The Effect of Osteopathic Manipulative Treatment on Proprioception in Adults: A Pilot Study

Krista Hoevemeyer, OMS IV; Kai Yuan Teng, OMS IV; Thomas Mehner, OMS IV; Ryan McMunn, OMS IV; Jose Figueroa, DO; and Chunfa Jie, PhD

ORIGINAL RESEARCH

Abstract

Introduction: This study aims to investigate if proprioception is the mechanism through which osteopathic manipulative treatment (OMT) corrects somatic dysfunctions. OMT focuses on resolving structural asymmetry in the body that may interfere with physiologic function, including proprioception. Multiple theories have been proposed regarding the physiologic mechanisms of OMT and the effect on proprioception, with few studies objectively establishing a connection.

Hypothesis: Significant change in measurements of proprioception was expected in the treatment group (OMT) over the 4-week period.

Methods: For the study, 35 adults recruited from the Des Moines University community were randomized equally into treatment and control groups. For 3 weeks, the treatment group received weekly osteopathic structural exams (OSE) and OMT, while the control group underwent the same OSE but without treatment. Proprioception was assessed using force plate measurements collected during two-leg and single-leg tests prior to the first intervention, immediately after the first intervention, and 1 week after last intervention. Measurements included anterior-posterior sway, medial-lateral sway, average velocity, area, path length and time, which were analyzed with a linear model of mixed effects for repeated measures to account for the fixed effects (time and treatments), interaction effects and the random subject effects.

Results: Over the 4-week period, significant differences were found for 4 measurements: two-leg eyes-open-path-length ($p=0.0342$), two-leg eyes-open-average-velocity ($p=0.0334$), single-right-leg eyes-open-average-velocity ($p=0.0145$), and single-right-leg eyes-closed-medial-lateral-sway ($p=0.0488$).

Conclusion: Certain measurements of proprioception changed in an adult population over a 4-week course with 3 weekly OMT treatments. These results indicate OMT may be altering proprioception through the correction of somatic dysfunctions. Our results suggest a need for further research investigating the effects of OMT on proprioception in symptomatic populations and larger sample sizes.

From Des Moines University.

Disclosures: none reported.

Correspondence address:
Krista Hoevemeyer, OMS IV
OMM Fellow
Des Moines University
3124 Kingman Blvd
Des Moines, IA 50311
(734) 478-2669
krista.hoevemeyer@dmu.edu

Submitted for publication May 8, 2020; final revision received August 18, 2020; manuscript accepted for publication August 25, 2020.

Introduction

The aim of this study is to investigate the mechanism of osteopathic manipulative treatment (OMT). Previous studies have shown the effectiveness of OMT on decreasing patient symptoms by removing somatic dysfunctions (SDs). We believe by removing somatic dysfunction, OMT changes proprioception. We will investigate this effect globally throughout the body by using balance measurements as a conduit for proprioception.

Osteopathic manipulative treatment is used to treat acute[1] and chronic pain,[2] gastrointestinal complaints,[3,4] respiratory disease,[5] and more. OMT addresses these diseases by reducing restrictions in the musculoskeletal, circulatory, respiratory, lymphatic, visceral, and nervous systems.

Proprioception is the brain's awareness of forces placed on the body, the positioning of joints and movements of the body.[6] Proprioception is collected by mechanoreceptors and muscle spindles present

(continued on page 12)

(continued from page 11)

in muscles, tendons, ligaments, and fascia in the periphery of the body and transmitted to the central nervous system (CNS).[6] Muscle spindles are collections of contractile muscle fibers (intrafusal muscle fibers) that while capable of contraction, do not contribute significantly to the generation of force for muscle contraction. These fibers lay parallel to force-generating extrafusal muscle fibers, and through innervation by two different types of afferent nerves, are capable of monitoring muscle length and rate of length change. Muscle length and rate of length change information from muscles is used by the CNS to sense where in space a specific muscle is and by extension provide positional information on bones, ligaments, and tendons present in the anatomic region of the muscle. Balance and proprioception are heavily related as the goal of balance is for the CNS to keep the body both upright and maintain the eyes in a level horizontal plane. Without proper proprioception, an individual will have poor balance. When somatic dysfunction is introduced into the body, balance can be compromised leading the body to compensate by contracting surrounding muscle groups.[7] These compensatory changes are often maintained in a chronic state as the body requires them for normal sensory perception and function.[7] Regardless of the mechanism through which somatic dysfunction is introduced to the body, be it trauma, chronic muscle imbalance, viscerosomatic reflex, etc., the proprioceptive elements of the body play a role in maintaining the compensatory changes made by the body.

Many osteopathic manipulative techniques target muscle spindles to reset aberrant proprioceptive activity. Counterstrain is an indirect passive osteopathic technique used to treat somatic dysfunctions that arise from reflex contraction of muscle in response to microscopic damage to muscle fibers.[8] When muscles are damaged by sudden or repeated lengthening from trauma or overuse, muscle spindles send information through afferent nerves to gamma motor neurons in the spinal cord, causing reflex contraction of the muscle and inhibition of antagonist muscle groups. This state of agonist contraction and antagonist relaxation or lengthening is maintained by the muscle spindle and CNS until the proprioceptive elements are reset. This is achieved by positioning the patient so that the origin and insertion of the muscle carrying the SD are approximated to alleviate the stretch of the affected muscle and stop the reflex contraction loop that was initiated by the affected muscle spindle.

