

The Effects of Muscle Energy on Low Back Pain: A 3D Analysis of running biomechanics

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ABSTRACT

Background: Muscle energy technique (MET) is an osteopathic treatment technique that is utilized frequently in the clinical setting, yet the overall effectiveness is minimally supported within literature. MET is an osteopathic technique that involves an isometric contract relax technique intended to improve alignment and enhance neuromuscular education. **Objective:** The purpose of this study was to determine the effectiveness of MET on running kinetics on subjects with low back pain. **Method:** A quasi-experimental research design was implemented and subjects, all of whom either had a history of or currently experience low back pain, underwent pre-intervention data collection of: anthropometric measurements, medical history, dorsaVi 3D running analysis, and a musculoskeletal and neurological clinical exam. Subjects underwent 6 weeks of isolated lumbo-pelvic MET at a frequency of twice a week, and were instructed to avoid all other treatment. Post-intervention data collected included a clinical exam and another dorsaVI running analysis. **Results:** Data was analyzed including: pre and post-treatment initial peak acceleration, ground contact time, and ground reaction force. A paired t-test comparing pre and post mean kinetic changes demonstrated the following p values: initial peak acceleration $p = .80$, ground contact time $p = .96$, and ground reaction force $p = .68$. **Conclusion:** This study demonstrated that isolated MET treatment is not statistically significant for changing 3D kinetic running variable in subjects with low back pain. **Clinical Implications:** Recommend healthcare providers to use a multi-treatment approach for low back pain. Future research should include a control group and larger sample size.

Key words: Kinetics, Low Back Pain, Running, Athletes

INTRODUCTION

Muscle energy technique (MET) is an osteopathic technique that utilizes an isometric approach to assist with strengthening physiologically weak muscles, improve mobility of a restricted joint, decrease edema, and improving the extensibility of shortened muscles. (Greenman, 2003; Mitchell & Mitchell, 1995). MET is an intervention that is used by osteopaths, chiropractors, and physiotherapists in the United States, Australia, and United Kingdom (Franke et al., 2016; Fryer, Johnson, Fossum, 2010; Orrock, 2009). During muscle energy, the patient isometrically contracts the agonist muscle against the resistance of the provider. Muscle energy is commonly indicated for muscle tightness, joint dysfunction, and myofascial trigger point pain (Chaitow, 2006). Commonly, muscle energy technique is performed with several other treatment techniques, and very few studies have solely examined the effect of MET as an isolated treatment (Fryer & Pearce, 2013). It has been reported that MET can provide short-term improvement in both muscle extensibility and range of motion of the spine (Fryer et al., 2013).

Physiologically, muscle energy may affect a variety of biomechanical and neurological mechanisms to improve pain, alter proprioception, and induce motor control changes (Fryer et al., 2010). Specifically, MET has demonstrated changes in extensibility of muscles to improve overall stretch tolerance and reduce pain in patients (Wilson, Payton, Donegan-Shoaf, Dec, 2003). In addition, this isometric technique may also demonstrate physiological effects on patients lacking a mechanical dysfunction (Fryer & Ruszkowski, 2004). It was also noted that MET has an effect of the overall activity of the agonist and antagonist muscle spindles with utilizing isometric contractions or strain-counterstrain techniques (Patel, Eapen, Ceepee, Kamath, 2018). However, studies have found a change in muscle extensibility after only one application of MET due to an improved tolerance, but there was no support to conclude changes in biomechanical or viscoelastic properties of the muscle. (Ballantyne, Fryer, McLaughlin, 2003; Magnusson et al., 1996). Osteopathic treatments continue to be investigated as providers continue to remain unclear on the physiological effects and workings of this type of practice (Franke, Fryer, Ostelo, Kamper, 2016).

