Evaluation of Methods to Assess Physiologic Tremor – A Pilot Study

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Summary: No conclusion on accuracy of tremor measurement.

Keywords: mindfulness; tremor; humans; vibration; hand; physiologic

Abstract:

Background: Physiologic tremor is one of the most common involuntary movement disorders seen in clinical practice. In order for tremor to be accurately quantified, costly equipment is needed. However, one specific methodology has not been proposed as the gold standard. While much research has included the source of physiological tremor, the ability to decrease this physiological tremor has not been researched extensively. This study seeks to determine which method to assess physiologic tremor is more accurate. Increased hand tremor could potentially affect surgical outcomes. Therefore, this study also seeks to examine the effects of the practice of mindfulness on physiological tremor in periodontal surgical residents,

Methods: Six periodontal residents were recruited from the Louisiana State University School of Dentistry. Subjects were tested for physiological tremor before and after mindfulness training using various methodologies; these included a macroscopic laser technique, a macroscopic pen tracing technique, and a microscopic pen tracing technique. All measurements were then compared using a Student's t-test (with a significance of $P < 0.05$). Assays for physiological tremor were compared using Correlation Coefficient in Microsoft Excel.

Results: Improvement was seen from baseline to post-mindfulness in the macroscopic tracing without the use of a hand rest. In contrast, increase in movement was seen from baseline to post-mindfulness in the macroscopic tracing with the use of a hand rest.

Overall, improvement was seen from baseline to post-mindfulness in the microscopic tracing with hand rest. In contrast, increased deviation from the guide line from baseline to post-mindfulness in the microscopic tracing without hand rest.

It was revealed that the laser measurements do not correlate with either tracing technique. However, the microscopic tracings with and without hand resting correlate well. The macroscopic tracings do not correlate well between resting and non-resting groups. Finally, macroscopic and microscopic tracing techniques correlated well with each other.

The pen tracing may not be as reliable as the laser technique. The pen tracings do not show change over time as the laser does. The laser technique shows vibration frequency but the pen tracing does not; so, while the pen tracing may show accuracy of being able to follow a guide line, it may not illustrate tremor well.

Conclusions: Based on the findings of this study, it is difficult to reach a definitive conclusion on the most valid methodology for the detection of tremor. However, within the limitations of this study, it is believed that the laser technique is a more reliable technique for the monitoring of physiologic tremor. The laser technique was repeated 3 times for each participant both before and after mindfulness training; therefore, the reproducibility was confirmed. Additionally, the laser technique was able to illustrate change over time in physiologic tremor and vibration frequency, while the pen-tracings did not.

In this current study, mindfulness training did not demonstrate an overall beneficial effect on the reduction of movement.

Many factors could affect the tremor recordings, such as sample size, gender, dominant hand, stress/fatigue, experience using a microscope.

Introduction

A tremor is an involuntary, rhythmic muscular contraction leading to trembling movements in a part of the body. Tremors are extremely common and usually affect the hands but can be seen in other parts of the body as well. A physiological tremor is a specific subset of tremor that occurs in all healthy individuals. It is not always visibly noticeable and includes a trembling of both the hands and fingers. Physiological tremor is a high frequency, low amplitude vibration that happens during steady state posture. The frequency of physiological tremor is <6 Hz before age 9 years, increasing to 12 Hz by the mid-teen years, and decreasing slightly above 60 years (Bhidayasiri 2005).

It has been acknowledged that fingers (Lippold, 1970) and hands (Lakie et al. 1986) have natural frequencies of movement and vibration that are very similar to their tremor frequencies, between 7-10Hz. This is demonstrated when hand tremor measured during a task completed while moving, is greater in amplitude than measurements taken during a static condition While there is no consensus on the cause of physiological tremor, there have been a few different theories reported in the literature. One theory is that tremor develops as a visco-mechanical characteristic of each muscle (Rietz and Stiles 1974). Another theory is that motor neuron discharge occurs as a result of muscle contraction, causing tremors (Sutton and Sykes 1967). Others have noted that between 3-40% of hand tremors are caused by vascular fixation (Elble 1978).

Physiological tremor can be differentiated from other movement disorders by its nature of repetitive, stereotypical movements with regular frequency. Each person has a varying degree of physiologic tremor, which is usually increased with stress, anxiety, or fatigue.

