THE ACCURACY AND PRECISION OF KINESIOLOGY-STYLE MANUAL MUSCLE TESTING:

DESIGNING AND IMPLEMENTING A SERIES OF DIAGNOSTIC TEST ACCURACY STUDIES

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A thesis submitted for the degree of

Doctor of Philosophy

Initial Submission 19 June 2014

Revision Submitted 24 October 2014

ABSTRACT

Introduction: Kinesiology-style manual muscle testing (kMMT) is a non-invasive assessment method used by various types of practitioners to detect a wide range of target conditions. It is distinctly different from the muscle testing performed in orthopaedic/neurological settings and from Applied Kinesiology. Despite being estimated to be used by over 1 million people worldwide, the usefulness of kMMT has not yet been established. The aim of this thesis was to assess the validity of kMMT by examining its accuracy and precision.

Methods: A series of 5 diagnostic test accuracy studies were undertaken. In the first study, the index test was kMMT, and the target condition was ***deceit*** in verbal statements spoken by Test Patients (TPs). The comparator reference standard was a true gold standard: the actual verity of the spoken statement. The outcomes of the muscle tests were interpreted consistently: a weak result indicated a Lie and a strong result indicated a Truth. A secondary index test was included as a comparator: Intuition, where Practitioners used intuition (without using kMMT) to ascertain if a Lie or Truth was spoken. Forty-eight Practitioners were recruited and paired with 48 unique kMMT-naïve TPs. Each Pair performed 60 kMMTs broken up into 6 blocks of 10, which alternated with blocks of 10 Intuitions. For each Pair, an overall percent correct was calculated for both kMMT and Intuition, and their means were compared. Also calculated for both tests were sensitivity, specificity, positive predictive value and negative predictive value.

The second study was a replication of the first, using a sample size of 20 Pairs and a less complex procedure. In the third study, grip strength dynamometry replaced kMMT as the primary index test. In the fourth study, the reproducibility and repeatability of kMMT

were examined. In the final study, TPs were presented with emotionally-arousing stimuli in addition to the affect-neutral stimuli used in previous studies, to assess if stimuli valence impacted kMMT accuracy.

Results: Throughout this series of studies, mean kMMT accuracies (95% Confidence Intervals; CIs) ranged from 0.594 (0.541 – 0.647) to 0.659 (0.623 - 0.695) and mean Intuition accuracies, from 0.481 (0.456 - 0.506) to 0.526 (0.488 - 0.564). In all studies, mean kMMT accuracies were found to be significantly different from mean Intuition accuracies ($p \leq 0.01$), and from Chance ($p < 0.01$). On the other hand, no difference was found between grip strength following False statements compared to grip strength following True statements ($p = 0.61$). In addition, the Practitioner-TP complex accounted for 57% of the variation in kMMT accuracy, with 43% unaccounted for. Also, there was no difference in the mean kMMT accuracy when using emotionally-arousing stimuli compared to when using affect-neutral stimuli ($p = 0.35$). Mean sensitivities (95% CI) ranged from 0.503 (0.421 - 0.584) to 0.659 (0.612 - 0.706) while mean specificities (95% CI) ranged from 0.638 (0.430 - 0.486) to 0.685 (0.616 - 0.754). Finally, while a number of participant characteristic seemed to influence kMMT accuracy during one study or another, no one specific characteristic was found to influence kMMT accuracy consistently (i.e. across the series of studies).

Discussion: This series of studies has shown that kMMT can be investigated using rigorous evidence-based health care methods. Furthermore, for distinguishing lies from truths, kMMT has repeatedly been found to be significantly more accurate than both Intuition and Chance. Practitioners appear to be an integral part of the kMMT dynamic because when replaced by a mechanical device (i.e. a grip strength dynamometer), distinguishing Lies from Truth was not possible. In addition, since specificities seemed to

be greater than sensitivities, Truths may have been easier to detect than Lies. A limitation of this series of studies is that I have a potential conflict of interest, in that I am a practitioner of kMMT who gets paid to perform kMMT. Another limitation is these results are not generalisable to other applications of kMMT, such as its use in other paradigms or using muscles other than the deltoid. Also, these results suggest that kMMT may be about 60% accurate, which is statistically different from Intuition and Chance; however it has not been established if 60% correct is *"good enough"* in a clinical context. As such, further research is needed to assess its clinical utility, such as randomised controlled trials investigating the effectiveness of whole kMMT technique systems. Also, future investigators may want to explore what factors, such as specific Practitioner and TP characteristics, influence kMMT accuracy, and to investigate the validity of using kMMT to detect other target conditions, using other reference standards and muscles other than the deltoid.

Summary: This series of diagnostic test accuracy studies has found that kMMT can be investigated using rigorous methods, and that kMMT used to distinguish Lies from Truths is significantly more accurate that both Intuition and Chance. Further research is needed to assess kMMT's clinical utility.

CHAPTER 2 : STUDY 1 – ESTIMATING THE ACCURACY OF KMMT

2.1 ABSTRACT

Research Objective: To estimate the accuracy (overall fraction correct) of kinesiology-style manual muscle testing (kMMT) to distinguish lies from truth in spoken statements, with varying degrees of blinding.

