The Manual Muscle Test: Meeting the Challenge of the Therapeutic Trial

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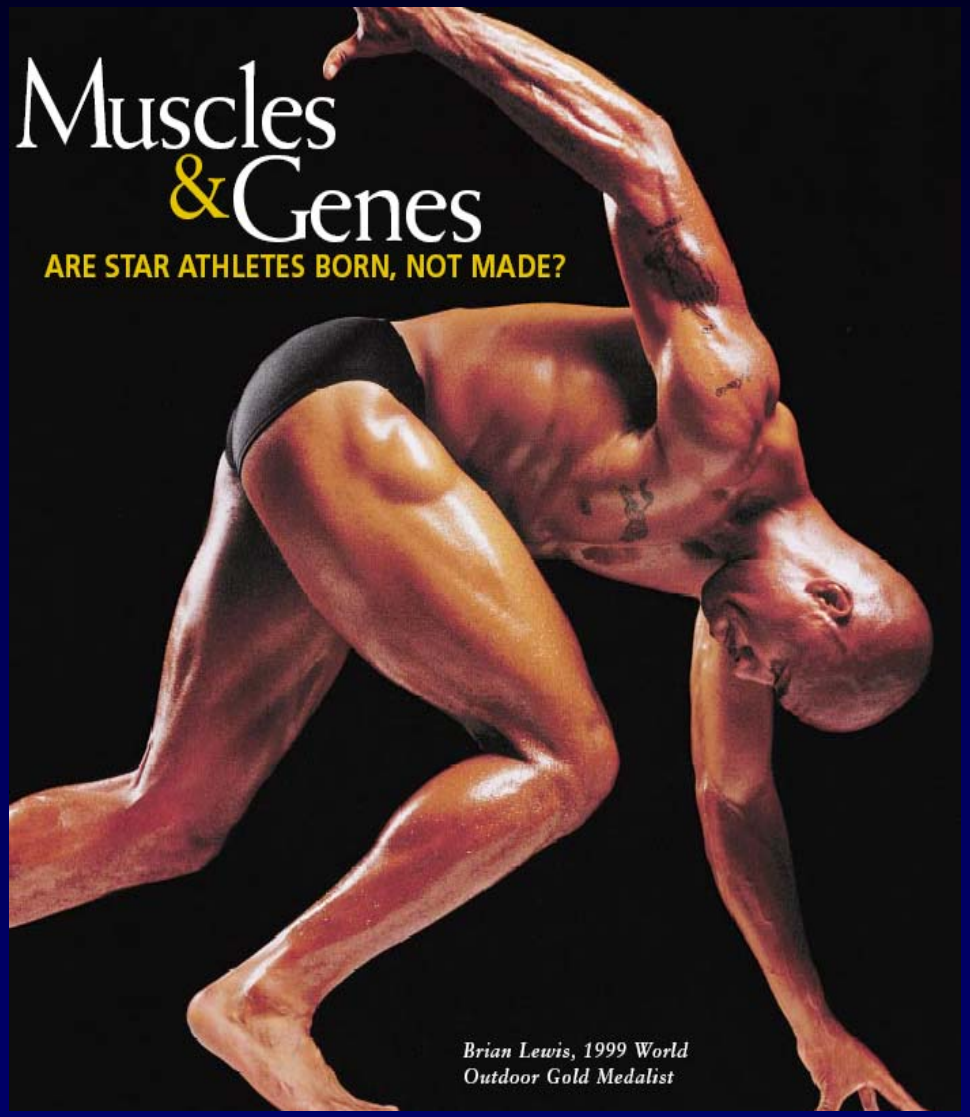
Overview

- Operational definitions
- Utility of MMT and other strength assessments methods
- Threats to MMT validity and reliability
- MMT grading criteria

