Research paper

Muscle testing for lie detection: Grip strength dynamometry is inadequate

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ABSTRACT

Introduction: Although DMT is primarily used in the diagnosis of neuromusculoskeletal (NMS) disorders, previous studies have attempted to use other forms of manual muscle testing (MMT) to detect conditions other than NMS. For instance, muscle response testing (MRT) was used to distinguish lies (a known stressor) from truth. Therefore, it is hypothesised that DMT might be used to detect deceit as well, and the aim of this study was to investigate if grip strength via dynamometric muscle testing (DMT) could be used to distinguish lies from truth.
Methods: A prospective study of diagnostic test accuracy was carried out. Twenty participants, aged 18–65 years, with healthy hands, were recruited. Participants were given a visual stimulus and followed an auditory instruction to lie or to tell the truth about the stimulus, before recording grip strength with a dynamometer. Testing proceeded in this manner until 20 DMTs were performed, 10 by each hand. We analysed the accuracy of grip strength for detecting lies.
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 ($p = 0.61$).
Conclusion: 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. A limitation of this study is it is not generalisable to other types or applications of MMT or MRT or to other target conditions.

1. Introduction

Muscle Response Testing (MRT) is a type of manual muscle testing (MMT) used by integrative health care providers to assess not muscular strength, but rather, MRT, a binary test, is used to detect other specified target conditions. The tester applies a force to an indicator muscle and labels the outcome as either "weak" or "strong" depending on the muscle's ability to resist the force. MRT is a commonly used in kinesiology techniques, such as Applied Kinesiology, HeartSpeak and Total Body Modification. This paper reports one study in a series of scientific experiments designed to assess the validity, accuracy and precision of muscle response testing (MRT).

Previous studies in this series demonstrated that MRT could be used to distinguish lies from truths [1,2]. As a comparator, in this study the practitioner-applied testing of MRT was replaced with an objective instrument, a handheld or grip-strength dynamometer (HHD; see Fig. 1), in order to assess its usefulness in the same application: to distinguish lies from truths.

Muscle strength testing is typically used to diagnose neuromusculoskeletal (NMS) disorders, however in recent times other applications

have emerged. One type of MMT, MRT, arose from Goodheart's Applied Kinesiology and other techniques in the 1980's [3,4], and is estimated to be used by over 1 million people worldwide [5]. MRT is distinct from other types of MMT in that typically only one muscle (usually the deltoid) is tested repeatedly, to detect the presence of potential target conditions, such as food allergies [6–10], phobia [11,12], and deceit [1,2]. However, despite its widespread use, many clinicians argue that MRT lacks credibility and validity (e.g. inter-examiner reliability) [5,13].

In an effort to quantify muscle strength measurement, and thereby gain objectivity, instruments such as the HHD were developed. Dynamometric muscle testing (DMT) has been shown to be reliable in different populations [14–16], and subjective practitioner judgement of muscle strength by MMT has been shown to correlate well with muscle strength measured objectively by HHD [17–21]. In addition, DMT correlates well with other forms of MMT [17], and its intra-subject test–retest variability has been found to be small [22].

If the loss of muscle strength is the underlying mechanism behind the observed ability of MRT to distinguish lies from truth, it suggests that DMT should also be able to distinguish lies from truth [17]. The

Fig. 1. (A) and (B) Proper positioning during grip strength dynamometry; (C) Sample face of a grip strength dynamometer.

aim of this study is to assess whether muscle strength (via DMT) can distinguish lies from truth.

2. Methods

This was a prospective diagnostic test accuracy study. No participant was assessed prior to enrolment. This protocol received ethics committee approval by the Oxford Tropical Research Ethics Committee (OxTREC; Approval #41-10) and the Parker University Institutional Review Board for Human Subjects (Approval # R19_10). In addition, this study protocol was prospectively registered with two clinical trials registries: the Australian New Zealand Clinical Trials Registry (ANZCTR; www.anzctr.org.au), and US-based ClinicalTrials.gov. Written informed consent was obtained from all participants. This study is reported in accordance with the Standards for the Reporting of Diagnostic Test Accuracy Studies (STARD) guidelines [23–26].