In order for tremor to be accurately quantified, costly equipment is needed. The current methods used to diagnose tremor include clinical evaluation. The methods of measurement used in a laboratory setting include a laser interferometric-based displacement technique, electromyography, and spirogram (Mansor 2007, Murbe 2001). However, one specific methodology has not been proposed as the gold standard; additionally, the cost of these methodologies may make future experiments cost prohibitive.

Physiologic tremor is one of the most common involuntary movement disorders seen in clinical practice. This is an unwanted effect faced by surgeons. Usually less than 1mm of movement in the hands can cause significant errors in surgical procedures – for example, vascular incisions that are too deep (Stephans 1974).

Mindfulness is a type of practice that is defined as present moment awareness. By being attentive to the present moment (whether it is frustration, bliss, anger, etc.), we can become more aware of our current bodily sensations. The best way to develop this ability is to practice, beginning with shorter periods and then progress to incorporating these practices into daily life (Fernando 2014). The goal of practicing mindfulness among clinicians is to allow practitioners to look at their clinical situations calmly and then respond accordingly.

While much research has included the source of physiological tremor, the ability to decrease this physiological tremor has not been researched extensively. Periodontal surgeons perform intricate surgical procedures involving gingival tissue and alveolar bone that require a high level of skill, precision and focus. Physiologic hand tremor may potentially affect the outcome of these procedures. Previous studies have discussed the effects of medication and the decrease of physiological tremor (Bain 2002). Additionally, studies have sought to determine the effects of mindfulness on surgeons' stress level and performance (Galantino 2005). However, no studies have specifically investigated the effect of mindfulness on physiological tremor in surgeons.

This study has three specific aims. First, to determine if physiological tremor can be detected macroscopically using a laser pointer technique versus macroscopically using a pen-drawing technique, and to determine if both are equally valid techniques. Second, to determine if physiological tremor is intensified when using a microscope versus the unaided eye. Lastly, to determine if mindfulness training can effectively decrease physiological tremor.

This study seeks to determine which method to assess physiologic tremor is more accurate. Additionally, this study seeks to examine the effects of the practice of mindfulness on physiological tremor in periodontal surgeons. If it is found that mindfulness does decrease physiological tremor, this would be a useful practice for surgeons, as it could result in more precise surgical skills with less tissue injury and decreased healing time for patients.

Materials/Methods:

Subjects: Six periodontal residents were recruited from the Louisiana State University School of Dentistry. Participants included both males and females that ranged in age from 26 years of age to 29 years of age.

Participants were asked to refrain from smoking, strenuous physical exercise, and consuming caffeine for at least 2 hours before testing, and consuming alcohol for at least 24 hours before testing, at baseline and 8-weeks.

Mindfulness Training: Subjects were tested for physiological tremor before and after mindfulness training. After the baseline macroscopic and microscopic techniques were completed, the residents then began a daily, eight-week mindfulness course. The participants listened to the same 7-minute guided mindfulness audio file daily (https://www.calm.auckland.ac.nz/files/sitting_meditation_u_vansa.mp3).

The participants were asked to record the date and time when the mindfulness training was done daily. The following measurements of physiological tremor were performed at baseline and after 8 weeks of mindfulness training.

Macroscopic Laser Technique: This technique was similar to that previously described by Nizet et al 2004. The participant held a laser pointer in their dominant hand, from a set distance of 20 feet and pointed it at a set target for a total of 30 seconds while attempting to hold their hand steady on the center of the target (Figure 1A). This task was repeated 3 times per participant. This task was video recorded using a Canon PowerShot ELPH-520OHS camera and saved as MOV files. Video recordings were uploaded into "Kinove-a" software and analyzed for movement. Ten (10) second clips of each video recording were analyzed via the software tracing a line following the laser light on the target (Figure 1B and C). Video recordings were analyzed at 0.04 second intervals, and the distance traveled by the laser light on the target was recorded. The average distance travelled for the full 10 second recording was reported in pixels.

Macroscopic Pen Tracing Technique: The participants traced a linear pattern (Figure 2A) over a time period of 30 seconds without resting their hand on a hard surface. The participants then traced the same linear pattern over a time period of 30 seconds while resting their hand on a hard surface. The traced patterns were scanned on a flat-bed scanner at 300dpi at 8-fold resolution and saved as jpeg files.