Muscle Energy (ME) is a direct active osteopathic technique focused on somatic dysfunctions that result from abnormalities in muscle lengths.[8] Differences between muscle tension and length can result in bony and fascial dysfunction around joints and along the spinal column. Muscle Energy targets these dysfunctional

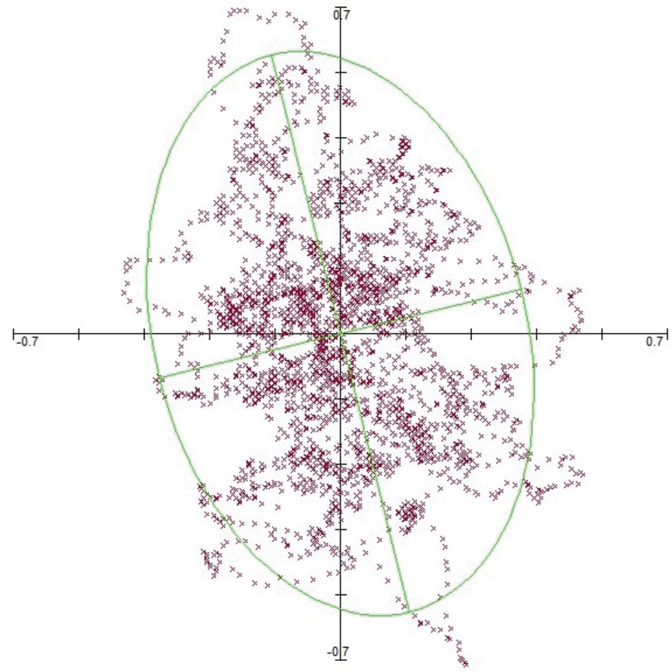

Figure 1. *COP output. Tracing of a subject's COP throughout the duration of one test. From this output, the AccuSway System calculates all desired variables.*

tissues by resetting intrafusal and extrafusal fiber lengths during the post-contraction relaxation phase of muscle contraction cycle.

High velocity/low amplitude OMT, also referred to as the thrust treatment method or HV/LA, is a direct passive osteopathic technique that treats ligamentous somatic dysfunction.[8] Malalignment or displacement of bones alters proprioceptive input from the ligaments to the CNS resulting in altered tonicity and length of surrounding musculature. By reducing the displacement of bones using a controlled directed short (low amplitude), thrust (high velocity), HV/LA resets afferent proprioceptive signaling from the ligaments terminating the feedback loop causing altered tonicity of the surrounding musculature.

Previous research has demonstrated that chiropractic spinal manipulation has had inconsistent results on trunk proprioception,[9] chiropractic neck manipulation improved head repositioning,[10,11] and elbow joint position sense,[10] and OMT improved balance in a patient with dizziness.[12,13] While these findings demonstrate support for a link between manual therapy and proprioception, there are no objective findings saying whether proprioceptive is affected by OMT.

We believe that when utilizing OMT to reset joints, muscle lengths, and muscle spindle signaling, the response in the body is manifested by improved proprioception. Based on this principle, we expect that in our study the non-treatment control group will

(continued on page 13)

(continued from page 12)

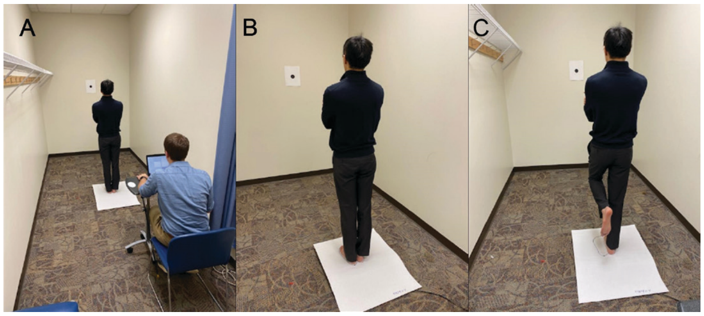

Figure 2. *Force plate setup for data collection. A. Two-leg test with the researcher sitting behind the subject to not affect the subject's line of sight. B. Force plate is placed six feet away from the wall, and the dot is placed at average eye level on the wall. C. Subjects stance during a single-leg test.*

have no change in proprioception while the OMT treatment group will exhibit improved balance and proprioception both immediately following the first treatment and over the course of consecutive treatments. By investigating this question, we begin to explore the foundational physiologic effect that OMT has on the body to remove structural dysfunction and promote the body's innate ability to heal. This pilot study could serve as a springboard for future studies to determine how OMT exerts its effect on the body.

Methods

The present study was approved by the Institutional Review Board of Des Moines University (DMU). The study was publicly registered on clinicaltrials.gov. Informed consent was obtained from each subject. All enrolled subjects underwent interventions and force plate measurements in the OMM laboratory at Des Moines University.

Subjects

Recruitment from the DMU community was accomplished through class announcements, flyers, posts on social media and word of mouth. Thirty-five subjects were initially recruited for the study. Inclusion criteria were ages 18-40 years old, ability to give consent and bear weight on both feet. Subjects were excluded from the study if they had manipulation performed by a doctor of osteopathic medicine, physical therapist, or chiropractor in the last two months, surgery in the last six months, fractured a bone in the last six months, an abnormal neurological exam, cerebellar dysfunction or ataxia, or a condition that impairs balance (including orthostatic hypertension, otoneurologic conditions, or arrhythmias). Subjects were also asked about dizziness, fainting, previous falls, fever, weight loss, pain that wakes them at night, morning stiffness or localized bone pain and were evaluated accordingly if subjects needed to be excluded for medical treatment. One subject was excluded after the initial assessment, three subjects withdrew after week 1 because they received manipulation elsewhere and one subject withdrew due to personal reasons. The final analysis included 31 subjects. Subjects were randomized using a random number generator and divided into two groups: those receiving OMT and those not receiving OMT (control). Subjects and researchers, except the researcher who collected the force plate measurements, were not blinded to group assignment. No financial compensation was provided for participation in the study.