2.1. Overview

Participants were given a visual stimulus (a picture displayed on a computer screen: for example, an apple) and followed an auditory instruction to lie or to tell the truth about the stimulus, before recording grip strength with a dynamometer. We analysed the accuracy of grip strength (via DMT) for detecting lies. This study is one in a series of studies assessing the validity of MRT, and as such it follows a similar protocol [1,2].

2.2. Participants and setting

Participants had to be aged between 18-65 years, have fully functioning and pain-free hands, and be fluent in English. Volunteers were excluded if they had visual, auditory or speech impairment. Both MRT-naïve and non-MRT-naïve participants were eligible for enrolment. Recruitment was by direct contact, social media and word of mouth. All recruitment took place in the states of Texas and New York, USA.

Each participant was given a Participant Information Sheet (PIS) and gave written informed consent. Pre- and post-test questionnaires (see Supplements 1 & 2, respectively) were completed by each participant to collect demographic information and participant opinions.

2.3. Test methods

The index test under investigation was hand-held grip strength DMT, which was compared to the actual verity of the spoken statement (i.e. the reference standard), and the target condition was deceit. Each participant performed 20 DMTs after speaking an instructed statement out loud, 10 with their dominant hand and 10 with their non-dominant hand, broken up into blocks of five: 5 dominant, 5 non-dominant, 5 dominant, 5 non-dominant. Participants always started with their dominant hand and ended with their nondominant hand.

Visual stimuli in the form of neutral pictures were randomly presented on a computer screen viewed by the participant. In addition, a verbal instruction was also randomly generated by the computer and paired with the picture, in which the participant was instructed to speak a true or false statement about the viewed picture. For example, on the computer screen might be presented an apple, and the participant might be instructed to say this true statement: "Say, 'I see an apple.' " Alternatively, the participant may be instructed to say a false statement, such as, "Say, 'I see a boat.' " Immediately after speaking the true or false statement, the participant then performed the DMT.

The stimuli presented were selected from a database of 100 affect-neutral pictures/statements. DirectRT© Research Software (Empirisoft Corporation, New York, NY) was programmed to randomly present a unique sequence of stimuli for each participant, randomising the verity of the statements (i.e. true or false) and keeping the prevalence of false statements constant at 0.50.

2.3.1. Grip strength dynamometry

All DMT was performed using the same factory calibrated hydraulic JAMAR (Model J00105, Lafayette, Indiana, USA) analogue hand-grip dynamometer and employing a standardised approach. This brand of dynamometer is the most widely used, and has proven inter-rater, intra-rater, and test-re-test reliability [27]. Participants were instructed to squeeze the dynamometer for 5 s, giving a maximum effort each time. They could rest as needed. The examiner read the scale (in kilograms, kg) on the dial face, which was facing away from the participant, and after recording the result, reset the peak-hold needle to zero, ready for the next effort. Grip strength was measured to the nearest 1 kg.

2.3.2. Procedures

The participant was seated comfortably in front of a computer and held the dynamometer vertically in his hand, elbow at his side and bent to 90°, forearm and wrist in neutral (i.e. palm facing medially). The dial of the dynamometer was facing away from the participant such that it was out of his view. See Fig. 1. One investigator (AJ) collected all data for this study. During testing, she was seated in front and to the side of the participant, positioned so that she could read the dial of the dynamometer, and was also unable to see the participant's computer screen. For the testing scenario layout, see Fig. 2. One repetition of DMT consisted of: (1) participant viewed a picture, (2) participant was instructed (via an earpiece) to say a statement in relation to the picture, (3) participant took the DMT position, (4) while viewing the picture, participant spoke the instructed statement, (5) participant immediately performed the DMT, and (6) the examiner recorded the grip strength result directly into the computer, which advanced the screen to the next picture/statement. Testing proceeded in this manner until 2 blocks of 5 DMTs were performed by each hand.