Microscope Pen Tracing Technique: The same linear pattern was used that was used in the macroscopic technique; however, the pattern was scaled down in size from the pattern used in macroscopic task. It was scaled down by a magnitude of 6.5. The microscope was then set at 10X magnification and the pattern was traced under the microscope without resting the hand, arm or fingers on a surface during a 30 second time interval. The same pattern was then traced again under the microscope during a 30 second time interval using a rest for the arm, hand, and fingers. The microscopic pen technique traced patterns were scanned on a flat-bed scanner at 2400dpi at 8-fold resolution and saved as jpeg files.

All tracings were analyzed via the ImageJ software using the Plot-Profile function. The numerical values produced for each tracing were quantified for deviation from the line and compared to a control center line without subject tracing.

Statistical Analysis: All measurements were then compared using a Student's t-test (with a significance of $P < 0.05$). Assays for physiological tremor were compared using Correlation Coefficient in Microsoft Excel.

Results:

The participants were asked to hold the laser pointer at the center of the target over the course of 30 seconds (Figure 1A). Tracing of the path the laser light traversed over 30 seconds revealed that some participants were able to remain close to the center of the target over the course of the allotted time (Figure1B), while others diverged further from the center of the target (Figure 1C). Upon analysis of a comparison from baseline to post-mindfulness training for the laser pointer technique, most residents (4 of 6) displayed an increased path of movement (Figure 3A) and only two residents displayed a decrease in movement. Two residents showed a marginal increase in movement, while two residents showed a significant increase in movement ($P < 0.05$) while the remaining two residents showed a significant decrease in movement ($P < 0.05$; Figure 3B). Thus, there was no significant trend in improvement (as measured by reduced length of path of movement to the laser light) for this groups of subjects.

These same participants were also asked to trace a macroscopic linear pattern over the course of 30 seconds, both without resting their hand on a surface (Macro-NR) and with resting their hand to increase stability (Macro-R) (Figure 2A). This same linear pattern was then scaled down to perform the same task microscopically – without resting their hand on a surface to increase stability (Micro-NR; Figure 2B) and while resting their hand on a surface (Micro-R; Figure 2C). Upon analysis of the data collected from baseline to post-mindfulness training for the macroscopic linear pen tracing measurements, most residents (5 of 6) displayed an improvement (or decreased variation from the guide line), when not resting their hand on a surface (Figure 4). However, when the residents completed this task while resting their hand on a surface to increase stability, most residents (4 of 6) showed an increased variation from the line (Figure 4). For the macroscopic pen tracing technique while resting their hand, the subjects displayed no reduction in physiological tremor ($P > 0.05$). In contrast, for the macroscopic pen tracing technique without resting their hand, the majority of subjects displayed a reduction in physiological tremor, although this was not statistically significant ($P > 0.05$).

Upon analysis of the microscope aided tracing (Figure 5), most (4 of 6) residents displayed an increased deviation from the guide line, when not resting their hand on a surface. However, when the residents completed this task while resting their hand on a surface, most (4 of 6) residents recorded a decreased deviation from the guide line (Figure 5A). Statistical analysis of these tracings revealed no significant reduction of physiological tremor in either case following mindfulness training ($P > 0.05$).

The results from post-mindfulness measurements of all techniques were then compared to one another (Figure 6), and all the techniques for measuring physiological tremor were examined for correlation across all the subjects (Table 1). It was revealed that the laser measurements do not correlate with either tracing technique. However, the microscopic tracings with and without hand resting correlate well. The macroscopic tracings do not correlate will between resting and non-resting groups. Finally, macroscopic and microscopic tracing techniques correlated well with each other.

Discussion :

In this study, we observed a decreased deviation from the guideline between baseline to post-mindfulness in the macroscopic tracing without the use of a hand rest. However, decline was seen from baseline to post-mindfulness in the macroscopic tracing with hand rest.

We also observed a decreased deviation from the guideline between baseline to post-mindfulness in the microscopic tracing with the use of a hand rest. In contrast, we observed an increased deviation from the guide line from baseline to post-mindfulness in the microscopic tracing without hand rest. However, the mean values showed very little change in both groups from baseline compared to post-mindfulness training.

It was noted that 2 of 6 residents had increased tremor post-mindfulness, 2 of 6 residents had decreased tremor post-mindfulness, and 2 of 6 residents had no real change. On an individual basis, there was a statistically significant difference; but no statistically significant difference was found in group data.