Measurements

Balance measures were obtained from AMTI AccuSway System for Balance and Postural Sway Measurement (Advanced Mechanical Technology, Inc., Watertown, MA) force platform. The force platform measures the movement of a person's center of pressure (average pressure between the feet) over a certain time period. Postural sway is the displacement of the center of pressure (COP). Figure 1 demonstrates an example of the output.

The balance measurements were obtained in a separate room within the OMM laboratory with minimal distractions. One researcher was designated to collect the measurements and was blinded to the subject's group throughout the study. Another researcher was present for the data collection to ensure patient safety with the single leg testing. Subjects were asked to stand barefoot on the force platform with the medial aspects of their feet touching or as close together as possible. Marks were made on paper corresponding to eight landmarks around the subject's feet and the marks were traced to ensure consistent foot positioning for subsequent tests. Subjects performed six balance tests: (1) two-leg eyes-open, (2) two-leg eyes-closed, (3) single-right-leg eyes-open, (4) single-right-leg eyes-closed, (5) single-left-leg eyes-open, and (6) single-left-leg eyes-closed. Each test was performed with the subject's arms crossed over their chest and their head straight with gaze fixed on a mark on the wall. These tests were chosen based on the Romberg's test for proprioception and the one-legged stork test.[7] Figure 2 shows the measurement setup and the subject positioning. One 15 second practice interval was performed prior to data measurement for each single leg test. Subjects were instructed to stand as still as possible with their arms crossed for the trial period. During single leg measurements, they were instructed to not let the non-support leg touch the support leg or the floor. Measurements were recorded for 60 seconds during the two leg tests and 30 seconds for the single leg tests. If subjects fell or their legs met before the completion of the trial, measurements were stopped, and the time was recorded. Outcome measures included average velocity, area, path length, medial-lateral sway, anterior-posterior sway, and time. Multiple studies have found these measurements to reliably assess postural

(continued on page 14)

(continued from page 13)

stability and have good intrasession and intersession reliability.[14,15,16] At week 1, balance tests were performed in both the OMT and control groups prior to the first intervention and immediately after. Subjects returned for final balance tests 1 week after the last intervention (week 4). Timing of tests were based on previous OMT research using force plate measurements prior to first intervention, immediately after the first intervention and one week after the last intervention.[11,12]

Intervention Protocol

Subjects received 3 weekly interventions depending on the assigned group (OMT vs control). Three DMU OMM fellows performed all interventions under supervision by DMU OMM Department faculty physicians. The OMM fellows were assigned to specific subjects for the entirety of the study to ensure consistent interventions. Figure 3 outlines the timeline of requirements, interventions, and measurements subjects underwent during each week of the study. For the treatment group, supervising physicians assessed structural landmarks for height differences (occiput, acromioclavicular (AC) joint, angle of scapula, iliac crests, posterior superior iliac spine (PSIS), greater trochanter, ankles, and feet), performed a spinal sweep and documented their findings. The OMM fellows assessed subjects for somatic dysfunctions (SD) in the following regions: head, cervical, thoracic, lumbar, sacrum, pelvis, ribs, upper extremities, and lower extremities using the common compensatory model to focus the treatment. This model focuses on fascial motion preference at axial transition zones including the occipital-atlantal joint, the thoracic inlet, the thoracolumbar junction, and the lumbosacral junction.[17] The SDs found were treated with OMT styles including high velocity-low amplitude (HVLA), muscle energy (ME), counterstrain (CS), balanced ligamentous tension (BLT), facilitated positional release (FPR) and myofascial release (MFR). Following intervention, the supervising physician rechecked the same structural landmarks for improvement and performed a spinal sweep. If an area required further treatment, the physician notified the OMM fellow, and additional treatment was performed. The treatment sessions lasted 10-20 minutes and the control sessions lasted at least 10 minutes. The subject then walked 3 laps inside the OMM lab (672 feet), for approximately 5 minutes to assess for post treatment reactions. For the control group, somatic dysfunctions were assessed in each subject the same way as the treatment group, but OMT was not performed.

Analysis

Data was collected at three occasions for six balance measurement variables of interest. The six variables included length of pathway of center of pressure, area covered by center of pressure, velocity of

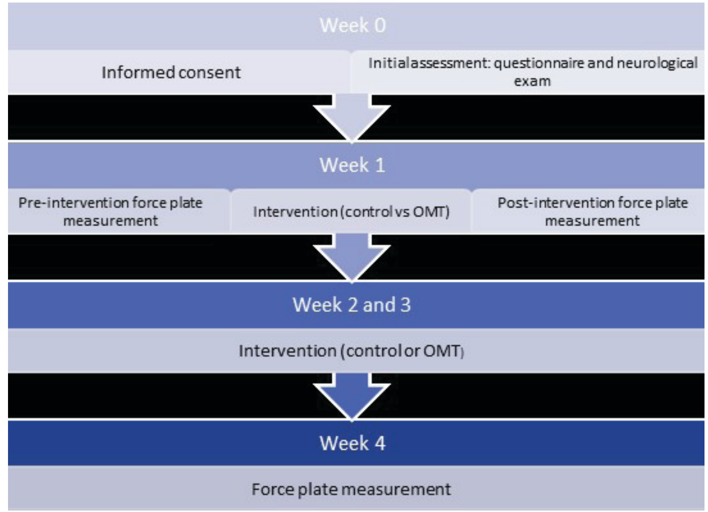

Figure 3. *The timeline of requirements, interventions, and measurements subjects underwent during each week of the study.*