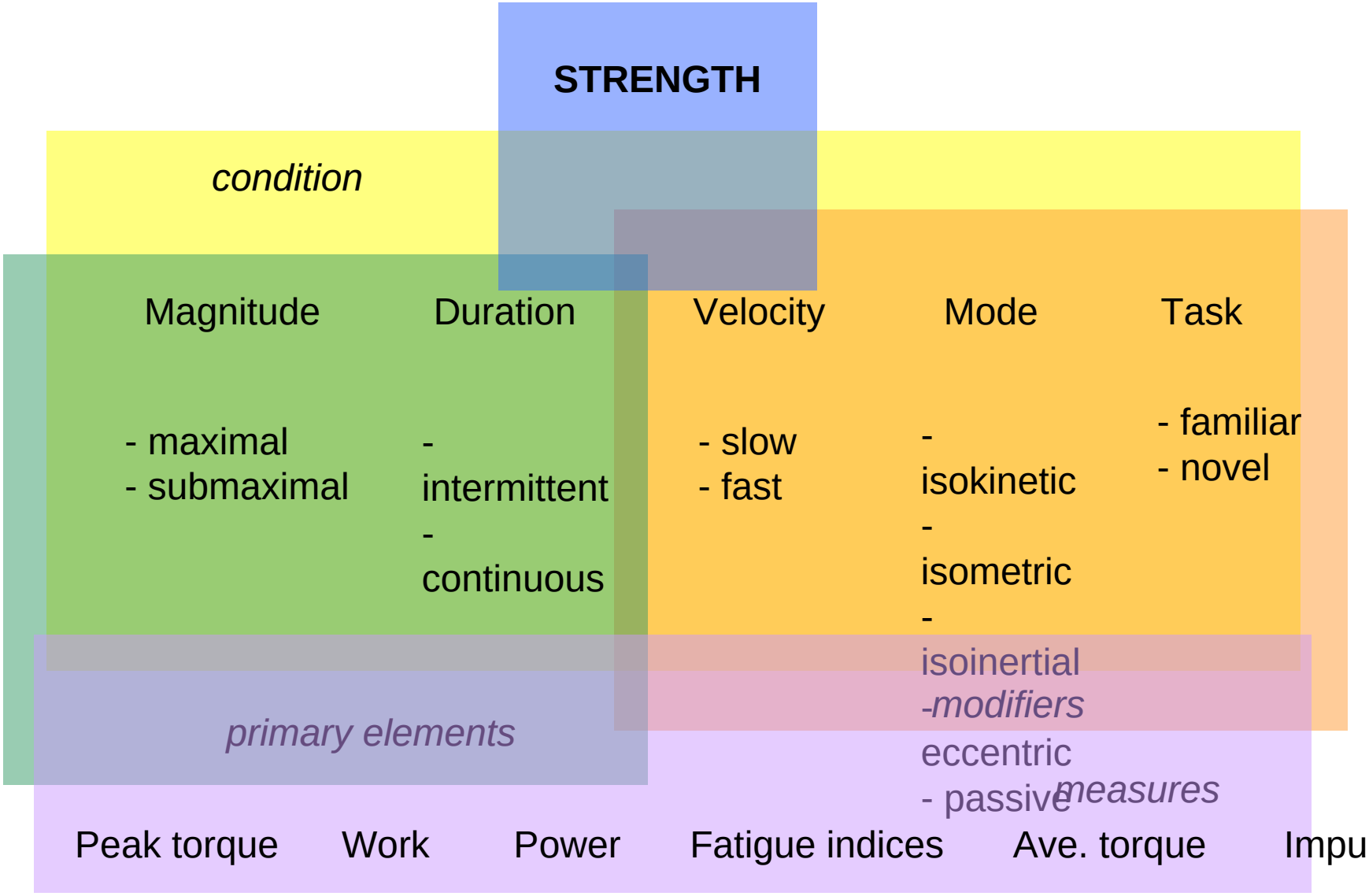
The Problem of Measuring Strength



Strength: Is it Just Peak Force?

- Harris and Watkins, 1993: the ability of skeletal muscle to develop force for stability and mobility…
- Buchner and de Lateur, 1991: maximum force exerted by a muscle… (depending on) intact neuromuscular function and … the condition of measurement
- Lieber, 1992: interaction between muscle and joint properties…torque is the product of muscle force and the joint moment arm

The Construct of Muscle Strength



Muscle Strength Assessment in IIM

- **Methods to assess muscle strength:**
  - Isometric Dynamometry
  - Isokinetic Dynamometry
  - Manual Muscle Testing

Muscle Strength Assessment in IIM

Microfet HHD

Biodex dynamometer

Jamar hydraulic grip dynamometer

QMT fixed dynamometer

Methods to Assess Muscle Strength

- **Isometric Dynamometry**
  - Hand held, fixed dynamometry, sphygmomanometry, etc.
  - Sensitive for all grades; good reliability
  - Depends on proper positioning, less dependent on technique; limited normative data; possible calibration errors
  - Moderate flexibility