Comparison of these techniques to those in the literature:

The trajectory of a movement of any object in space has 6 degrees of freedom; 3 for translations in a 3-dimensional space, and 3 for rotations. In order for tremor to be accurately quantified, usually, costly equipment is necessary. From current research, the methods of measurement used in a laboratory setting include accelerometry (via piezoelectric accelerometer sensor), electromyography, and spirogram (Mansor 2007). In order to detect these measurements, ideally, a triaxial accelerometer plus a triaxial gyroscope are used. This machine would include a 16-channel amplifier: 3 channels for 3-axial accelerometry, 3 channels for 3-axial gyroscope, and two electromyography (EMG) channels.

Portable transducers for assessing tremor have become more readily available, and they seem to provide valid measures of tremor amplitude, occurrence, and frequency. Transducers provide very precise linear measures of tremor, in contrast to the subjective, imprecise, nonlinear measures produced by clinical ratings. However, transducers have limitations. In the clinical assessment of tremor severity, the precision of transducers is limited by the test-retest variability in tremor amplitude: resulting in minimum detectable change values that are comparable to those of clinical findings (Elble 2016).

Tremor has been measured previously via a laser pointer technique (Nizet 2004). In this study, participants were asked to aim the pointer at the target center at a set distance over various time points. Tremor was measured when the arm was un-aided and straight, when the arm was by an armrest, and after holding a 2-kg weight until fatigue. The examiner watched the target within which the participant succeeded to aim during the last 20 of those 30 s of each interval.

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It was seen that there was a difference in measurements when the arm is supported by an armrest and when the arm is outstretched. There was also a significant difference between tremor measured in the morning and tremor measured in the afternoon (Nizet 2004).

In past studies, tremor severity measured while the arm is horizontally outstretched and measured with the arm supported by an armrest, it was seen that tremor severity decreases in resting position. Additionally, physiological tremor increases when under stress, but also anxiety and fatigue can increase physiological tremor.

Overall, no specific methodology has not been proposed as the gold standard; additionally, the cost of these methodologies make some experiments cost prohibitive.

The laser pointer and pen tracing methods used in this study to assess physiologic tremor potentially offer a cost-effect method to detect physiologic movement patterns.

Comparison of these techniques (laser vs Pen)

It was expected that the macroscopic pen technique would be more sensitive and detect less intense physiological tremor than the laser technique.

It was difficult to prove which technique was able to detect more intense tremor. This may be because the distance from the laser (20 feet) resulted in a larger angular deviation due to the distance; hence, tremor was magnified. The line tracings you cannot increase or decrease distance; therefore, magnification can only be changed so far. With line tracing, there was no constant set amount of distance that was needed to be reached over the set time period of 30 seconds. Therefore, some participants traced 5 lines while others only traced two. The speed at any time measurement is not known.

However, it was demonstrated that the pen tracing may not be as reliable as the laser technique. The pen tracings do not show change over time as the laser does. This is because the pen tracing does not show vibration frequency and only shows amplitude; so, while the pen tracing may show accuracy of being able to follow a guide line, it may not illustrate tremor well. For example, an individual may be able to draw a very straight line, but if this drawn line is off center from the guide line, the calculations will show that the individual has a severe tremor.

Use of a hand rest for tracing

Past studies have analyzed differences in tremor while supporting the wrist versus without supporting the wrist. Murbe et al. examined hand tremor while performing a simulated microsurgical task using a fine-needle while supporting the wrist. When the hand was stabilized, the tremor amplitude was smaller (Murbe 2001). A study by Coulson found supporting the wrists significantly decreases the amplitude of the tremor by a factor of 2.67 (Coulson 2010).

Therefore, it was expected that the use of a hand rest while tracing using both the microscopic and macroscopic techniques would demonstrate a decreased physiological tremor compared to the hand tracing without the use of a rest.

When examining both the macroscopic and the microscopic results with hand rest, it was discovered that overall improvement was seen from baseline to post-mindfulness in the microscopic pen tracing. However, increased deviation from the line was noted during the macroscopic pen tracing technique with the use of a hand rest.