center of pressure, medial-lateral sway, anterior-posterior sway, and time lapsed during the single-leg tests. Summary descriptive statistics were first obtained for the selected variables and demographics covariates as appropriate. For a particular variable, the change (delta value) between pre- (or baseline) and post-treatment during the first week reflects the immediate treatment effect while the difference between the pre-treatment baseline and the last measurement during week 4 represents the long-term lasting accumulative effect. The data bear the characteristics of repeated measurements on the same study participants since more than one measurement was taken on the same study participant over time. Thus, it is usually plausible to assume the measurements on the same individual subjects are correlated. Ignoring the covariance between such measurements may result in erroneous statistical inference, and avoiding it by data transformation may result in inefficient statistical inference. The statistical technique of linear mixed model for repeated measures allows the covariance structure to be integrated into the modeling while accounting for the randomness of the study subjects. Thus, the data was analyzed separately for each variable with a linear mixed-effect model with repeated measures design to assess the OMT effects on the balance measurement metrics over time. In the model fitting process, several candidate covariance structures were selected and evaluated according to the experimental design (i.e., unequal spacing of the time points but with the same time points across the study participants, within-subject correlation over time and convergence of model

	Control (n=15)	Treatment (n=16)
Mean Age (Range)	24.1 (22-27)	25.5 (22-28)
Gender (M/F)	4/11	2/14

Table 1. *Subjects Demographic*

(continued on page 15)

(continued from page 14)

fitting). The optimal covariance structure was separately selected for variables over the candidate covariance structures (compound symmetry first-order auto correlation and unstructured covariance) using the Akaike information criterion (AIC). Based on the chosen models for the respective variables, statistical contrasts were set up to compare the mean values of variable measurements between time points to assess the immediate and long-term effects of OMT treatment.

Results

A total of 31 subjects completed the entire study over the period of 4 weeks. Subjects in the treatment group received 3 weekly treatments. Table 1 summarizes the age and gender demographic of subjects.

A total of 34 proprioception variables were collected by the force plate with comparison between the treatment group and the control group using linear mixed model analysis. Out of 34 variables, 4 showed significant changes over time between the treatment group and the control group. Table 2 shows the p-values of all the 34 variables collected by the force plate with comparison between treatment and control groups using linear mixed model analysis. Significant changes over time were found in 4 variables (bolded in Table 2): the change of pathway length of center of pressure over time in two-leg eyes-open position (p=0.0342), the change of medial-lateral sway over time in single-right-leg eyes-open position (0.0488), the change of average velocity over time in two-leg eyes-open position (p=0.0334), the change of average velocity over time in single-right-leg eyes-open position (p=0.0145). The mean measurements and standard error of the control and treatment groups of these four significant variables and their p values of changes over time are shown in Table 3. Figure 4 shows the changes over time of the variables that were significant between treatment and control groups.

When looking at the variable of path length for subjects during the two-leg eyes-open test, the treatment group had a decrease in path length over the 4-week course, (Figure 4A). The control group had a decrease in path length from pre-intervention to post-intervention in week 1 and returned to baseline during the week 4 measurement (Figure 4A). Another variable that showed a similar pattern was two-leg eyes open for average velocity. While the treatment group maintained the decrease in velocity throughout the 4-week course, the control group showed an initial decrease with a rise back to baseline at week 4 (Figure 4B). Other significant results were found in the single-right-leg test, and they displayed different patterns. For average velocity, the control group had an initial increase during week 1, then decreased in week 4 (Fig. 4C). The treatment group, however, had an initial decrease during week 1, then increased in week 4. (Fig 4C). For single-right-leg medial-lateral sway, the control group showed an initial decrease during week 1, then increased in week 4 (Fig. 4D). The treatment group showed the opposite trend, displaying an initial increase in week 1, then decreased in week 4 (Fig 4D). The change (the delta value) between week 1 and week 4 for the treatment group is lower than that change of the control group by 1.521 (p=0.028).

There were no significant changes between treatment and control groups over time in the other 30 variables. However, there were 3 variables that showed trends: single-left-leg eyes-open medial-lateral sway, single-right-leg eyes-open time, two-leg eyes-closed Area.

	Path length of COP	Area	Medial-lateral sway	Anterior-posterior sway	Average Velocity	Time
TL-EO	**0.0342**	0.2105	0.7059	0.1451	**0.0334**	
TL-EC	0.9488	0.0759	0.9459	0.2055	0.9488	
SRL-EO	0.2427	0.5775	**0.6975**	0.6321	**0.0145**	0.4764
SRL-EC	0.786	0.2843	0.0488	0.9147	0.475	0.8743
SLL-EO	0.2292	0.4787	0.6223	0.7404	0.3682	0.7802
SLL-EC	0.5361	0.7925	0.3535	0.8417	0.0709	0.6749

Table 2. *P-value Of All 34 Proprioception Variables Changes Over Time. TL-EO: two-leg eyes-open; TL-EC: two-leg eyes-closed; SRL-EO: Single-right-leg eyes-open; SRL-EC: Single-right-leg eyes-closed; SLL-EO: Single-left-leg eyes-open; SLL-EC: Single-left-leg eyes-closed*