Past studies and clinicians have commonly used low back pain (LBP) to determine the effectiveness of MET. LBP is a diagnosis with the potential for several different etiologies, all which can be multifactorial, which correlates to a determining the sole risk factors. (Gilkey, Keefe, Peel, Kassab, & Kennedy, 2010). One proposed etiology for mechanical LBP is asymmetrical spinal loading due to poor postural muscle function (Farapour, Jafamez, Damarandi, Bakhtwari, & Allar, 2016). Manual therapy is a common treatment that may include spinal mobilization or manipulation, muscle energy, passive range of motion, or soft tissue treatment. While anecdotal studies have found no strong support for the effectiveness of these techniques, specifically MET, additional studies have suggested that there are benefits to both manipulation and muscle energy. (Franke et al., 2016; Fryer et al., 2013). Clinical studies have been completed that advise utilization of MET and similiar isometric techniques on the spine to improve pain or overall discomfort (Ballantyne et al., 2003; Magnusson et al., 1996). Patel et al. (2018) conducted a randomized clinical trial to determine the effectiveness of MET on acute LBP and determined that due to possible neurophysiological changes, subjects demonstrated short term improvement in pain and disability, however overall range of motion was unchanged.

Franke et al. (2016) examine the literature, specifically aimed at determining the effect of MET as an isolated treatment and also, when MET was combined with other rehabilitation treatment options. Their systematic review unveiled only one study that had assessed the effect of isolated MET intervention, with this study revealing that the intervention resulted in no relevant clinic changes in pain or function. (Franke et al., 2016). However, two other studies have deemed pain and function changes with MET intervention plus the addition of other spinal isometric techniques (Ballantyne et al., 2003; Magnusson et al., 1996). Overall, Franke et al. (2016) confirmed that currently there was no significant data that validated the effectiveness of MET on low back pain for addressing joint or muscle restrictions. Although joint or muscle restriction changes were found to not change with MET for low back pain, one study did find a decrease in lumbopelvic pain was found after an isolated MET intervention to the lumbar spine (Selkow, Grindsta, Cross, Pugh, Hertel, Saliba, 2009). However, the overall change in Visual Analog Pain scores was only reported 24 hours post-treatment, therefore possibly suggesting only short-term gains (Selkow et al., 2009).

Low back pain is typically assessed through self-reported patient or subject questionnaires (Papi, et al., 2018). However, it has been recommended that objective measures should be collected to determine functional status of patients who suffer from low back pain, which in turn should assist with determining prognosis (Papi et al., 2018). Studies have demonstrated that clinical range of motion changes, specifically hip internal rotation, are correlated with low back pain in athletes who undergo repetitive rotational movements (Gombatto, Collins, Sahrman, Engsborg, Van Dillen, 2006; Van Dillen, Gombatto, Collins, Engsborg, Sahrman, 2007; Van Dillen et al., 2001). Furthermore, Sadehisani et al.

(2017) researched the etiology of mechanical low back pain and determined that repetitive asymmetric mechanical loading on the lumbar spine is a primary cause of low back pain in athletes. Due to the mechanical loading, athletes who participate in rotational dominate sports (e.g. golf and tennis) typically will demonstrate asymmetrical hip internal rotation (Sadehisani et al., 2017).

To expand upon the use of objective outcome measures, multiple 3D systems that have been created to analyze kinematic and kinetic (e.g. spinal loading) variables in both healthy and injured subjects (Lanovaz, Musselman, Oates, Treen, & Unger, 2017). Multiple 3D systems incorporate the use of accelerometers, inertial sensors, and gyroscopes to capture kinematic and kinetic data on gross or segmental movement, speed, force, and time (Lanovaz et al., 2017). IMU (inertial measurement units) have been utilized to quantify gross movement patterns by subjects wearing the 3D technology, therefore decreasing the clinician subjectivity of movement during an exam (Garner, Parish, Shaw, Wilson, & Donahue, 2020). Madadi-Shad, Jafarnez-Hadgero, Sheikhalizade, Dinoisio (2020) implemented a 3D system to measure changes in kinetic variables for subjects who suffered from low back pain and pronation. Specific objective measures, kinetic and EMG, were used to determine overall effectiveness of an exercise program with these patients, which alluded to an increase in walking speed, increased ground reaction forces (GRF), and decreased lumbopelvic muscular activity (Madadi-Shad et al., 2020). Furthermore, a systematic review was conducted to determine the effect of kinematic and kinetic parameters for assessment measures for changes in low back pain (Papi, Bull, McGregor, 2018). Studies within the systematic review revealed several limitations including poor sample size and experimental protocol standardization, leading the authors to conclude that these kinematic and kinetic measures could not be used as a clinical assessment technique for patients with low back pain (Papi et al., 2018). In addition, within the studies reported, only hip and lumbar kinematic and kinetic variables were mainly considered (Papi et al., 2018).