Methods: A prospective study of diagnostic test accuracy was carried out. Forty-eight Practitioners who routinely practised kMMT were paired with kMMT-naïve Test Patients (TPs) and performed 60 kMMTs as TPs spoke True and False statements. Blocks of kMMT alternated with blocks of Intuition. Other conditions, such as Not-blind and Practitioner Misled were also introduced. Bias was controlled for using varying degrees of blinding and randomisation of True and False statements.

Results: kMMT accuracy was found to be 0.659 (95% CI 0.623 - 0.695), while Intuition accuracy was 0.474 (95% CI 0.449 - 0.500), which were significantly different ($p<0.01$). When the mean accuracy of kMMT was compared to the likelihood of Chance (0.500), a significant difference was also achieved ($p<0.01$). Testing for various factors that may have influenced kMMT accuracy failed to detect any correlations.

Summary: kMMT had significant accuracy for distinguishing lies from truths, compared to both Intuition and Chance. However, despite tracking on a variety of participant characteristics, no factor was identified that influenced kMMT accuracy. Strengths of this study include a high degree of blinding, the heterogeneity of the samples, the choice of a

clear target condition, and the choice of a “gold standard” reference standard, while the main limitation was its lack of generalisability to other applications of kMMT.

Keywords: sensitivity; specificity; kinesiology; muscle weakness; lie detection; deception; lying; intuition; arm; upper extremity

CHAPTER 3 : STUDY 2 – REPLICATION OF STUDY 1

3.1 ABSTRACT

Research Objectives: To replicate Study 1 (Chapter 2, page 47) using a simplified methodology, and to estimate the accuracy (overall fraction correct) of kinesiology-style manual muscle testing (kMMT) used to distinguish lies from truth in spoken statements.

Methods: A prospective study of diagnostic test accuracy was carried out. Twenty Practitioners who routinely practised kMMT were paired with Test Patients (TPs) who may or may not have been kMMT-naïve. The Pairs performed 40 kMMTs as TPs spoke True and False statements. Blocks of kMMT alternated with blocks of Intuition. The verity of the spoken statements was randomly assigned, with the prevalence of Lies fixed at 0.50.

Results: kMMT accuracy was found to be 0.594 (95% CI 0.541 - 0.647), which was significantly different from Intuition accuracy (0.514; 95% CI 0.483 - 0.544; p=0.01) and Chance (0.500; p<0.01). These results fell within or close to the 95% Confidence Intervals of Study 1. Also, similar to the previous study (see page 88), testing for various factors that may have consistently influenced kMMT accuracy failed to detect any correlations.

Summary: This study successfully replicated Study 1 by again finding that kMMT can be used with significant accuracy to distinguish lies from truths, compared to both Intuition and Chance. Moreover, this study further supports the concept that a simple yet robust methodology for assessing the value of kMMT as a diagnostic tool can be developed and implemented effectively. Comparable to Study 1, no factors were identified that seemed to

consistently influence kMMT accuracy. Also similar to Study 1, the main limitation of this study is its lack of generalisability to other applications of kMMT.

Keywords: sensitivity; specificity; kinesiology; muscle weakness; lie detection; deception; lying; intuition; arm; upper extremity

CHAPTER 4 : STUDY 3 – GRIP STRENGTH DYNAMOMETRY FOR LIE DETECTION

4.1 ABSTRACT

Research Objectives: To investigate if dynamometric muscle testing (DMT) could be used to distinguish Lies from Truth.

Methods: A prospective study of diagnostic test accuracy was carried out. Twenty Test Patients (TPs), aged 18-65 years, with fully functioning and painfree hands, were recruited. After viewing a picture on a computer screen, TPs were instructed to speak a specific statement about the picture and then squeeze a dynamometer for 5 seconds, giving a maximum effort each time. The examiner recorded the grip strength (to the nearest 1 kg) directly into the computer, which advanced the screen to the next picture/statement. Testing proceeded in this manner until 20 DMTs were performed, 10 by each hand.

Results: The mean grip strength after True statements was found to be 24.9 kg (95% CI 20.3 to 29.6), and after False statements, 24.8 (95% CI 20.2 to 29.5), which were not statistically different (p=0.61). No significant correlations were detected between difference in grip strength (False – True) and age, gender, confidence in MMT (pre-testing or post-testing), or change in confidence scores. Also compared were mean grip strengths by block and were found to be stable throughout testing

Summary: DMT via hand-held grip strength dynamometry failed to distinguish Lies from Truth. These results seem to suggest that strength, as measured by DMT, is not impacted by deceit. However, some other yet undetermined quality may allow kMMT to accurately make

this distinction unlike DMT. A limitation of this study is it is not generalisable to other applications of muscle testing or other target conditions.

Keywords: sensitivity; specificity; kinesiology; muscle weakness; muscle contraction; lie detection; deception; lying; grip strength; dynamometry.