Categories	Week 1: Pre		Week 1: Post		Week 4		P-Value
	Mean Measurement (SE)		Mean Measurement (SE)		Mean Measurement (SE)		
Groups	Control	OMT	Control	OMT	Control	OMT	
TL-EO-PL	41.45 (1.56)	43.53 (1.57)	39.37 (1.47)	42.36 (1.79)	42.09 (1.82)	42.01 (1.48)	0.0342
SRL-EC-ML	3.37 (0.57)	2.70 (0.30)	2.71 (0.33)	3.47 (0.46)	3.19 (0.52)	2.32 (0.29)	0.0488
TL-EO-AV	0.69 (0.02)	0.72 (0.02)	0.65 (.02)	0.70 (0.02)	0.70 (0.03)	0.70 (0.02)	0.0334
SRL-EO-AV	1.78 (0.11)	2.01 (0.11)	1.95 (0.10)	1.83 (0.09)	1.85 (0.10)	2.03 (0.12)	0.0145

Table 3. *Measurements of control and treatment groups of four significant proprioception variables and their p values of change over time.*

(continued on page 16)

(continued from page 15)

The changes over time of these variables are shown in Figure 5. For time elapsed in the single-right-leg eyes-open test, both the control group and the treatment group improved in their ability to stay on the right leg longer (Fig. 5A). For the two-leg and eyes closed test, the control group had a decrease in area from pre- to post-intervention during week 1 which was maintained in week 4 (Fig 5B). The treatment group, however, had an increase in area from pre- to post-intervention during week 1, then returned to a mean similar to baseline in week 4 (Fig. 5B). For anterior-posterior sway the control group stayed fairly consistent throughout the 4 weeks, whereas, the treatment group displayed increased sway pre- to post-intervention during week 1, and displayed slightly worse sway than baseline in week 4 (Fig. 5C).

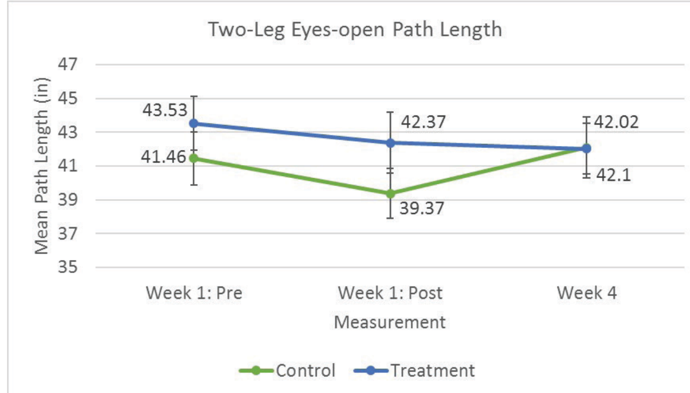

Figure 4A. *The changes over time of mean proprioception measurements for Two-leg Eyes-open Path Length*

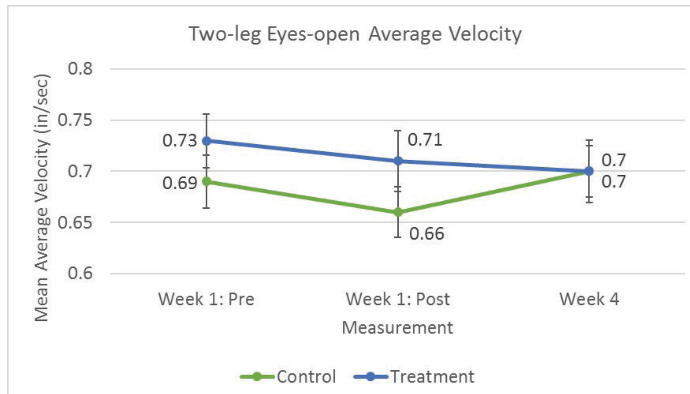

Figure 4B. *The changes over time of mean proprioception measurements for Two-leg Eyes-open Average Velocity*

Comments

Our study aimed to investigate the mechanism by which OMT corrects somatic dysfunction. We used balance testing to link the correction of somatic dysfunction with proprioception. The data effect is non-conclusive because not all variables showed significance or the same pattern over time. The decrease in path length seen in the control group for the two-leg eyes-open test could be attributed to learning because the task was performed within 20 minutes. This could also mean the decrease in path length in the treatment group is due to learning, but the treatment group sustained the decrease over the 4 weeks, whereas the control only showed the decrease from pre-to post intervention during week 1. This indicates the treatment group could have had decrease of path length due to improved proprioception from receiving treatment. This is similar to the decrease in average velocity for the two-leg eyes-open test. The sustained decrease over the 4 weeks in the treatment group indicated improved proprioception potentially due to treatment.

In the single-right-leg eyes-open test we believe the initial decrease of average velocity pre-to post intervention in the treatment group could be due to the OMT creating improved proprioception; however, we are unsure why the control group displayed the opposite pattern.

In the single-right-leg eyes-open test the medial-lateral sway displayed interesting results. The control group had a decrease initially, which could have been from learning, and then went back to baseline. The treatment group displayed increased medial-lateral sway pre-to post treatment during week 1, indicating a worsening of proprioception. The initial increase of sway during week 1 could have occurred for multiple reasons. The treatment lasted 15-20 minutes, whereas the osteopathic structural exam for the controls lasted approximately 10 minutes. The increased length of time the treatment group relaxed while lying on the table could have affected their balance testing. The OMT may also have caused the change. When OMT is performed, there is increased blood flow into the tissue, which can bring increased inflammation for healing. The beginning of the healing process could have altered their balance. We believe the increase in inflammation occurs when there is a diagnosed medical problem, so there may have been some undiagnosed conditions within the participant population. Additionally, by changing lengths of muscles or ligament, OMT can produce soreness which may have affected the participant's balance.