The *dorsaVi Professional Suite* is a new, portable wearable inertial motion (IMU) capture system, which was created to improve accessibility to 3D variable capturing within the clinical or sport setting. The *dorsaVi Professional Suite* was primarily developed to assist clinicians in the evaluation of lower extremity kinetic variables. (Charry, Hu, Ronchi, Taylor & Umer 2013). The *dorsaVi Professional Suite* has the capability of analyzing knee, low back, and running kinetic and kinematic variables ("Wearable Device Technology," n.d.) The *dorsaVi Professional Suite* also has the potential for quantifying kinetic and kinematic variables that can possibly contribute to running related injuries. It was suggested by Willy (2018) that the multitude of etiologies for running related injuries could be determined by quantifying biomechanical variables with an IMU system.

Furthermore, numerous studies have been conducted to examine the role that biomechanical errors play in running injuries (Becker, James, Wayner, Osternig, Chou, 2017; Davis, Bowser, Mullineaux, 2016). In one study, kinetic vari-

ables, loading rate and impact peak force, were collected from 249 runners during a running analysis and found an overall lower loading rate in females who had a significant history of injuries. (Davis et al., 2016). Furthermore, Becker et al. (2017) conducted a study to determine the correlation between kinematic variables and running injuries. It was concluded that excessive rearfoot eversion, a kinematic variable, in the late stance phase of running correlated with injury. However, the injured subjects that were recruited for the study had only sustained injuries to the Achilles and iliotibial band, therefore other lower extremity or low back injury subjects were included (Becker et al., 2017). Furthermore, Davis et al. (2016), studied the casual correlational relationship of kinetic variables with runner's injuries, and found a positive relationship between vertical loading rate and soft tissue injuries in females. However, Bramah, Preece, Gill and Herrington (2018) did conduct a quasi-experimental study to determine kinematic differences between injured runners and a healthy runners (control group), where it was concluded that injured runners had the following kinematic differences: greater contralateral pelvic drop, forward trunk lean, and excessive knee extension at early stance phase. In conclusion, Bramah et al. (2018) recommended that future research be conducted to determine the correlation between specific kinematic patterns and other running related injuries. Furthermore, it was recommended that additional information on determining what specific variables contribute to low back pain, hip pain, and other related running injuries are minimally investigated (Bramah et al, 2018).

The current study was conducted to address the limited evidence regarding long term changes with isolated lumbopelvic MET, as well as the overall effectiveness of using kinetic variables as a clinic assessment tool for LBP (Becker et al., 2017; Fryer, 2011; Papi et al., 2018; Selkow et al., 2009). Patel et al. (2018) indicate that additional research is necessary to determine the effect and define the clinical implementation of MET over a longer time period for treatment of low back pain. The purpose of the study was to examine the changes in kinetic variables after application of muscle energy to the lumbopelvic region for subjects suffering from low back pain. The focus for this study was to determine to what extent is there a statistically significant difference in pre and post running kinetic and kinematic variables in subjects after isolated muscle energy treatment.