CHAPTER 5 : STUDY 4 – EXPLORING THE VARIATION IN KMMT ACCURACY THROUGH REPEATABILITY AND REPRODUCIBILITY

5.1 ABSTRACT

Research Objectives: To explore the variation in mean kMMT accuracy and whether this variation can be attributable to participant characteristics.

Methods: A prospective study of diagnostic test accuracy was carried out in a round-robin fashion, similar in methodology to Study 2 (see page 111). Sixteen Practitioners tested each of 7 Test Patients using 20 kMMTs broken into 2 blocks of 10 which alternated with 2 blocks of 10 Intuitions. Mean kMMT accuracies (as overall percent correct) were calculated for each unique pair. Reproducibility and repeatability was assessed using analyses of variance (ANOVA) and scatter and Bland-Altman plots.

Results: The mean kMMT accuracy (95% CI) was 0.616 (0.578 - 0.654), which was significantly different from both the mean Intuition accuracy, 0.507 (95% CI 0.484 - 0.530; $p<0.01$) and Chance ($p<0.01$). Visual inspection of scatterplots of mean kMMT accuracies by Practitioner and by TP suggest large variances among both subsets, and regression analysis revealed that kMMT accuracy could not be predicted by TP ($r= –0.14$; $p=0.19$), nor by Practitioner ($r=0.01$; $p=0.90$). A significant effect imposed by both Practitioners and TPs individually and together was found at the $p<0.05$ level; however, together they account for only 57.0% of the variance, with 43.0% of the variance unexplained by this model. From a a statistical perspective, Bland-Altman Plots of mean kMMT accuracy by Practitioner do show adequate repeatability since all scores fell within 2 SDs of the mean; however, the wide range of scores also suggests insufficient repeatability from a clinical perspective. Finally,ANOVA

demonstrated that an insignificant amount of variance could be explained by Block [$F(1,21) = 0.02$, $p = 0.90$].

Summary: The variation in the mean kMMT accuracy can only be explained 57% by participant characteristics; therefore, there are other factors at play that could not be explained by the model used. Additional research is needed to explain this variance.

Keywords: variability; stability; precision; reproducibility; repeatability; reliability; validity; intra-examiner; inter-examiner; kinesiology; muscle weakness; lie detection; deception; lying.

CHAPTER 6 : STUDY 5 – USING EMOTIONALLY-AROUSING STIMULI

6.1 ABSTRACT

Research Objectives: To determine if using emotionally-arousing stimuli influences kMMT accuracy compared to affect-neutral stimuli.

Methods: A prospective study of diagnostic test accuracy was carried out. Twenty Practitioners who routinely practised kMMT were paired with Test Patients (TPs) who may or may not have been kMMT-naïve. The Pairs performed 40 kMMTs as TPs spoke True and False statements about a mix of affect-neutral and emotionally-arousing pictures. Blocks of kMMT alternated with blocks of Intuition. The verity of the spoken statements was randomly assigned, with the prevalence of Lies fixed at 0.50.

Results: kMMT accuracy using emotionally-arousing stimuli was no better or worse than when using affect-neutral stimuli (p=0.35). However, using all stimuli, kMMT accuracy (0.648; 95% CI 0.558 - 0.737) was found to be significantly better than Intuition accuracy (0.526; 95% CI 0.488 - 0.564; p=0.01) and Chance (0.500; p<0.01). In addition, similar to previous studies in this series, this study also failed to detect any characteristic that consistently influenced kMMT accuracy.

Summary: This study found that using emotionally-arousing stimuli was no different from using affect-neutral stimuli. However, this study would have been strengthened by adding personally-relevant, high-stakes lies instead of lies instead of emotionally-arousing (impersonal) stimuli. The primary limitation of this study is its lack of generalisability to other applications of kMMT. The main strengths of this study were its choice of a “gold standard” as the reference standard and its high degree of blinding. Finally, this study is

further evidence that a simple yet robust methodology for assessing the value of kMMT as a diagnostic tool can be developed and implemented effectively.

Keywords: sensitivity; specificity; kinesiology; muscle weakness; lie detection; deception; lying; arm; upper extremity; emotional stress.

APPENDIX C : THE PREVALENCE OF USE OF KMMT

ABSTRACT

Research Objectives: To investigate the prevalence of use of kinesiology-style manual muscle testing (kMMT).

Methods: First, a search of internet databases, textbooks and expert opinion were used to compile a list of known kMMT technique systems. Then, direct contact was attempted via email and telephone to representatives of each individual kMMT technique system. Once contacted, the representative was asked to provide a conservative estimate of the number of people trained in their form of kMMT. For those organisations unable to provide an estimate, additional expert opinion was sought to approximate the numbers trained.

Results: Seventy-nine kMMT technique systems were identified, 46 of which provided the requested estimate and 33 did not (for various reasons). From the information collected, kMMT was estimated to be used by over 1 million people worldwide.

Summary: With over 1 million people trained worldwide, the widespread use of kMMT merits further consideration, and proper exploration of its usefulness in clinical settings. This estimation might be amplified due to the possibility of redundancies or attrition. Likewise, it might be low due to misclassification or too narrow search methods.

Keywords: prevalence; education; kinesiology; muscle weakness; muscle contraction.