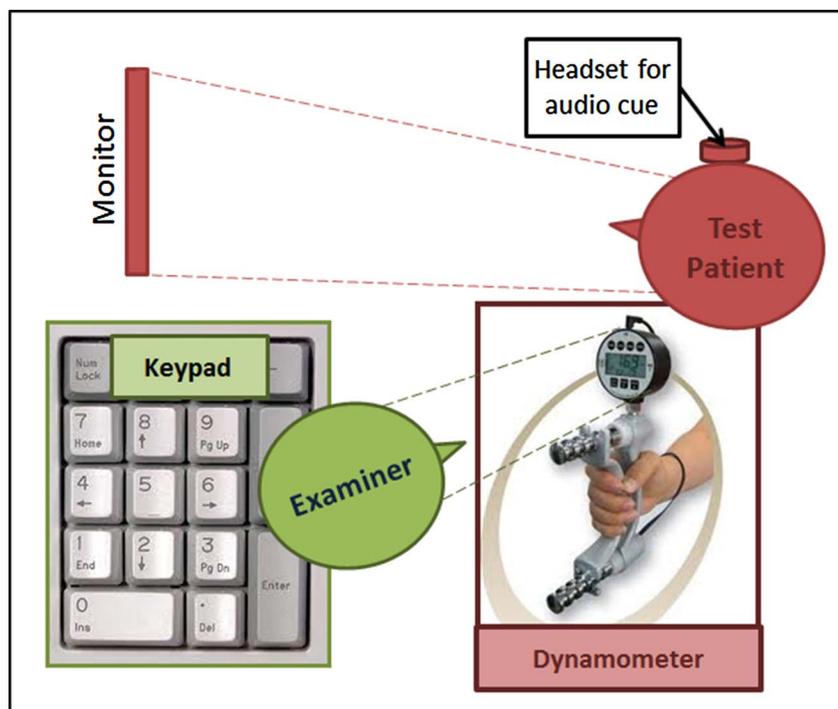In the post-testing questionnaire (see Supplement 2), participants

were asked if they noticed anything different in their tests following true statements compared to false statements. This question was included to ascertain if they guessed the aim of the study, which was to investigate if grip strength can be used to distinguish lies from truth. It was likely that those with prior MRT experience were aware of the paradigm that MRT following false statements resulted in a "weak" outcome, and MRT following a true statement resulted in a "strong" outcome. Therefore, it was necessary to track on both the MRT-naivety of the participants and if they noticed a difference or guessed the paradigm.

2.4. Sample size

Based on a previous study, in which the accuracy of manual MRT for lie detection had mean 66% and standard deviation 13% across participants [1], we estimated that a sample size of 20 participants would have greater than 99% power to detect an overall accuracy of 66% compared to 50%.

2.5. Statistical methods

Mean grip strengths following false statements and true statements were calculated for each participant and are reported with their 95% confidence intervals. Then since the data were not normally distributed, the means were compared using a two-tailed rank sign test. In MRT, false positives (Type I Errors) are equally as important as false negatives (Type 2 Errors), and was defined as the overall percent correct. However, in this study, we simply compared the mean grip strength (kg) after true statements and compared this to the mean grip strength (kg) after false statements to determine if there was a difference. Finally, correlation analyses were made between mean grip strengths and other participant characteristics, such as gender, MRT-naïveté, confidence in MRT, and if the TP reported guessing the paradigm. All data were analyzed using Stata/IC 12.1 (StataCorp LP, College Station, Texas), specifically the commands "signrank" and "pwcorr."

3. Results

3.1. Participants

Twenty participants were enrolled in the United States between June and August 2011, and included 11 males and 9 females. The mean (SD) age was 48.4 (12.1) years. Seventeen reported being right-hand dominant, 3, left-hand dominant, and 14 reported being MRT-naïve and 6 reported having had some prior experience with MRT. For a summary of participant demographics, see Table 1. Also, see Fig. 3 for the Participant Flow Diagram.

