FORCE-TIME PROFILE CHARACTERIZATION OF THE MCTIMONEY TOGGLE-TORQUE-RECOIL TECHNIQUE

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ABSTRACT

Objectives: The purpose of this study was to characterize the force-time profile of the McTimoney toggle-torque-recoil (MTTR) technique.

Methods: Two licensed chiropractors trained in the McTimoney Method applied MTTR thrusts to a tabletop where a dynamic load cell had been mounted. Each clinician applied 10 thrusts (5 with each hand) to the load cell in a repeated measures design. Peak forces, time durations, and time to peak force were computed from each of the force-time histories. Descriptive statistics were performed to compare the forces, durations, and times to peak force of the MTTR thrusts. A Mann-Whitney *U* test compared variables between the 2 clinicians, whereas a Wilcoxon signed-rank test compared right- and left-handed thrusts within clinicians.

Results: Considering all MTTR thrusts, the average peak force was 87.22 N (SD = 24.18 N), the average overall thrust duration was 36.38 milliseconds (SD = 9.58 milliseconds), and the average time to peak force was 12.31 milliseconds (S.D. = 4.39 milliseconds). No significant differences in mean peak force, duration, or time to peak force were observed between clinicians. When comparing intraclinician right and left hand thrusts, differences in peak force and duration were observed individually ($P < .05$).

Conclusion: For the 2 chiropractors tested, MTTR thrusts were relatively lower in peak force and appreciably faster than other commonly used chiropractic techniques. Future work aims to investigate the relationships between the force-time profiles of MTTR thrusts and resultant physiologic and clinical responses. (J Manipulative Physiol Ther 2009;32:372-378)

Key Indexing Terms: *Biomechanics; Chiropractic; Manipulation, Spinal*

A variety of chiropractic techniques have been developed to provide doctors of chiropractic with choices of technique application for a particular patient or condition in the application of chiropractic adjustments. Specifically, manual articular manipulative and adjusting procedures have been classified into four categories to better describe the technique and mechanism of force production: Specific contact thrust procedures (ie, high-velocity, low-amplitude thrusts), nonspecific contact thrust procedures (ie, mobilization), manual-force, mechanically-assisted procedures (ie, drop tables or flexion-distraction tables), and mechanical-force, manually-assisted (MFMA) procedures (ie, stationary or handheld instruments).[1] Biomechanical investigations of individual differences in performance have begun to be studied for the purposes of education and assessing proficiency of particular technique strategies.[2-4] Common among all technique categories are the inherent goals of optimizing the potential for therapeutic benefits, while maximizing the comfort and safety of the patient and maximizing the efficiency of the thrust application.[5]

Developed by the late John McTimoney in the 1950s in the United Kingdom,[6] the McTimoney method is a light, whole-body approach to chiropractic care which is now estimated to be used by over a quarter of the chiropractors in the United Kingdom.[7] Based on the toggle-recoil technique developed by Palmer,[8] McTimoney adapted the classic hand position to better isolate the pisiform bone to ensure a more

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Fig 1. *A clinician applies a McTimoney technique thrust into a table-top mounted load cell.*

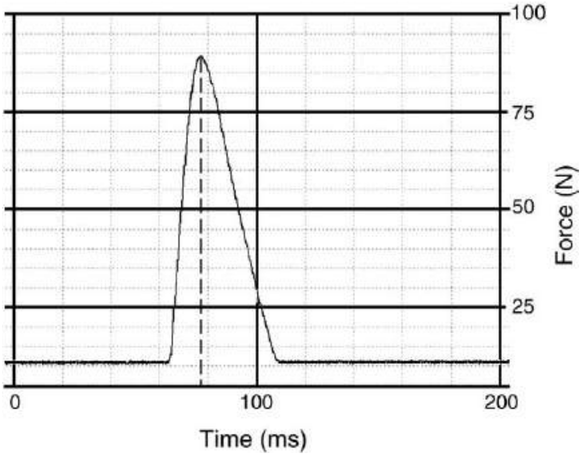

Fig 2. *Typical force-time profile of a McTimoney technique thrust. Thrust duration was defined as the total time under the force-time curve, while the time to peak force of the thrust was defined as the time duration from the onset of the force to peak force production.*