MATERIALS

Subjects and Design of Study

Subjects were recruited from a Division 1 college by being informed by sports medicine staff and paper flyers regarding the purpose of the study and overall methodology. All subjects reported a self or provider diagnosed history of low back pain and volunteered from a diverse background of athletic teams that included Volleyball (1), Football (1), Crew (2), and Track (1). Brief characteristics of these subjects can be found in Table 1 below. The quasi-experimental research design was approved by the University institutional review board (IRB # 2018-19108). The purpose of this study

was then explained to all subjects, after which each subject was provided the informed consent before the clinical exam and medical history intake. Exclusion criteria included any subject that had undergone lumbar surgery or was currently undergoing active treatment for low back pain.

Test Procedure

Upon initial assessment, the principle investigator collected each subject's medical history and conducted both an initial clinical examination and a dorsaVi Professional Suite 3D running analysis. The clinical exam included hip and lumbar range of motion tests, a neurological exam, anthropometric measures, and lumbopelvic alignment assessment. The principal investigator (PI) performed the clinical exam in the University lab and utilized a anthropometric scale for height and weight. In addition, the PI grossly measured standing lumbar range of motion and hip internal rotation in a supine position. Furthermore, the PI performed a neurological exam to include myotomes, reflexes, and straight leg raise testing. Finally, the lumbopelvic alignment was assessed in both sitting and supine for pelvic and lumbar abnormalities including: facet dysfunctions (ERS, FRS), pubic dysfunction, innominate dysfunction, and sacral torsion.

Following the clinical exam, the principal investigator and research assistant measured and applied the 3D sensors to the subject's bilateral tibia (one sensor on the left and one sensor on the right) by utilizing the dorsaVi placement ruler. The dorsaVi system utilizes a sensor system that includes accelerometers, magnetometers, and gyroscope, which calculate kinetic variables using a patented algorithm ("Wearable Device Technology", n.d.)

After calibration with the dorsaVi system, each subject was instructed to warm up on the treadmill for 2 minutes with a low speed walk. After warm up, the subject was instructed to increase the speed on the treadmill to a jogging pace for one minute, which was proceeded by a walking interval for 1 minute. The same protocol was initiated for both a running interval (self-selected speed) and sprinting interval (self-selected speed) at both the initial and final running analysis, with identical instruction. Through this clinical exam, the dorsaVi system is able to calculate each subject's initial peak acceleration, ground contact time, and ground reaction force. Initial peak acceleration is a direct measure of the vertical acceleration and tibia loading rate during foot strike, which is measured in g's (acceleration due to gravity). Ground contact time is measured in milliseconds and determines how long the foot is in contact with the ground from

Table 1. Descriptive Statistics of Participants

Subjects	Height (in)	Weight (lbs.)	Sport
1	72	181	Volleyball
2	76	296	Football
3	64	154	Crew
4	68	183	Track
5	70.5	139	Crew

Demographics for each of the participants

initial contact and toe off, whereas ground reaction force (GRF) measures the force (Newtons) that the foot applies to the ground in midstance (“Run Metrics Overview,” 2020)

Intervention

At completion of the running analysis, all sensors were removed and the subject completed the initial data collection of the study. The subject was instructed to complete a 6-week protocol of muscle energy treatment with the principal investigator based on clinical exam findings. Six weeks of treatment was chosen by the PI to allow for changes in both neuromuscular education and muscle physiology. One week following the initial data collection, subjects underwent 12 treatment sessions (2 times a week) of solely muscle energy techniques to the lumbar spine and pelvis with identical instruction in self-correction neuromuscular exercises. The self-correction neuromuscular exercises included self-correction techniques for anterior innominate, L5/S1 rotation, and pubic symphysis correction and each subject was asked to demonstrate the exercise prior to dismissal from the session. Following the 12 treatment sessions, the subject underwent the same clinical exam and 3D gait analysis as completed at the initial part of the study.

Statistical Analysis

After collecting all data, data analysis was completed by using the software State SE 15.1. A paired t-test was completed to determine statistical significance of data between initial and final data for all three kinetic measurements (i.e. initial peak acceleration, ground contact time and ground reaction force) as well as significance of mean change from pre to post intervention.