Methods to Assess Muscle Strength

- **Isokinetic Dynamometry**
  - Biodex, Cybex, and other multi-mode dynamometers
  - Excellent stabilization; good reliability overall
  - Research tool; ↑ expense; not recommended for <3/5 strength
  - Less flexibility

Methods to Assess Muscle Strength

- **Manual Muscle Test**
  - Most commonly used method of strength assessment
  - Fair stabilization; partial validation for subjects with IIM; poor to good reliability (depending on methods, subjects, and testers)
  - ↓ expense; may be stature dependent for ≥ 4/5 strength
  - Most flexibility

Muscle Strength Assessment in IIM

The Manual Muscle Test (MMT):

Full or partial primary outcome measure in > 93% of IIM clinical trials

The History of the MMT

- Introduced by Wright and Lovett in 1912

(Wright, 1912; Hislop and Montgomery, 1995; Kendall, 1993)

The History of the MMT

- Important modifications by Daniels and Worthingham in 1946, and H. Kendall and F. Kendall in 1949

- F. Kendall advocated the “10-point MMT” (12-point scale) in 1993

(Wright, 1912; Hislop and Montgomery, 1995; Kendall, 1993)

MMT Reliability

Authors	Testers	Number of Subjects	Type of Subjects	Reliability Type	Results
Wadsworth et al,[3] 1987	1	11	ortho/neuro	intrarater	r = .67-1.00^
Frese et al,[4] 1987	11	110	various	**interrater**	κ_w = .11-58
Barr et al,[5] 1991	6	36	dystrophy	intrarater/**interrater** (balanced, incomplete block design)	ICC = .90^ ICC = .80-.96
Florence et al,[6] 1992	4	102	dystrophy	intrarater	κ_w = .65-.93^
Great Lakes ALS Group,[7] 2003	4	63	ALS	intrarater/**interrater**	CV = 2.4%^ CV = 4.4%
Jepsen et al,[8] 2004	2	41	ortho	**interrater**	κ_w = .25-.72
Jain et al,[9] 2005	4	9	JDM	intrarater/**interrater**	r = .70-1.00^ *W* = .51-.76

MMT Reliability

J Orthop Sports Phys Ther. 1997 Oct;26(4):192-9. Related Articles, Links

The ability of male and female clinicians to effectively test knee extension strength using manual muscle testing.

Mulroy SJ, Lassen KD, Chambers SH, Perry J.

s Amigos Medical Center, Downey, CA 90242,

f manual muscle testing is dependent on examiner
and female clinicians' upper extremity strength to
nd detect weakness in patients using manual muscle
n and 12 women with postpoliomyelitis were tested
while forces were recorded with a hand-held
ic knee extension force was recorded with a Lido
rtical push force was recorded with the hand-held
ces, patient maximum quadriceps forces, and
h repeated measures analysis of variance. Female
235.7 +/- 54.3 N) was not significantly different
imal quadriceps force (166.8 +/- 66.7 N and 341.6
of the isometric knee extension forces generated by
e examiners were significantly stronger (357.0 +/-
patients and produced 90% and 60% of the normal

Perceptual and Motor Skills, 1998, 87, 1123-1128.

SUBJECTIVITY OF FORCES ASSOCIATED WITH MANUAL-MUSCLE TEST GRADES OF 3+, 4−, AND 4[1]

CARYN KNEPLER AND RICHARD W. BOHANNON

University of Connecticut, Storrs

Summary.—This study examined the subjectivity of forces applied by 10 testers during simulated manual-muscle testing. Individual testers were able to modify appropriately the forces they applied for muscle test grades of 3+, 4−, and 4, that is, the forces rose concomitantly with the grades. Testers were consistent between trials in the forces they applied for each grade while testing each specific action. They varied, however, in the forces they applied for each grade during the testing of the two different muscle actions. Moreover, testers differed significantly from one another in the forces they applied for each manual muscle test grade (3+, 4−, and 4). If an individual's strength is to be monitored using manual-muscle testing, grades obtained by a single tester are recommended.