specific contact with the body, and added greater torque to the thrust which is thought to make the adjustment faster. His purpose was to create a fast, low force technique that could be applied comfortably to patients of all ages, from the newly born to the old and infirm.[9] The actual thrust used by chiropractors practicing the McTimoney method to perform a chiropractic adjustment is subsequently termed, the McTimoney toggle-torque-recoil (MTTR) technique.

Studies of spinal manipulative techniques have been reviewed and rated for their clinical effectiveness.[10,11] Most of the randomized controlled clinical trials in low back pain, neck pain, and headache patients[12] have been conducted using high-velocity, low-amplitude (HVLA) thrusts. Recently, however, studies have also begun to compare the effectiveness of other techniques including HVLA to MFMA procedures.[13-15] Within the HVLA categorization, other studies have examined the effectiveness of the Toggle-Recoil technique in the treatment of headache and cervical range of motion with encouraging results.[16,17] Although clinical outcome studies have gained attention, basic experimental science is lacking that might assist in explaining biomechanical mechanisms.[18]

Biomechanical investigations to characterize the forces and speeds of chiropractic adjustments or spinal manipulation have been conducted to better understand both the mechanisms and risks of treatment. Consequently, a number of studies have investigated the forces produced during a variety of spinal manipulative procedures.[19-26] In one of the earliest reported comprehensive studies of forces applied in various chiropractic techniques, Kawchuk and Herzog[25] analyzed the force-time profiles of several HVLA and MFMA cervical spine manipulation procedures (lateral break, Gonstead, Instrument, toggle, and rotation). The authors noted differences in forces and durations that are characteristic of the different chiropractic techniques used to treat the cervical spine. The MTTR technique taught in the McTimoney method is a variant of the standard toggle-recoil technique with an emphasis on speed. However, to date, no study has investigated the biomechanics of the variation of the toggle-recoil technique performed by McTimoney practitioners. Thus, the purpose of this study was to characterize the force-time profile of the MTTR technique.

METHODS

The study was conducted at the Biomechanics Laboratory in the Department of Kinesiology of Arizona State University (Tempe, Ariz). Two experienced licensed doctors of chiropractic with certified training in the McTimoney method were given instructions to apply MTTR thrusts as they would normally do in routine clinical practice to a tabletop where a load cell had been mounted (Fig 1). The clinicians were given an opportunity to practice on the experimental setup which also verified the proper functioning of the equipment. Following load cell calibration, each clinician then applied ten MTTR thrusts to the dynamic load cell (PCB model 200A02, PCB Piezotronics, Depew, NY) in a repeated measures design. In this manner, 5 thrusts were performed with the right hand, and 5, with the left hand of each clinician.

A constant current amplifier (PCB model 483A02) was used to acquire the dynamic force-time histories. The load cell force range and resolution were 445 and 0.0089 N, respectively. The load cell has a low frequency and high frequency response of 0.001 and 75,000 Hz, respectively. Forces were sampled at 5 kHz over a time period of ten seconds using a 16-bit, analog-to-digital converter. The resulting force-time history data were stored on a portable computer. Peak forces, time durations and times to peak force were computed from each of the force-time histories.