RESULTS

Paired-samples t-tests were used to identify the extent to which there was a statistically significant difference (alpha at 0.05) in pre and post kinetic running variables. These variables included initial peak acceleration, ground contact time and ground reaction force and were collected during each subject’s walking, running and sprinting intervals; as a result, there were 15 different data points collected for each variable in total across all five patients. The paired-samples test was not statistically significant for initial peak acceleration ($t(14) = -0.87, p = 0.80$), indicating that on average the subjects had no significant change in initial peak acceleration after treatment ($M = -0.26, SD = 1.15$). The 95% confidence interval ranged from -0.90 to 0.38, which also indicates the lack of statistical significance given that the value of zero is included in this range. The t-test for ground contact time was not statistically significant as well ($t(14) = -1.83, p = 0.96$), indicating that on average the subjects had no significant change in ground contact time after treatment ($M = -0.26, SD = 1.15$); its 95% confidence interval ranging from -36.16 to 2.83 is consistent with this finding. Finally, the t-test for ground reaction force was not statistically significant either, ($t(14) = -0.47, p = 0.68$), indicating that on average the subjects had

no significant change in ground reach force after treatment ($M = -16.67, SD = 35.20$); similarly, this finding is also demonstrated by the 95% confidence interval ranging from -36.61 to 23.41 and again including the value of zero.

Table 2 includes the pre and post clinical assessment of the five subjects. The data includes bilateral hip internal rotation range of motion (measured in supine) and the designated sport affiliation for each of the subjects. The degrees of internal rotation are reported as degrees of range of motion.

Table 3 reports the differences in initial peak acceleration from pre to post treatment (6 weeks of muscle energy treatment) for all subjects. Tables 4 and 5 do so for ground contact time and ground reaction force, respectively. Each table indicates the mean differences between right and left lower extremity, in addition to the p-value. As demonstrated, these differences for all three kinetic variables were non-significant with a p value > 0.05 .

Table 2. Hip Internal Rotation (IR) Range of Motion (Supine): Pre and post treatment changes Normal: 51.7 degrees male, 62.6 degrees female (St.Pierre, Sobczak, Fontaine, Saade, Boivin, 2020)

Subject	Pre-Treatment Hip IR (degrees)	Post-treatment Hip IR (degrees)
1	25 left, 30 right	35 bilateral
2	2 left, 0 right	20 left, 10 right
3	50 left, 75 right	35 bilateral
4	25 left, 45 right	25 bilateral
5	50 left, 55 right	25 bilateral

Table 3. Initial Peak Acceleration (IPA): Pre and Post treatment comparison of right LE and left LE. Unit of measurement: g

IPA	Pre-Treatment Mean	Post-Treatment Mean	p
Left LE	6.27	5.85	0.44
Right LE	5.95	5.79	0.77

Table 4. Ground Contact Time (GCT): Pre and Post treatment comparison of right LE and left LE. Unit: Milliseconds

GCT	Pre-Treatment Mean	Post-Treatment Mean	p
Left LE	289.1333	281.9333	0.22
Right LE	279.8667	289.3333	0.20

Table 5. Ground Reaction Forces (GRF): Pre and Post treatment comparison of right and left lower extremity (LE). Unit: Newtons

GRF	Pre-Treatment Mean	Post-Treatment Mean	p
Left LE	1772.93	1778.6	0.84
Right LE	1769.53	1781.8	0.60

DISCUSSION

The purpose of this study was to determine the effects of muscle energy on low back pain by measuring changes in 3D running kinetic and kinematic variables. Specifically, this quasi-experimental study examined the effect of a 6-week isolated treatment program of muscle energy techniques for lumbopelvic alignment by running a paired t-test on pre and post intervention running kinetic and kinematic variables.