Macroscopic vs Microscopic

The use of microscopic magnification during periodontal surgery may lead toward the use of minimally invasive procedures in exchange for the need for more extensive surgical procedures. To achieve an excellent result in terms of both esthetics and function, it is fundamental to perform extremely fine and accurate incisions. It is also imperative for the surgeon to have a relaxed state of mind, good posture, and a well-supported hand (Tibbetts 2009). In our study, lesser deviation was seen from baseline to post-mindfulness in the microscopic tracing with hand rest. In contrast, increased deviation from the guide line from baseline to post-mindfulness in the microscopic tracing without hand rest. However, the mean values show very little change in both groups from baseline compared to post-mindfulness training.

Interestingly, the macroscopic laser technique completed both pre and post mindfulness showed varying results. Two of seven (2/6) of the residents demonstrated a worse tremor post-mindfulness, 2/6 of residents demonstrated an improved tremor post-mindfulness, and 2/6 of the residents demonstrated no real change.

Effect of Mindfulness training:

Overall, it was expected that the practice of mindfulness would decrease physiological tremor in periodontal surgeons.

However, our cumulative findings showed that 1/3 of participants showed an increase in movement post-mindfulness training, 1/3 of participants showed no change, and only 1/3 showed improvement post-mindfulness training., Therefore, in this study, mindfulness training did not have an overall beneficial effect on the reduction of movement.

Potential Pitfalls

Many factors may affect the tremor recordings, such as gender, dominant hand, stress/fatigue, experience using a microscope. Additionally, each person has a varying degree of physiologic tremor, which is usually increased with stress, anxiety, or fatigue.

It should be noted that the measurements in our study were taken at a set time period; however, it was not documented what each participant was doing prior to their recordings. Therefore, some results may have been skewed by some factors such as surgical fatigue and stress from preparing for an examination. In the future, it would be beneficial to have all participants either be fully rested both physically and mentally or to run the measurements after experiencing mental or physical fatigue.

Conclusions

Based on the findings of this study, it is difficult to reach a definitive conclusion on the most valid methodology for the detection of tremor. However, within the limitations of this study, it is believed that the laser technique is a more reliable technique for the monitoring of physiologic tremor. The laser technique was repeated 3 times for each participant both before and after mindfulness training; therefore, the reproducibility was confirmed. Additionally, the laser technique was able to illustrate change over time in physiologic tremor and vibration frequency, while the pen-tracings did not.

In this current study, mindfulness training did not demonstrate an overall beneficial effect on the reduction of movement.

Future studies should include a larger sample size in order to expect results for analysis. In addition to better evaluate reproducibility, it would be beneficial to conduct recurrent measurements for the pen tracing techniques.

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Figure 1: Laser Tracking Path

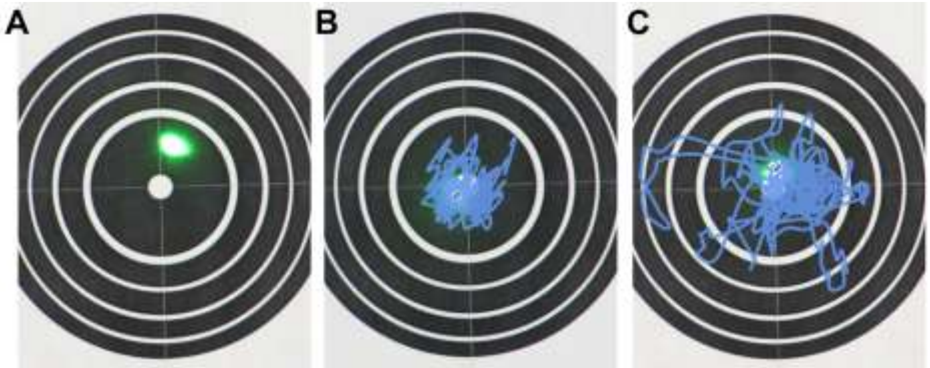

Figure 1: Laser Tracking Path

Example of subject holding laser against the pattern used during laser technique (A). Example of a tracing of the path the laser light traversed over 30 seconds for a participant who remained close to the center of the target over the course of the allotted time (B). Example of a tracing of the path the laser light traversed over 30 seconds for a participant who did not remain close to the center of the target over the course of the allotted time (C).