Table 1. *Peak force, duration, and time to peak force (δt) are shown for the 10 thrusts for each of the two clinicians applying McTimoney technique thrusts*

Clinician 1 Trial	Peak Force (N)	Duration (milliseconds)	δt (milliseconds)	Clinician 2 Trial	Peak Force (N)	Duration (milliseconds)	δt (milliseconds)
1	66.36	58.40	21.00	1.00	61.76	38.90	20.70
2	62.04	53.30	13.50	2.00	88.93	32.40	8.70
3	78.93	45.40	14.70	3.00	122.86	32.40	6.50
4	117.58	45.40	10.10	4.00	104.34	28.10	7.60
5	99.61	32.40	10.10	5.00	116.37	30.20	6.50
6	71.50	30.00	10.10	6.00	72.31	49.70	12.00
7	53.53	28.10	11.30	7.00	105.69	30.20	14.10
8	55.14	23.40	19.80	8.00	88.40	34.60	8.70
9	110.96	43.20	8.70	9.00	55.82	30.20	13.10
10	123.80	31.00	14.70	10.00	88.53	30.20	14.20
Mean	83.95	39.06	13.40	Mean	90.50	33.69	11.21
SD	26.71	11.70	4.23	SD	22.38	6.39	4.49
SEM	8.45	0.00	0.00	SEM	7.85	0.00	0.00

The calculated mean, SD, and SEM derived are shown.

Time to peak force was defined as the time duration (δt) from the onset of the force to the maximum peak force (Fig 2).

Comparisons and descriptive statistics were calculated on all dependent variables to characterize the forces, durations, and times to peak force of the MTTR thrusts. A Mann-Whitney *U* Test was conducted to compare forces, durations, and times to peak force between the 2 clinicians, and a Wilcoxon signed-rank test was performed to compare forces, durations, and times to peak force for right handed and left handed thrusts within clinicians. The level of significance for both statistical evaluations was $P < .05$.

Results

Considering all MTTR thrusts, peak force ranged between 55.14 and 123.80 N, and the average peak force was 87.22 N (SD = 24.18 N). For all MTTR thrusts, the duration of the thrust ranged from 23.40 milliseconds to 58.40 milliseconds and averaged 36.38 milliseconds (SD = 9.58 milliseconds). Considering time to peak force of MTTR thrusts, δt ranged from 8.70 to 21.00 milliseconds, and the average time to peak force was 12.31 milliseconds (S.D. = 4.39 milliseconds). Data for each clinician's 10 thrusts are compared in Table 1.

Mean peak force, thrust duration, and time to peak force for MTTR thrusts for each clinician are shown in Figure 3. No significant differences in mean peak force, duration, or time to peak force for MTTR thrusts were observed between clinicians ($P < .05$). When comparing intraclinician right-and left-handed thrusts, a significant reduction in the duration of the thrust was observed for the left handed MTTR thrusts of clinician 1 and the peak force for the right handed thrusts of clinician 2 ($P < .05$) (Table 2). This difference was not observed when comparing right and left handed thrusts for peak force of clinician 1 or duration of clinician 2. In addition, no differences were detected in time to peak variables for right and left handed MTTR thrusts within either clinician.

Discussion

This is the first study to characterize the force-time profiles of MTTR thrusts as performed using the McTimoney technique. Generally speaking, MTTR thrusts, as observed in the current study, are characterized by a low-force, short duration impulse resembling a half-sine wave. The MTTR thrusts quantified herein differ from standard toggle-recoil techniques in that they are appreciably faster (shorter in duration)[25] but, like standard toggle-recoil thrusts, do not impart any substantial preload force in their delivery. Considering the mean peak force of MTTR thrusts observed in this work, the approximately 90 N of force measured is substantially lower than other HVLA thrusts and more similar to mechanical-force manually-assisted type thrusts using chiropractic adjusting instruments on their low force setting. Colloca et al[27] reported peak forces of approximately 125 N for the low setting on the Impulse Adjusting Instrument (Neuromechanical Innovations, Phoenix, Ariz) and Activator IV Adjusting Instrument (Activator Methods International, Ltd, Phoenix, Ariz). Benefits of utilizing low-force chiropractic adjusting techniques include a viable alternative technique for patients potentially at risk for side-effects of spinal manipulation or to improve patient satisfaction in those patients adverse to higher loading forces as determined in their physical examination, although these notions have not been rigorously studied.[28]