MMT Grade Conversion

MMT GRADES				
Normal	10	5	5.00	5
Good +	9	4 +	4.50	
Good	8	4	4.00	4
Good –	7	4 –	3.66	
Fair +	6	3 +	3.33	
Fair	5	3	3.00	3
Fair –	4	3 –	2.66	
Poor +	3	2 +	2.33	
Poor	2	2	2.00	2
Poor –	1	2 –	1.50	
Trace	T	1	1.00	1
Zero	0	0	0.00	0

(Kendall, 1993)

MMT Grade Conversion

MRC–Adaptation A(13)	
5	Normal strength
5-	Uncertain muscle weakness
4+	Inability to resist against maximal pressure throughout ROM
4	Ability to resist against moderate pressure throughout ROM
4-	Ability to resist against minimal pressure throughout ROM
3+	Ability to move through full ROM AG and resist against minimal pressure through partial ROM, then contraction breaks abruptly
3	Ability to move through full ROM AG
3-	Ability to move through > 50% ROM AG
2+	Ability to move through < 50% ROM AG
2	Ability to move through full ROM GE
2-	Ability to move in any arc of motion with GE
1	Visible or palpable muscle contraction
0	No contraction palpable

Kendall "10-point" Scale(4;24)	
10	Holds test position against strong pressure
n/a	
9	Holds test position against moderate to strong pressure
8	Holds test position against moderate pressure
7	Holds test position against slight to moderate pressure
6	Holds test position against slight pressure
5	Holds test position (no pressure)
4	Gradual release from test position
3	Moves through < 100% ROM AG, or through full ROM GE against resistance, or through full ROM GE and holds against resistance
2	Moves through full ROM GE
1	Moves through < 100% ROM GE
T	Visible or palpable muscle contraction
0	No contraction palpable

MMT Grade Conversion

MRC		Kendal	
2	Ability to move through full ROM GE	2	Moves through full ROM GE
2-	Ability to move in any arc of motion with GE	1	Moves through < 100% ROM GE
1	Visible or palpable muscle contraction	T	Visible or palpable muscle contraction
0	No contraction palpable	0	No contraction palpable

(Rider, Giannini, Harris-Love, et al 2003)

MMT Grade Conversion

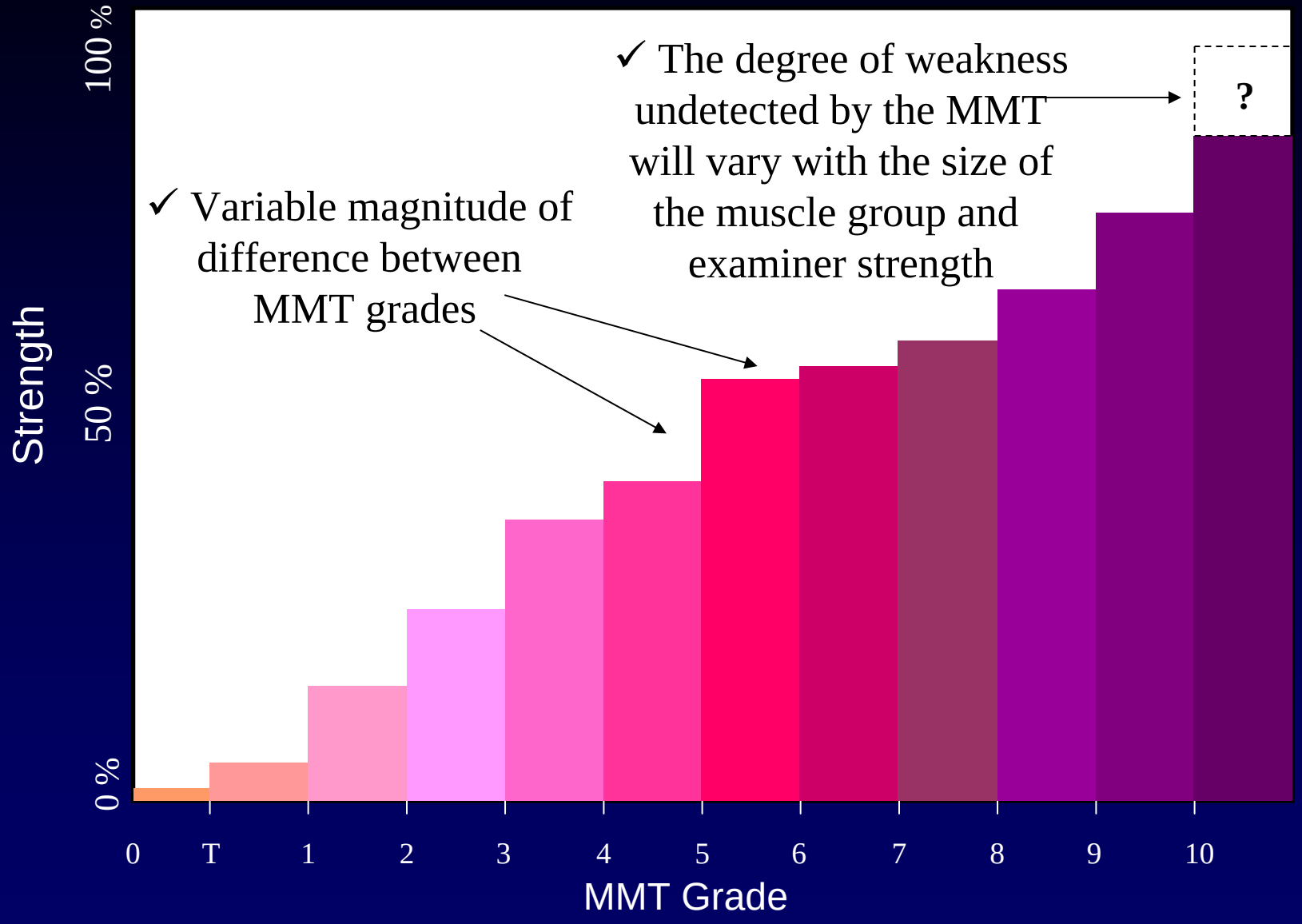
MRC		Kendal	
3+	Ability to move through full ROM AG and resist against minimal pressure through partial ROM, then contraction breaks abruptly	6	Holds test position against slight pressure
3	Ability to move through full ROM AG	5	Holds test position (no pressure)
3-	Ability to move through > 50% ROM AG	4	Gradual release from test position