Figure 2. Linear Pen Tracing Measurement of Hand Stability

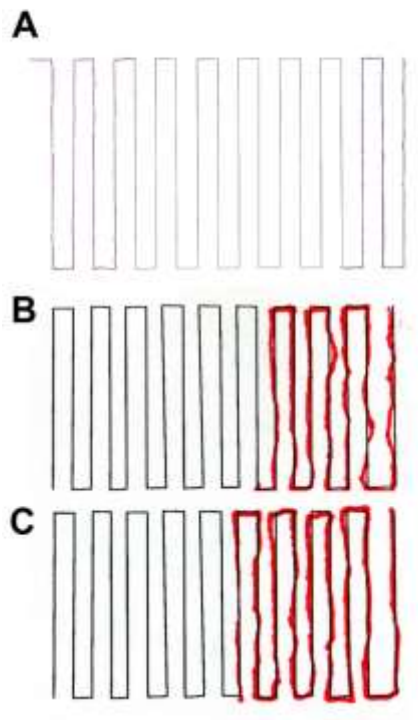

Figure 2. Linear Pen Tracing Measurement of Hand Stability

Example of macroscopic pen tracing technique (A). Example of microscopic pen tracing technique while resting their hand on a surface to increase stability (B). Example of microscopic pen tracing technique without resting their hand on a surface to increase stability (C).

Figure 3. Laser Tracking Analysis

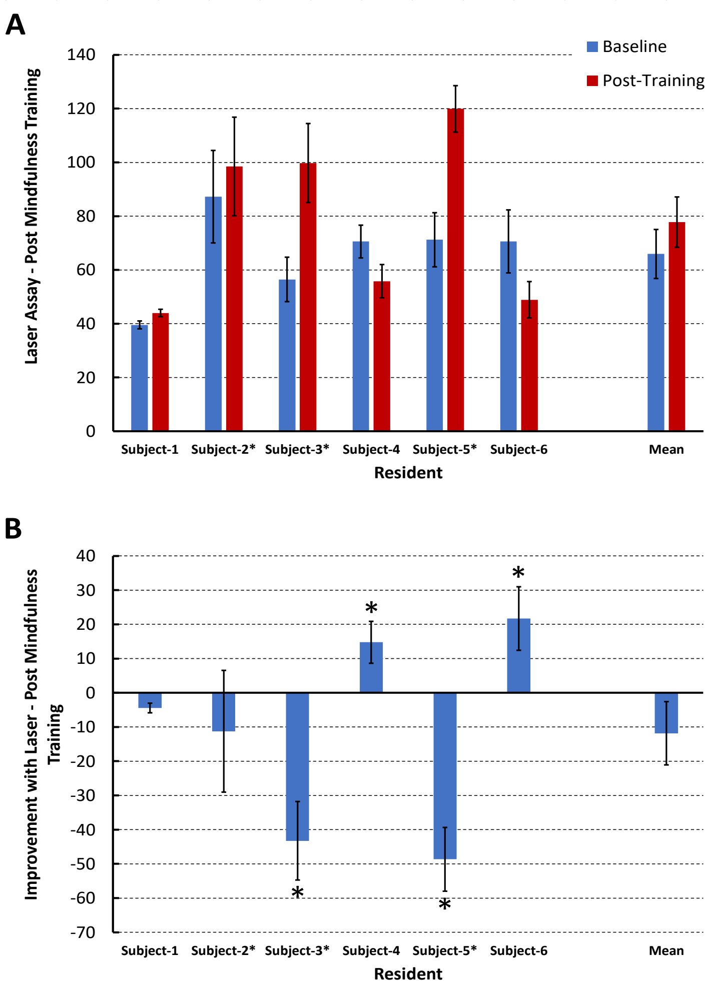

Figure 3. Laser Tracking Analysis

Measurement of average laser movement per 0.04 seconds for six subjects, as well as the mean for those six subjects. Average distance travelled before and after mindfulness training (A), and the difference between pre- and post mindfulness training (B). Bars represent the mean and standard deviation of three samples. Significance is indicated by asterisk (*) with $P < 0.05$.