The average peak forces measured for MTTR thrusts in the current study are similar to those previously reported for the standard toggle-recoil technique, albeit, substantially faster. In 1993, Kawchuk et al[25] reported mean peak forces of 117.6 N at 47.5 milliseconds for toggle-recoil thrusts. The notably faster average time to peak force of the MTTR thrust

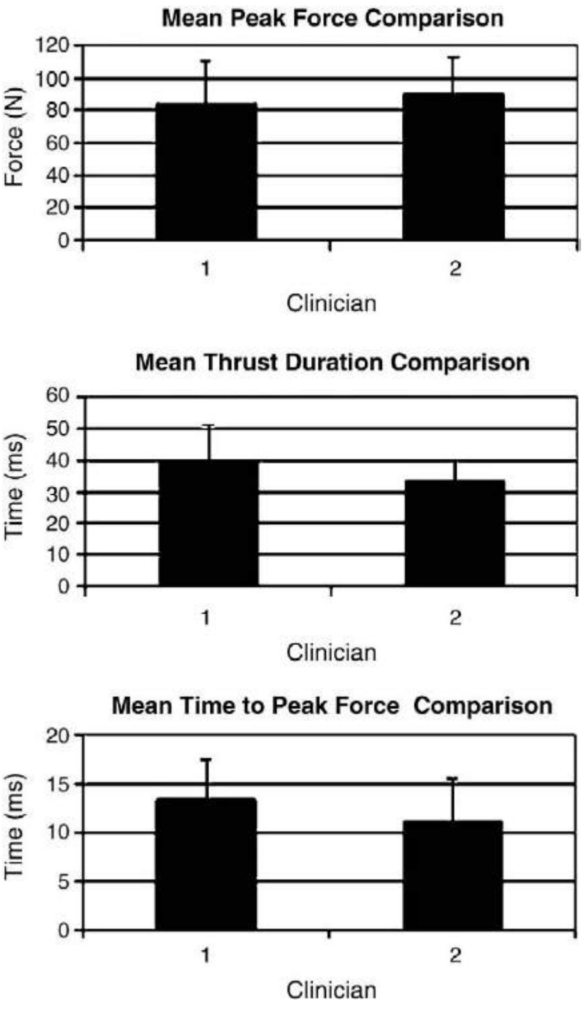

Fig 3. *Mean peak force, thrust duration, and time to peak force comparison between clinicians for McTimoney technique thrusts.*

Table 2. *P value results of the Wilcoxon signed-rank test comparing the right- and left-handed applied McTimoney technique thrusts for variables of peak force, duration, and time to peak force (δt)*

Clinician	Peak force	Duration	δt
1	0.686	0.043 *	0.109
2	0.043 *	0.357	0.498

* Significant P values ($P < .05$).

represents a substantial difference between the McTimoney technique and standard toggle-recoil type thrusts. Various studies investigating forces produced during traditionally HVLA spinal manipulations have reported wide variations in peak forces ranging from 40 to more than 1000 N.[21] Differences of applied force during chiropractic adjustments are dependent upon the spinal region being treated (cervical spine, thoracic spine, or lumbar spine), the technique being administered, and the clinical judgment of the clinician. In 1993, Herzog et al[23] reported the results of their investigation of forces exerted during spinal manipulative therapy delivered to various regions of the spinal column. Peak forces for the cervical spine ranged from 99 to 140 N. Peak forces for forces delivered to the thoracic spine at T4 were 399 N (SD = 119 N), and peak forces for thrusts applied to the sacroiliac joint ranged between 200 to over 600 N. These results are comparable to those of Triano and Schultz[22] who examined spinal manipulative forces as delivered in routine chiropractic practice using a mamillary push, hypothenar ischial contact, and long-level techniques. Peak load magnitudes ranged between 384 and 515 N in spinal manipulative forces applied to the lumbosacral region in their work. The current study did not examine peak forces produced for MTTR thrusts delivered to different spinal regions, which is clearly warranted. Indeed, the peak forces of MTTR thrusts are substantially lower, on the order ranging between 2- and 10-fold lower than other studies of HVLA thrusts.