3.2. Test results

Participants took between 5 and 15 min to complete their participation, all completed all DMT in full and there were no adverse events reported from any testing. Histograms of grip strength scores showed that the data were not normally distributed (see Supplemental Fig. 1), so nonparametric statistics (e.g. sign test) have been applied.
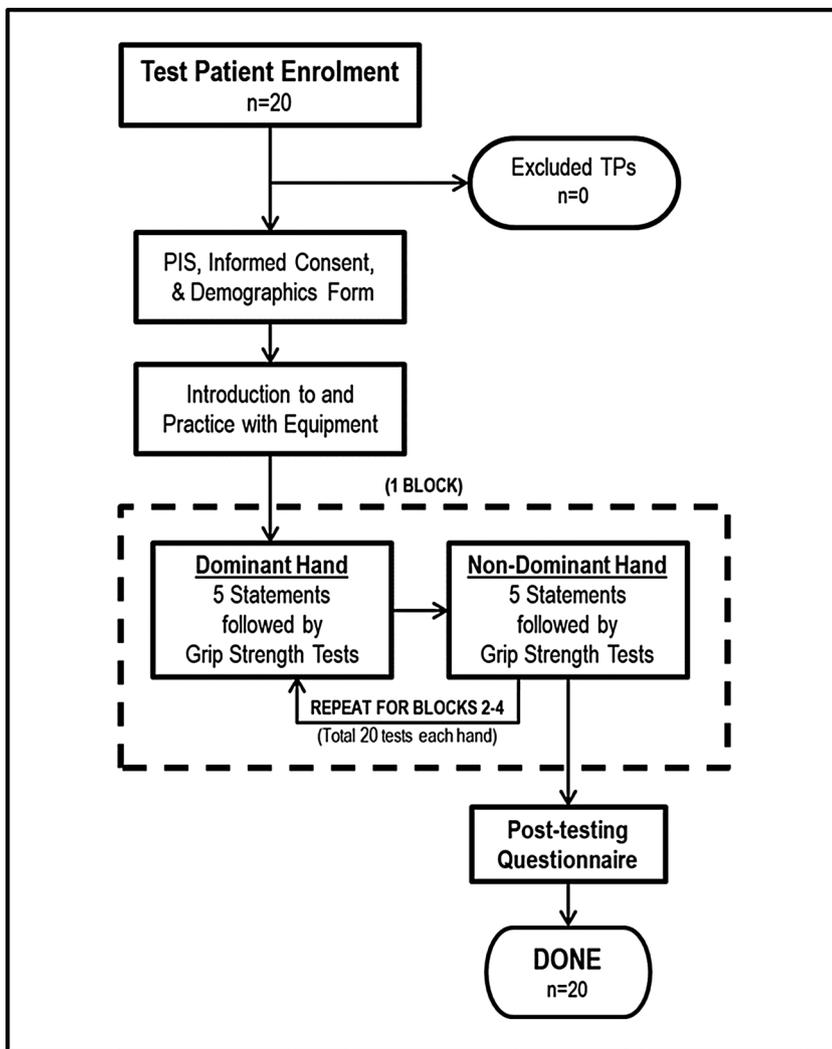
The mean grip strength after true statements was found to be 24.9 kg (95% CI 20.3 to 29.6), and after false statements, 24.8 (95% CI 20.2 to 29.5), which was not statistically different ($z = 0.60$). The difference in mean grip strengths between true and false statements (Difference = Mean Grip Strength$_{True}$ − Mean Grip Strength$_{False}$) was 0.1 (95% CI −0.4–0.6), which was no different from 0.0 ($p = 1.00$).

Table 1
Demographics of Participants.

	Participants (n = 20)
Gender (M:F)	11:9
Mean age in years (SD)	48.4 (12.1)
Age range (years)	19–61
Dominant Hand (R:L)	17:3
Prior MRT Experience (MRT-naïve: non-naïve)	14:6
Mean degree of confidence in MRT (pre-testing)† (SD)	5.9 (2.0)

MRT, Muscle Response Testing; SD, Standard Deviation; M, Male; F, Female; R, Right; L, Left; †Measured using a 10 cm Visual Analog Scale, from 0 = "None" to 10 = "Most Ever".

Fig. 3. Participant Flow Diagram.