We can also look at the marginally insignificant trends. The treatment and control group displayed improvement in elapsed time on the right leg with eyes open, which could have been from learning the task. The two-leg eyes-closed test for area demonstrated a decrease in area for the control group interpreted as improved proprioception, but again the treatment group had an initial increase in area potentially due to treatment or difference in time on the table as previously explained. The only single-left-leg trend we found was for eyes-open and the variable was medial-lateral

(continued on page 17)

(continued from page 16)

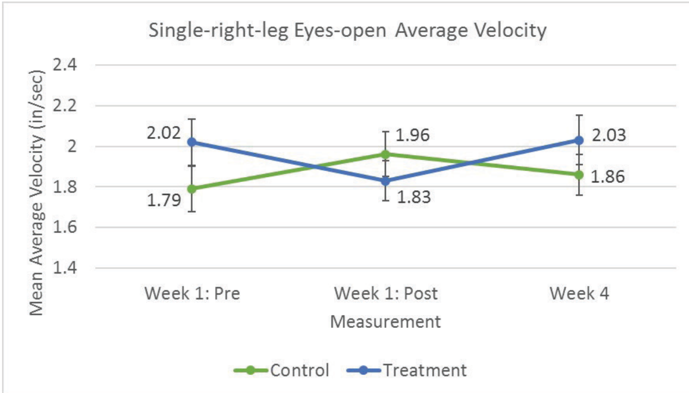

Figure 4C. *The changes over time of mean proprioception measurements for Single-right-leg Eyes-open Average Velocity*

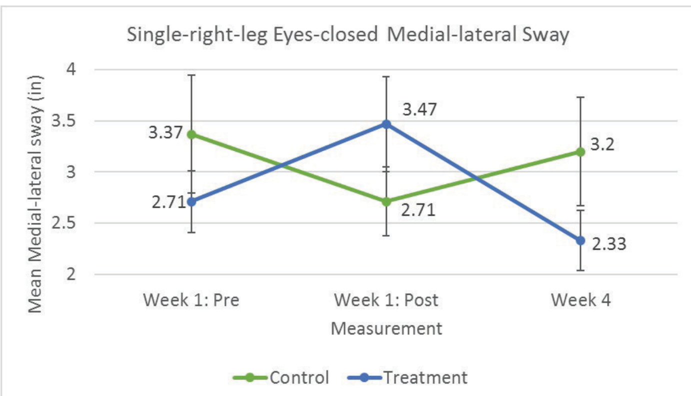

Figure 4D. *The changes over time of mean proprioception measurements for Single-right-leg Eyes-closed Medial-lateral Sway*

sway, which again displayed an increase pre-to post intervention during week 1 further leading us to investigate why a worsening of proprioception would be seen immediately.

The decrease in medial-lateral sway we saw over the four weeks in single-right-leg eyes-open is consistent with the findings in two-leg testing in elderly patients found previously.[18] A previous study also found a decrease in anterior-posterior sway after OMT, however, this was not displayed in our data.[18] Another study found better postural stability and decreased symptoms of dizziness after OMT.[11] Further comparison of the results of our study to other studies is difficult, as the body of knowledge examining the link between OMT and proprioception is small. The measurements used for balance also vary greatly from study to study.

Some limitations of our study include our study population, multiple treaters, sample size, and less sensitive proprioception measurements. The subjects enrolled in the study were considered healthy, so the result might not reflect a population with symptoms. If we had used a population with symptoms, similar to a clinic population, we may have found increased differences after treatment. Patients with symptoms, especially chronic, may have altered proprioception due to pain, or moving in a guarded position to reduce pain. After treatment, we usually see better posture, movement, and control. Some subjects were osteopathic medical students who practiced OMT in labs, which might have affected the results. In addition, there were no sham treatments given, so the subjects were not blinded to the assigned group. Since the participants were not blind to the treatment, participants in the treatment group may have tried harder to improve their balance, yet we were comparing the subjects to their own baseline, mitigating some of this effect. Three OMM fellows provided treatments during the study period. The study was designed this way because of the time availability of the OMM fellows. The fact that subjects in the treatment groups were treated by three OMM fellows could be a strength and weakness. It could be argued that the results could be biased because of multiple treaters; however, having multiple treaters still produced significant results showing that OMT did show effect regardless of the styles used. In clinical settings, every OMT practitioner has a different approach to the patient. Thus, our result could be applied to clinicians regardless of their style preferences. It would be interesting to further stratify the result based on the OMM fellow. However, due to the small sample size of the subjects, it was challenging to do so. Another potential confounding factor was the ratio of females to males. We overwhelmingly had more females to males (25:6). However, there were 4 males in the control group and 2 males in the treatment group, so the gender effect should be minimal. We are unsure why this occurred, but would be an interesting aspect to look at for future studies. Our sample size also made our error large, making it harder for the data to produce significant results. When treating with OMT, we used a common compensatory model to structure our treatment approach. This is only one approach to addressing somatic dysfunction throughout the body, and different approaches may have varying effects on proprioception.