Although controversial, it has been argued that the peak force achieved during a manipulative treatment may determine the success of the treatment.[29] For example, in order to elicit an audible release during thoracic spine spinal manipulative procedures, an average thrusting force of approximately 400 N is required.[30] Similarly, Brennan et al[31] reported an elevated burst of polymorphonuclear neutrophils in treatments where peak forces exceeded about 400 N but not in those where peak forces were below about 400 N. Other research has not shown a relationship between force magnitude or the presence of an audible release on physiological responses as measured by electromyography.[32] Gillette[33] noted that only 40 N of force is required to coactivate mechanoreceptive afferents deemed appropriate in neuromuscular reflexes, which is appreciably lower than the peak forces during MTTR thrusts obtained in the current study. Further research is necessary to assess the physiological effects of MTTR thrusts.

Noteworthy was the speed of the MTTR thrusts observed from the data herein. Comparing the time to peak force of MTTR thrusts obtained in the current research to other study of standard toggle-recoil technique thrusts (mean = 47.5 milliseconds),[25] the MTTR thrusts observed herein were approximately 1.3 times faster. The speed component of spinal manipulative thrusts has been found to be associated with the elicitation of neuromuscular reflexes thought to be related to the mechanisms underlying successful treatments.[32,34,35] When considering other HVLA techniques, the impulse duration of spinal manipulation ranges from 30 to 420 milliseconds[23-25] depending on the skill of the clinician and the region of the spine being manipulated. Consequently, the MTTR thrusts in the current study are on the order of one to nearly fourteen times faster than commonly administered chiropractic techniques. Just how the speed or rate of force production of a chiropractic adjustments or spinal manipulation relates to clinical outcomes is not clearly understood.

Neural responses arising from the mechanical input during spinal manipulation are thought to contribute its therapeutic effects.[36] A number of studies suggest that spinal manipulation alters central neural processing of innocuous mechanical stimuli.[37-39] In addition, spinal manipulation both increases the excitability of motor pathways in the spinal cord and depresses the inflow of sensory information from muscle spindles.[38,39] These changes may be related to the reported decrease in paraspinal muscle electromyography activity after spinal manipulation in some patients.[35,40] Sung et al[41] found that abrupt changes in neural discharge (instantaneous frequency) of low threshold muscle mechanoreceptors of the lumbar spine occur as the duration of a biomechanical load became shorter. Similarly, Colloca et al[42] reported significant increases in intervertebral motion responses and needle electromyographic responses for shorter duration spinal manipulative thrusts. Based upon these basic science studies, it appears that the short duration nature of the MTTR thrusts delivered in the McTimoney technique may be a desired attribute. Further research is necessary to understand how MTTR thrusts affect vertebral motions, neurophysiological responses and clinical outcomes in patients.

Specific to the toggle-recoil technique, one study noted improvement in a complex reaction-time task after an upper cervical adjustment, indicating preliminary evidence of their affect on cortical processing. Preliminary research into the effects of toggle-recoil technique have reported increases in cervical range of motion following said treatments.[16,17] In another work, a series of 4 toggle-recoil treatments over the course of 2 weeks was associated with a reduction in headache frequency, duration and severity.[16] Further research is necessary to understand the effects of MTTR thrusts on various patient outcomes. Just how the rotational “torque” component of the MTTR thrusts affects the speed of the thrust is worthy of investigation. In the current study, a tri-axial load cell was not used to sample compressive loads as opposed to shear forces. Future investigation of shear forces would be useful to characterize rotational “torque” components of the clinicians’ applied force. From study of biomechanics related to the term “torque” as used in chiropractic technique,[43,44] and knowledge of the negligible friction that the skin fascia interface possesses[45] it is likely that said “torque” does not cause any axial (z-axis) rotational motion of the spine.