TP, Test Patient

Table 2
Comparison of Mean Grip Strengths (kg) for False vs. True Statements. Combined data for both hands, and Dominant and Non-Dominant Hands separately.

| | | Grip Strength (kg) | | | Grip Strength (kg) | | | | | |
| | | | | | Dominant Hand | | | Non-Dominant Hand | | |
	n	Mean	95% CI	*z*-value	Mean	95% CI	*z*-value	Mean	95% CI	*z*-value
False Statements	20	24.8	20.2 to 29.5	0.55	23.5	18.9 to 28.2	0.04	26.1	21.2 to 31.0	0.74
True Statements	20	24.9	20.3 to 29.6		23.9	19.3 to 28.5		26.0	21.3 to 30.7	

kg, Kilogram; CI, Confidence Interval.

See Table 2. Also see Supplemental Table 1 for the mean grip strengths for each participant.

Finally, mean grip strengths by block were found to be consistent throughout testing (see Supplemental Fig. 2). Also, it is noted that mean grip strengths in this study fell toward to lower end of the of normative range grip strengths reported in current literature [28,29].

4. Discussion

4.1. Statement of principal findings & possible explanations of results

This study failed to demonstrate that deceit can be detected using grip strength dynamometry, an instrument form of MMT. This contradicts the findings of similar previous studies which demonstrated that another form of MMT, the practitioner-applied muscle response testing (MRT), can accurately distinguish false statements from true [30].

One may be tempted to interpret this contradiction to mean that perhaps the MRT studies simply by chance produced a false positive (that is, it found an effect where none exists). However, because these studies were rigorously designed to prevent potential biases and because they produced replicated results [1], it is less likely that these findings were due to chance, and rather due to some other feature, which at this stage, remains largely unknown [2,30]. Accordingly, then, there must be other plausible explanations for the findings of the present study.

One of the first difference to note is that the DMT in this study tested the participants' grip strength, whereas the prior studies in this series tested shoulder strength via MRT of the deltoid muscle. It is possible

that the deltoid muscle behaves differently compared to the muscles used for grip. It has not been established that the results of the MRT studies can be generalized to testing muscles other than the deltoid. Secondly, while both types of MMT (DMT and MRT) use isometric muscle contractions (at least initially), DMT uses a patient's maximum effort, whereas MRT uses submaximal force and this may be a relevant factor [31].

Another difference between the two methodologies is the presence of a practitioner. Interaction with a practitioner is integral to the implementation of MRT, but not of DMT, in which a practitioner is not required. It is possible that the practitioner is, in some way, a necessary component of the success of MRT.

Another possible explanation of the results in this study is that the instrument used (i.e. the HHD) lacked the sensitivity necessary to make a distinction between grip strengths. Because previous research has found that DMT was more discriminating than MMT in identifying small differences in muscle strength [17,22,32], we think that this reason is highly unlikely. Another possible explanation of these findings is that while DMT is measuring strength, deceit does not cause changes in strength, per se, but instead, changes in some other quality (or qualities) perceptible by MRT but not by DMT. It would be important to think what element is biologically plausible. One possibility is that MRT evaluates power rather than strength, like DMT. The strength of a muscle is the degree of force it can exert, and is dependent upon the size of the muscle and its nerve supply, but not dependent upon time or displacement [33]. However, time and displacement (and therefore, velocity) may be important factors in MRT [34–36]. Power, which takes into consideration force and velocity, might be detectable by MRT but is not detected by DMT.

These negative findings might also be attributable to inconsistencies in patients' efforts throughout their testing, such as through fatigue or lack of attention or motivation. However, mean grip strengths remained consistent throughout testing, so this explanation is implausible.

Also interesting is the finding that there was a statistically significant difference in mean grip strengths after true statements compared to false statements in the group that reported guessing the paradigm under investigation. Because there was no significant difference in the group that did not report guessing the paradigm, this finding might be accounted for by social desirability bias, or the desire of the participant to please the investigator [37]. An enhancement to this study design might be to screen participants using a psychometric instrument, such as the Marlowe-Crowne Social Desirability Scale [38], to track on the possibility of this type of bias.

