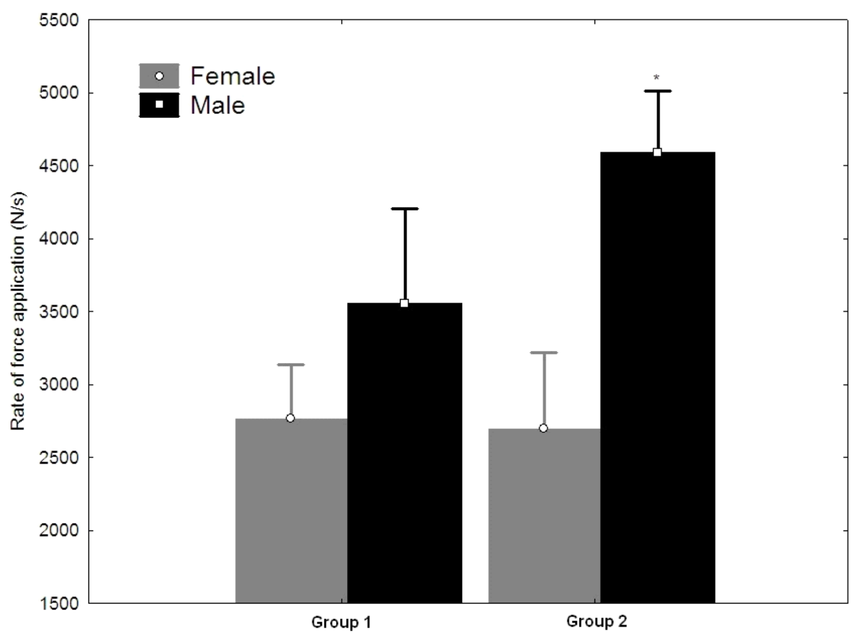

Figure 2. Mean (CI 95%) rate of force production (N/s) for males and females from each group. The rate of force production for males from group 2 is significantly higher than the rate of force production in females from group 2 and both males and females from group 1.

Triano et al.[9] previously demonstrated that training with a more extensive and practical premanipulation curriculum resulted in improved manipulation skills for a single procedure compared with didactic and demonstration programs. In their study, the students with adequate preparatory training involving skilled procedures showed spinal manipulation force and speed parameters reflecting expertise, compared with students who trained with a higher proportion of theoretical presentations. The literature suggests that skilled spinal manipulation performance is promoted through guided rehearsal and experience. From a motor learning standpoint, an increase in the number of hours spent on procedural learning should yield better motor performance in tasks involving bimanual and global coordination.[12]

In the current study, the rate of force production, which reflects the mastering of force modulation during the learning process, was significantly higher for participants of group 2. Rates of force production values observed in this study were similar to values reported for experts and graduating students with basic clinical experience evaluated with the same instrumented manikin.[13] Although these values are slightly different than those measured when adjusting human subjects,[14, 15] they clearly illustrate the level of expertise reached by these participants. In the first stage of learning, preload forces are usually ignored by learners.[1] In this study, participants of group 2 showed higher levels of preload forces. Even if this difference did not reach statistical significance (p = .055), this could indicate that the process of force modulation was, at this stage, already mastered in this group.

These results clearly highlight that complete practice leads to earlier acquisition of fundamental aspects of spinal manipulation skills compared with the patient–doctor positioning learning model. It must be noted that both groups were similar in terms of trial-to-trial variability and global coordination. These parameters are closely related to the final stage of expertise and, despite several group differences, mastering of specialized aspects of spinal manipulation skills was not reached by either group.[1]

An unexpected result of this study was a significant gender effect observed for several biomechanical parameters of spinal manipulation skills. This difference is best exemplified by the rate of force production for which the males in group 2 (complete practice) showed significantly higher values compared with all other subgroups of participants. This gender difference has been observed in various motor tasks, such as throwing darts and projectile interception.[16, 17] Spinal manipulation skills seem to follow this trend. However, the gender differences observed in this study may represent a temporary lag in learning processes since previous data indicate that such differences are not observed in experienced male and female chiropractors.[14]

Educational Implications

From an educational point of view, one could argue that being taught in a patient–doctor positioning model does not allow participants to fully master fundamental aspects of spinal manipulation skills defined as essential components of expertise.[1] Advantages related to an earlier acquisition of spinal manipulation skills may include improvement in patient care as well as optimizing clinical training through internship. Although it has not been investigated, some authors have suggested that improved spinal manipulation motor performance could be linked to improved clinical outcomes and safety. Moreover, the potential fear of executing spinal manipulation on a real patient may interfere with appropriate clinical management and educational goals.

Study Limitations

Although this study followed an experimental protocol previously used in spinal manipulation learning studies, the global coordination index differed in both its assessment and quantification. The values reported in this study may differ from previously reported data and both its interpretation and significance should be further investigated. Although significant between-group differences were observed, the clinical consequences of such differences in HVLA spinal manipulation execution are actually unknown. Future studies should investigate the clinical significance and safety issues related to spinal manipulation biomechanical parameters modulation. Finally, development of expertise probably depends on a complex combination of elements such as hereditary factors, environmental factors, and the influence of instructors, as well as an individual's commitment and motivation to practice.[18]

CONCLUSION

Overall, the results of the present study suggest that a specific and constant regimen of spinal manipulation skill practice seems to promote a refined motor execution. Gender differences may exist in spinal manipulation learning processes and such differences should be addressed in future studies. Although the observed differences between both gender and teaching strategies may be attenuated over time and clinical practice, early mastery of these motor skills offers several advantages in the educational process.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

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