This study uses a force plate as a measurement of proprioception, specifically, a Romberg test plus single leg tests. Romberg tests are commonly used in clinic settings to assess the dorsal columns of the spinal cord, where the signals from proprioceptors in the body transmit their signal to the brain through the fasciculus gracilis and cuneatus.[19] Romberg is also a form of balance testing, and balance testing has historically been used to measure lower extremity proprioception and can give the assessor insight to see if there was a problem with proprioception.[20] However, because vision, the cerebellum, proprioception, and the vestibular system make up balance, it is difficult to discern which is changing pre-to post-treatment. We also found most of the significant results during eyes open testing, which would decrease the specificity to proprioception.

(continued on page 18)

(continued from page 17)

Perhaps using a localized proprioception measurement could produce a clearer result. Additionally, the use of a full body motion tracking system for data collection could provide a better picture for global proprioception. In addition to the limitation above, single measurements were taken for each variable. Repeated testing during each measurement would strengthen the data collected.

One interesting aspect is that we had no significant findings in the single-left-leg tests. Single-leg testing tests more specifically the lower-extremities and the proprioceptive input from the sole of the foot.[21] Additionally, by crossing their arms, we remove the balancing assistance of the upper extremity.[21] As shown in Table 4, we did treat the right lower extremity more than the left. There were also more somatic dysfunctions found and treated on the right lower extremity for each treatment, and a higher percentage of treatment participants had their right lower extremity treated. Because of the differing interpretations across multiple variables taken from the force plate measurements, we are unable to state if removing somatic dysfunctions through OMT improves proprioception. However, there are variables indicating it may.

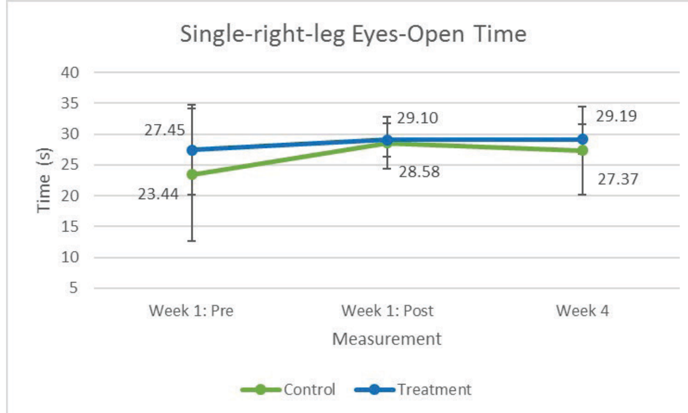

Figure 5A. *Changes over time of proprioception variables that were marginally insignificant but showed trends: Single-right-leg Eyes-Open Time*

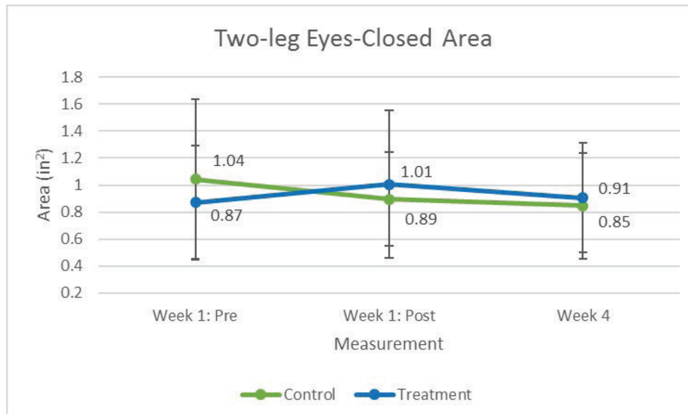

Figure 5B. *Changes over time of proprioception variables that were marginally insignificant but showed trends: Two-leg Eyes-Closed Area*

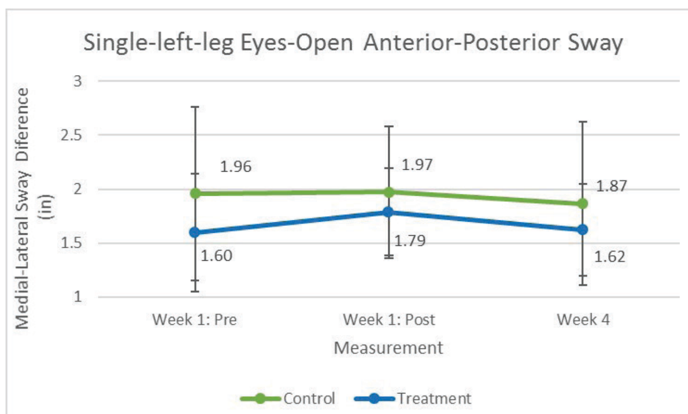

Figure 5C. *Changes over time of proprioception variables that were marginally insignificant but showed trends: Single-left-leg Eyes-Open Anterior-Posterior Sway*

Conclusion

While this study is not conclusive, it shows OMT may improve proprioception. If the link between OMT and proprioception is solidified, the osteopathic community could better communicate to the overall medical community and patients how we are helping them and improving their physiology and function. The theories previously explained postulate the physiology behind certain OMT techniques, but this study allows us to investigate further objective data about those theories. We found multiple variables in both two-leg and single-leg testing that were significantly impacted by OMT. Some of the variables showed improvement in proprioception, while others showed an immediate worsening of proprioception. More conclusive results may be shown with a bigger sample population, symptomatic patients, or with a more sophisticated proprioception assessment.

Acknowledgements

We would like to acknowledge all of the physicians that supervised treatments which include: Hillary Hass, DO, Assistant Professor at Des Moines University; Shannon V. Crout, DO, Assistant Professor at Des Moines University; Drew D. Lewis, DO, FAAO, Professor at Des Moines University; Adrian L. Woolley, DO, Assistant Professor at Des Moines University; and Katherine L. Heineman, DO.