Another finding was that participants in this study achieved remarkably lower mean grip strengths than normative means. Numerous internal and external factors exist that may impact a person's ability to contract maximally, such as fatigue, pain, volition, motivation and even time of day [39]. Reasons why our participants scored lower may be because of their high mean age (48.4 years, SD 12.1 years), or that all data collection occurred in America, or that this sample was particularly unhealthy. Because no information was collected on health status, fatigue, time of day or motivation level, it is difficult to speculate as to the cause of this marked difference.

The lack of significant findings may also be explained by the use of s single HHD. While on the one hand, this may be considered a strength of this methodology, since all participants used the same instrument, it could be that the instrument may have lost its calibration and therefore was not measuring accurately. This could account for both the results differing from population norms and the failure to detect a true effect.

Furthermore, since grip strengths were found to be block-wise stable throughout testing, it is unlikely that learning, fatigue or other internal/external factors played a significant role. Lastly, the DMT in this study was patient-initiated while MRT is usually tester-initiated. This may have had an influence as it seems that there are fundamental differences between the two [40,41].

A final explanation for the discrepant findings between this study

and the MRT studies could be that, despite the rigorous methods and statistical tests, this study is a false negative finding (that is it failed to pick up a true underlying weakening of the muscles).

4.2. Other DMT studies

Although DMT is mainly used in the diagnosis of NMS disorders, previous studies have attempted to use DMT and other forms of MMT to detect conditions other than NMS. For instance, Radin successfully used grip strength to distinguish refined sugar (purportedly, a toxic substance and a stressor) from sand (hypothetically inert or nontoxic, and hence, not a stressor) [42]. However, three replication studies failed to support his findings [43–45].

4.3. Strengths and limitations

A strength of this study is its rigorous design, which adhered to the STARD guidelines for studies of diagnostic test accuracy. In addition, since one examiner (AJ) performed all assessment, adherence was high. A more explicit strength was the duration of participation was appropriate: given that maximum effort tests like DMT are limited by patient fatigue, and since the results show that fatigue was not influencing factor. In addition, the inclusion of participants with and without prior MRT experience was a strength. While there was a significant difference between those participants who reported guessing the paradigm and those who did not, there was no significant difference found between MRT-naïve and non-MRT-naïve participants.

A limitation of this study is that with 20 participants, it may have been underpowered. Also, it is possible that the analogue dynamometer used may have lacked the necessary sensitivity required, and that a digital one may have been a better choice. Another limitation is the lack of generalizability of these results to other types of MMT. In addition, the recruitment method of direct contact of potential participants may have introduced selection bias, and so may be considered a limitation.

4.4. Implications for clinical practice

Because these results failed to confirm the research hypothesis that DMT can be used to distinguish lies from truth, the clinical implications of these results are limited: DMT is not useful for detecting deceit. Accordingly, these results cannot be generalised to other forms of MMT.

4.5. Unanswered questions and future research

In this study, an analog DMT dynamometer was used, however, future researchers may want to use a digital/computerised dynamometer, which might produce useful information about force, time, displacement and power. These factors might be what MRT is detecting that DMT is not. Also, future researchers may consider using a larger sample size and more than one HHD for assessing grip strength, to avoid potential calibration errors.

Although previous studies of MMT and MRT used force plates to quantify practitioner-applied pressure [35,36,46], the force still involved a practitioner. To remove their potential subjectivity, future research may want to test the deltoid muscle employing an instrument which can measure strength without the intervention of an intermediary, such as with a cable tensiometer [47] or an isokinetic dynamometer (e.g. a Biodex dynamometer) [48,49]. Using specifically quantified measurements may further establish if instrument-only MMT is able to distinguish truths from lies.

5. Summary

DMT via hand-held grip strength dynamometry failed to distinguish lies from truth. One explanation of this might be that strength, as measured by DMT, is not impacted by deceit. For instance, perhaps it is

not strength, but some other yet undetermined quality (e.g. power), that allows MRT to accurately make this distinction but not DMT. Another explanation might be that the practitioner is an important part of the MMT complex, since previous studies found that MRT was useful for detecting deceit. Further research is needed to reconcile these apparently contradictory findings of this study.

Authors declaration

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Conflicts of interest

The authors declare that there are no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.eujim.2017.11.001.

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