Figure 4. Macroscopic Pen Tracing

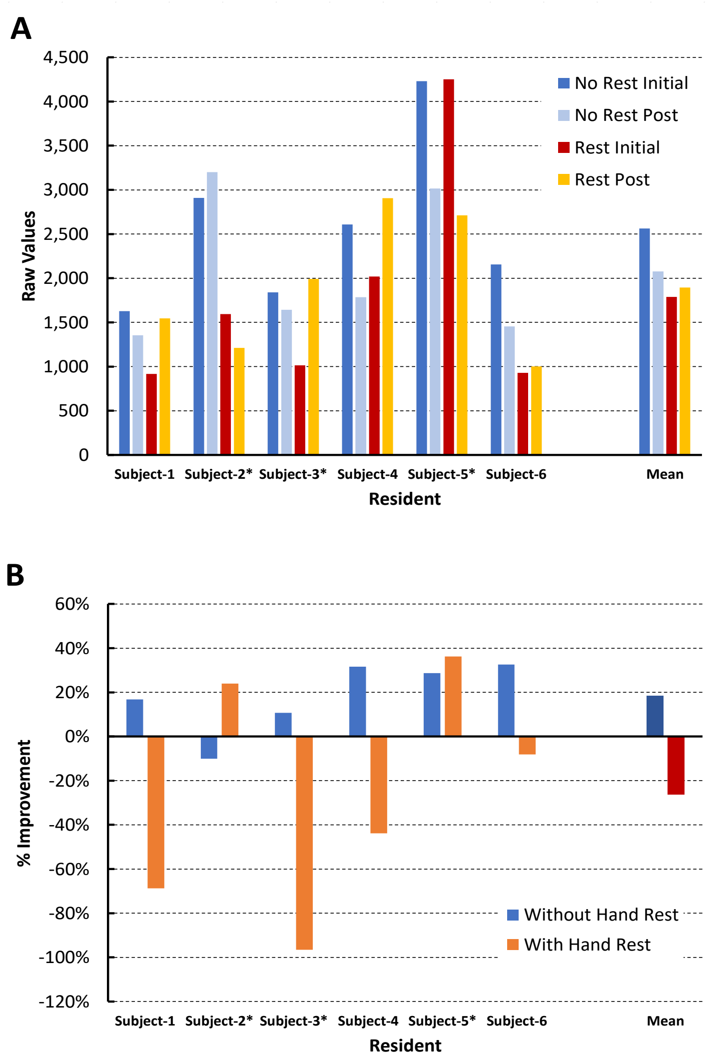

Figure 4. Macroscopic Pen Tracing

Measurement of distance of the pen tracing from the guide line for six subjects, as well as the mean for those six subjects. Average deviation from the central guide line before and after

mindfulness training (A), and the difference between pre- and post-mindfulness training (B). Bars represent the average deviation from the central line for a single sample. Significance is indicated by asterisk (*) with P < 0.05.

Figure 5: Microscopic Pen Tracing

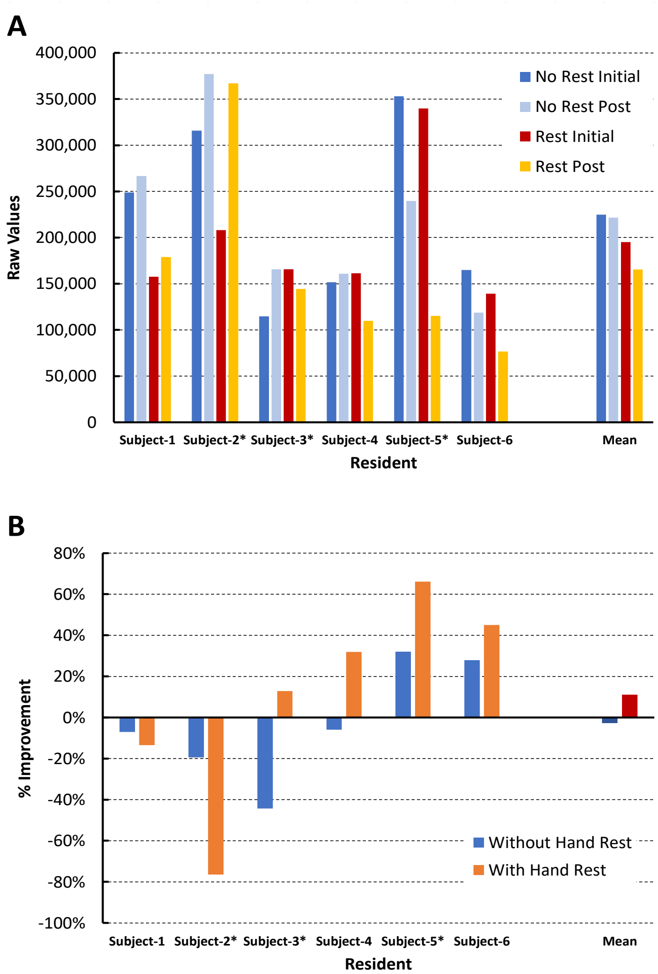

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Figure 6: Comparison of All Assays