References

1. Eisenhart AW, Gaeta TJ, Yens DP. Osteopathic manipulative treatment in the emergency department for patients with acute ankle injuries. *J Am Osteopath Assoc*. 2003;103(9):417-421.
2. Licciardone JC, Brimhall AK, King LN. Osteopathic manipulative treatment for low back pain: a systematic review and meta-analysis of randomized controlled trails. *BMC Musculoskeletal Disorders*. 2005; 6:43. https://doi.org/10.1186/1471-2474-6-43

(continued on page 19)

(continued from page 18)

3. Crow WT, Gorodinsky L. Does osteopathic manipulative treatment (OMT) improve outcomes in patients who develop postoperative ileus: A retrospective chart review. *Int J Osteopath Med*. 2009;12(1):32-37. https://doi.org/10.1016/j.ijosm.2008.03.004
4. Bjornaes KE, Elvbakken G, Balhoi, et al. Osteopathic manual therapy (OMT) in treatment of gastroesophageal reflux disease (GERD). *Clin Pract.* 2019;16(3):1109-1115.
5. Zanotti, E, Berardinelli, P, Bizzarri, C, et al. Osteopathic manipulative treatment effectiveness in severe chronic obstructive pulmonary disease: a pilot study. *Complement Ther Med*. 2012;20(1-2):16-22. https://doi.org/10.1016/j.ctim.2011.10.008
6. Roijezon, U, Clark, NC, Treleaven, J. Proprioception in musculoskeletal rehabilitation. Part 1: Basic science and principles of assessment and clinical interventions. *Man Ther*. 2015;20(3):368-377. https://doi.org/10.1016/j.math.2015.01.008
7. Greenman, PE. *Principles of Manual Medicine*. 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2003.
8. Seffinger, MA; American Osteopathic Association. *Foundations of Osteopathic Medicine: Philosophy, Science, Clinical Applications, and Research*. 4th ed. Philadelphia, PA: Wolters Kluwer; 2018.
9. Learman, KE, Myers, JB, Lephart, SM, Sell, TC, Kerns, J, Cook, CE. Effects of spinal manipulation on trunk proprioception in subjects with chronic low back pain during symptom remission. *J Manipulative Physiol Ther*. 2009;32(2):118-126.
10. Haavik, H, Murphy, B. Subclinical neck pain and the effects of cervical manipulation on elbow joint position sense. *J Manipulative Physiol Ther*. 2011;34(2): 88-97. https://doi.org/10.1016/j.jmpt.2010.12.009
11. Palmgren, PJ, Sandstrom, PJ, Lundqvist, FJ, Heikkila, H. Improvement after chiropractic care in cervicocephalic kinesthetic sensibility and subjective pain intensity in patients with nontraumatic chronic neck pain. *J Manipulative Physiol Ther*. 2006;29(2):100-106. https://doi.org/10.1016/j.jmpt.2005.12.002
12. Fraix, M, Gordon, A, Graham, V, Hurwitz, E, Seffinger, MA. Use of the SMART balance master to quantify the effects of osteopathic manipulative treatment in patients with dizziness. *J Am Osteopath Assoc*. 2013;113(5):394-403. https://doi.org/10.7556/jaoa.2013.113.5.394
13. Papa, L, Amodio, A, Biffi, F, Mandara, A. Impact of osteopathic therapy on proprioceptive balance and quality of life in patients with dizziness. *J Bodyw Mov Thers*. 2017;21(4):866-872. https://doi.org/10.1016/j.jbmt.2017.03.001
14. Baldini, A, Nota, A, Assi, V, Ballanti, F, Cozza P. Intersession reliability of a posturo-stabilometric test, using a force platform. *J Electromyogr Kinesiol*. 2013;23(6):1474-1479. https://doi:10.1016/j.jelekin.2013.08.003
15. Laughton, CA, Slavin, M, Katdare, K, et al. Aging, muscle activity, and balance control: physiologic changes associated with balance impairment. *Gait Posture*. 2003;18(2):101-108. https://doi:10.1016/s0966-6362(02)00200-x
16. Cultrera, P, Pratelli, E, Petrai, V, Postiglione, M, Zambelan, G, Pasquetti, P. Evaluation with stabilometric platform of balance disorders in osteoporosis patients. A proposal for a diagnostic protocol. *Clin Cases Miner Bone Metab*. 2010;7(2):123-125.
17. Zink JG, Lawson WB. An Osteopathic Structural Examination and Functional Interpretation of the Soma. *Osteopathic Annals*. 1979;7:12-19.
18. Lopez D, King HH, Knebl JA, Kosmopoulos V, Collins D, Patterson RM. Effects of comprehensive osteopathic manipulative treatment on balance in elderly patients: a pilot study. *J Am Osteopath Assoc*. 2011;111(6):382-388. https://doi.org/10.7556/jaoa.2011.111.6.382
19. Khasnis A, Gokula RM. Romberg's test. *J Postgrad Med.* 2003;49(2):169-172.
20. Clark NC, Roijezon U, Treleaven J. Proprioception in musculoskeletal rehabilitation. Part 2: Clinical assessment and intervention. *Man Ther.* 2015;20:378-387. https://doi.org/10.1016/j.math.2015.01.009
21. Blanchard Y, Carey S, Coffey J, et al. The influence of concurrent cognitive tasks on postural sway in children. *Pediatr Phys Ther*. 2005;17(3):189-193. ■