The se results suggest that isolated bouts of MET for low back pain is not significant at changing kinetic running variables, which contraindicates Brahmah et al. (2018) findings that abnormal kinematic variables (e.g. greater contralateral pelvic drop) were common in injured runners. However, as our study indicated, significant changes in kinetic variables with injured runners (LBP) was not found. Similar to the findings of Franke et al. (2016) and Papi et al., (2018), the effect of muscle energy technique on changing overall function (sit to stand, stair negotiation, walking) and kinetic variables is limited. However, similar to Selkow et al. (2009), in this study, each subject verbally self-reported that overall pain levels had decreased over 6 weeks of treatment. Subjects self-reported that each of their pain levels decreased with treatment over 6 weeks. Although not statistically significant, the average initial peak acceleration (IPA), vertical load, and tibial acceleration rate decreased from pre to post treatment for all 5 subjects. Therefore, there is potential that the overall change in lumbopelvic alignment changed the vertical load and speed at initial contact, as subjects chose a consistent speed for both their warm up, run, and sprinting trials. Similar to Willy (2018) and Brahmah et al., (2018) recommendations, quantifying kinetic or kinematic variables with a 3D gait analysis could lead to potential investigation of the causes of running related injuries, including low back pain.

These findings are consistent with those found in several previous studies. Smith (2019) demonstrated evidence for a biopsychosocial approach to musculoskeletal pain, suggesting that one treatment or one-dimensional approaches are not effective. As demonstrated by this study, the isolated treatment of MET was ineffective at changing kinetic gait variables. In addition, Patel et al. (2018) determined that pain and disability changed with MET, but MET was not effective with changing objective lumbar range of motion (ROM). As demonstrated by Table 2 and supported by previous literature findings, the hip internal rotation of each of the subjects was asymmetrical prior to the initiation of treatment (Sadehisani et al., 2017). After 6 weeks of muscle energy techniques, overall hip kinematics (internal rotation range of motion) was more symmetrical between right and left LE in all of the subjects. Although dorsaVi does not capture kinematic variable through the IMU system: running analysis, it is suggested that the changes in hip internal rotation with these athletes was a component of the overall subjective reports of decreased pain (Sadehisani et al., 2017).

There are several limitations with this study. Due to the small sample size of only five subjects, the overall generalizability of these findings is certainly limited; in addition, several potential subjects chose not to participate as they

desired additional treatment approaches beyond the isolated methods approach utilized in this study. Another limitation is the researcher's positionality as the primary investigator and physical therapist, therefore overall confirmation bias. Furthermore, another limitation of the study was not using a valid survey (e.g. Oswestry or Visual Analog Scale) to capture changes in reported pain levels pre and post intervention. Also, to improve the overall quasi-experimental research design, a control group should have been utilized to improve quality of comparison data, however due to overall low recruitment of subjects, the control group was unable to be formed. Finally, the kinetic variables that were measured by the dorsa Vi were based on the subject's self-selected speed, therefore the changes in the kinetic variables may have had direct correlation with discrepancies in pre and post running speeds. Future research on muscle energy for the treatment of low back pain should include a larger sample group and a control group. With the usage of 3D wearable device units in the clinical setting, kinetic variables could be used as an assessment tool to determine an overall effect of a specific treatment or treatment protocol. Furthermore, 3D wearable devices should be utilized to determine changes in musculoskeletal pain after inducing a multi-dimensional treatment approach (Smith, 2019).

CONCLUSION

Muscle energy technique effectiveness continues to remain an uncertain for treatment of low back pain. This study found that 6 weeks of low back treatment using isolated muscle energy techniques to the lumbopelvic area did not significantly affect running kinetic variables. However, the muscle energy techniques did improve symmetry of hip internal rotation and decrease initial peak acceleration, vertical load, and tibial acceleration rate in all subjects. Future research should include a control group to improve the quasi-experimental design and collect subjective responses through valid questionnaires on pain changes. In addition, future research should include an IMU 3D system that is able to collect both kinetic and kinematic variable changes to determine the effectiveness of muscle energy on running mechanics.

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