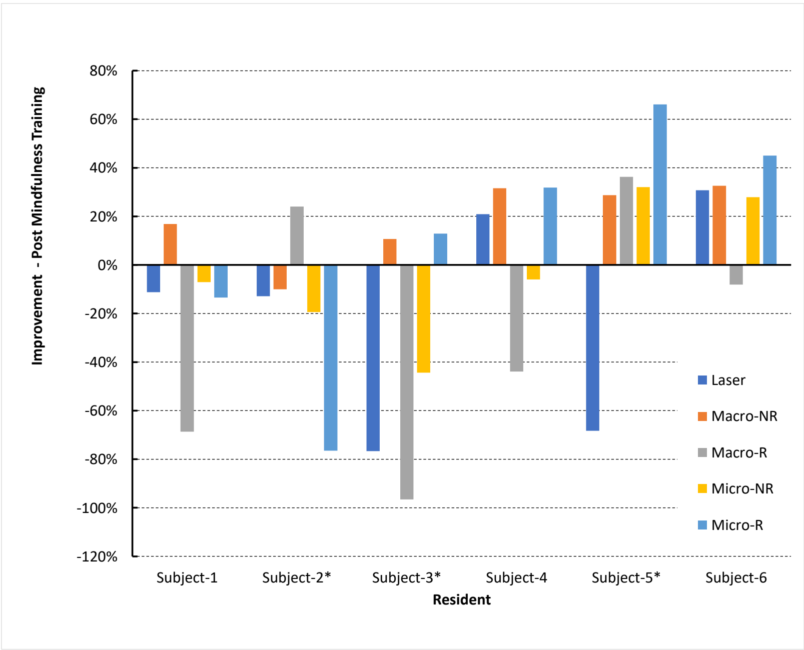

Figure 6: Comparison of All Assays

All data were compared as the percentage reduction in laser movement or deviation from the guide lines for six subjects. Macro-NR = macroscopic pen tracing without hand rest for stabilization, Macro-R = macroscopic pen tracing with hand rest for stabilization, Micro-NR = microscopic pen tracing without hand rest for stabilization, Micro-R = microscopic pen tracing with hand rest for stabilization.

Table 1: Correlation Coefficients for the Five Measurement Assays

Correlation	Laser	Macro-NR	Macro-R	Micro-NR	Micro-R
Laser	**1.000**	0.269	0.098	0.301	-0.091
Macro-NR	0.269	**1.000**	-0.035	0.653	0.919
Macro-R	0.098	-0.035	**1.000**	0.665	0.015
Micro-NR	0.301	0.653	0.665	**1.000**	0.596
Micro-R	-0.091	0.919	0.015	0.596	**1.000**

Table 1: Correlation Coefficients for the Five Measurement Assays

All data were compared using the percentage reduction in laser movement or deviation from the guide lines for six subjects using Correlation Coefficient in Microsoft Excel. Macro-NR = macroscopic pen tracing without hand rest for stabilization, Macro-R = macroscopic pen tracing with hand rest for stabilization, Micro-NR = microscopic pen tracing without hand rest for stabilization, Micro-R = microscopic pen tracing with hand rest for stabilization.

Figure Legends:

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Figure 2. Linear Pen Tracing Measurement of Hand Stability

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Figure 3. Laser Tracking Analysis

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mindfulness training (A), and the difference between pre- and post-mindfulness training (B). Bars represent the average deviation from the central line for a single sample. Significance is indicated by asterisk (*) with $P < 0.05$.

Figure 5: Microscopic Pen Tracing

Measurement of distance of the pen tracing from the guide line for six subjects, as well as the mean for those six subjects. Average deviation from the central guide line before and after mindfulness training (A), and the difference between pre- and post-mindfulness training (B). Bars represent the average deviation from the central line for a single sample. Significance is indicated by asterisk (*) with $P < 0.05$.

Figure 6: Comparison of All Assays

All data were compared as the percentage reduction in laser movement or deviation from the guide lines for six subjects. Macro-NR = macroscopic pen tracing without hand rest for stabilization, Macro-R = macroscopic pen tracing with hand rest for stabilization, Micro-NR = microscopic pen tracing without hand rest for stabilization, Micro-R = microscopic pen tracing with hand rest for stabilization.