Others have reported spinal manipulative forces applied to table tops or bench test experiments.[20,27,46] Applying forces to a tabletop as opposed to a living subject has both its benefits and limitations. One benefit of such an experimental setup is to provide a consistent rigid surface to optimize the reproducibility of the surface over which thrusts are applied to better appreciate the true force-time attributes of the force input, as opposed to a measure of transmissibility that must account for the dampening in the target tissue or structure. Secondly, concerns of applying repeated chiropractic adjustments or spinal manipulations to the same spot in repeated measures design on nonorganic table top do not raise concern of risk to the study participant that are of concern with human subject participation. Understandably, the force-time characteristics of the MTTR thrusts reported herein and other thrusts are expected to be different between these two designs based on the deformation of the objects of which the transducers are placed (ie, person vs desk). Because of a lack of available data on MTTR thrusts, our comparisons of the force-time profiles of other manual chiropractic techniques administered to the spine in vivo as opposed to the MTTR data being applied to a table-top must be considered in context with the respective study designs. Further work will examine the MTTR thrusts delivered to the spine in human participants to enable better comparisons with similar previous work. Actual technique comparisons made side-by-side in the same experimental design would be optimal.

Another limitation of the study design was the small sample of chiropractors examined (n = 2), and both clinicians being of the same sex, female. One cannot say for certain that the findings of this study can be extrapolated to other practitioners who use MTTR. Further study with a larger sample of clinicians of both genders is necessary to understand the generalization of these findings to other McTimoney practitioners. It is likely that no differences exist in the force-time variables between male and female chiropractors, yet this remains to be investigated using the McTimoney thrusts. Forand et al compared the forces applied by female and male chiropractors during thoracic spine spinal manipulation and found no difference in peak forces.[29]

Trained experts in the McTimoney method were selected to perform the MTTR thrusts in the current study. This may explain the consistency of the biomechanical results between examiners for their thrusts delivered. Other research has shown that duration, extent and content of prerequisites for learning the dynamic and complex nature of manual skills for chiropractic adjustment or spinal manipulation can significantly influence the level of skill attainment even early in the course of training.[2] For this reason, it is necessary to characterize the force-time profiles of novice students and compare results to trained and expert practitioners to better appreciate any biomechanical variables that may differ in these groups. Likewise, measuring the force-time profiles in students learning the McTimoney technique may assist in providing quantitative feedback of student performance. To this extent, implementing training procedures may optimize results, such as consistency of force and improvement of speed which has been accomplished in other research.[4] Differences in thrust duration between the right an left handed MTTR thrusts in one clinician and peak forces in the other suggest different motor control strategies in technique application or a handedness bias which deserve further study.

CONCLUSIONS

McTimoney toggle-torque-recoil thrusts are characterized by a controlled low-force short duration force-time profile when compared with other chiropractic adjustment or spinal manipulative techniques. The speed generated during MTTR thrusts for the 2 subjects studies was approximately 1.3 times faster than standard Toggle-Recoil techniques and about 14 times faster than other chiropractic techniques. The lower magnitude of peak force and its reproducibility between the 2 experienced clinicians are important when assessing risks of MTTR treatments and is testimony of the consistency of forces and speeds using the MTTR technique. These results have implications for educational training within the technique. Further work will investigate the relationship between force-time profiles of MTTR thrusts and the resultant physiologic responses and potential health benefits from their application.

Practical Applications

- For the 2 subjects in this study, peak forces for all MTTR thrusts averaged 87 N, appreciably lower than other chiropractic techniques.
- For the 2 subjects in this study, mean thrust durations of MTTR thrusts were 36 milliseconds, considerably faster than other chiropractic techniques.
- Consistency between clinicians was observed for both clinicians, but differences were noted for the left handed MTTR thrusts.
- Biomechanical investigations to characterize the forces and speeds of chiropractic adjustments are important to better understand the mechanisms and risks of chiropractic care.

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