(Rider, Giannini, Harris-Love, et al 2003)

The MRC and Kendall MMT Scales

- All modified British Medical Research Council (MRC) and Kendall MMT scales are not equivalent
- The MRC MMT: 6, 11, 12 or 13-interval scale; the Kendall MMT: 6 or 12-interval scale
- Differences in scoring criteria may include:
  - Application of resistance
  - ROM in horizontal plane
  - Isometric contraction vs AROM

Intervals Between MMT Grades are not Equivalent



(Based, in part, on Barr, 1991; Beasely, 1961; Divir, 1997)

Intervals Between MMT Grades are not Equivalent

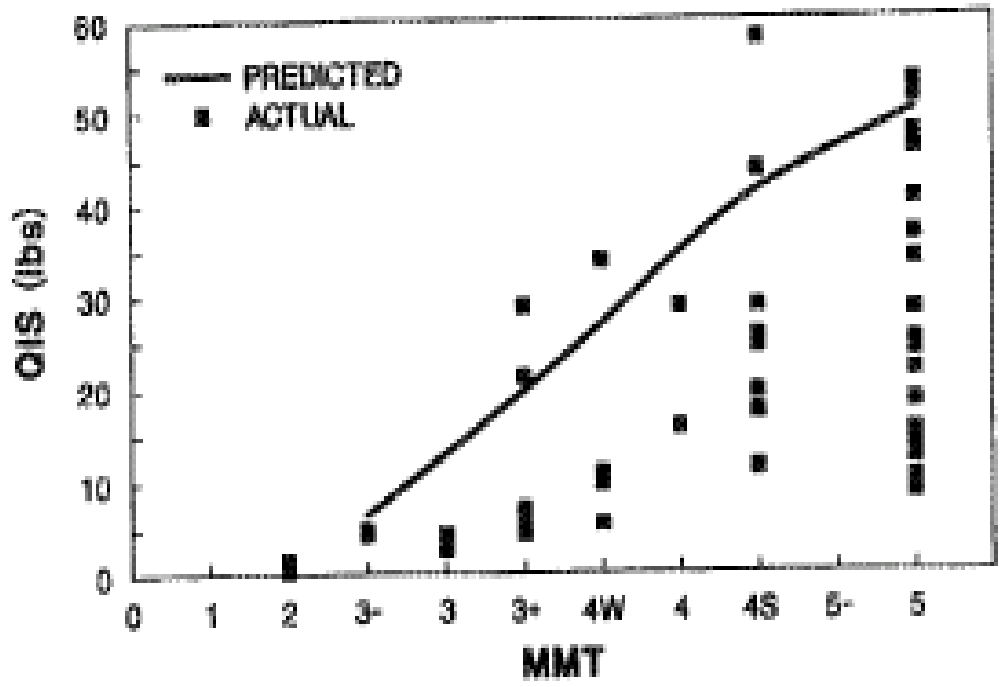
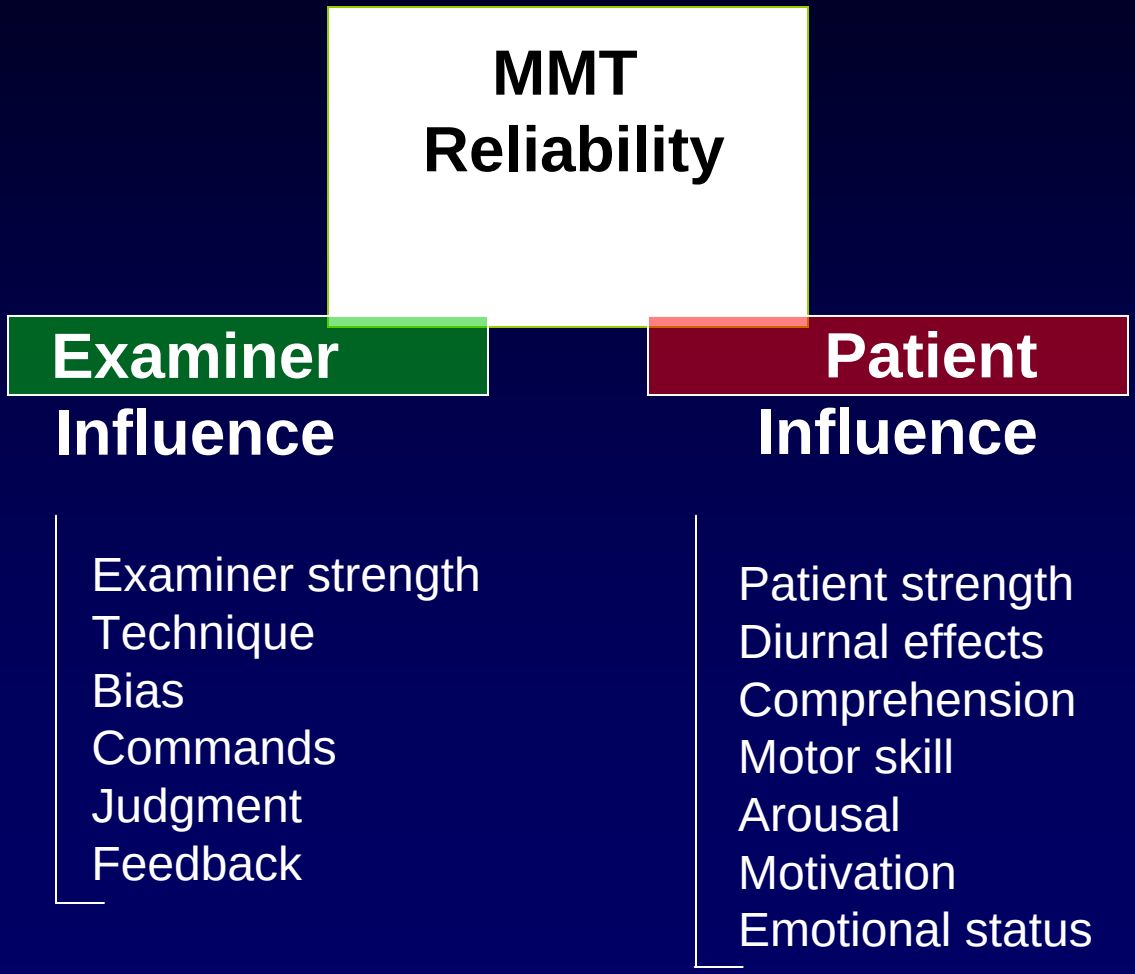


Figure 1. Knee extension: actual values of QIS in pounds versus MMT scores and Lowess curve of predicted values.

(Aitkens, 1989)

Influences on MMT Performance



(Hislop and Montgomery, 1995; Mulroy, 1997; Martin, 1999; K. Hinderer and S. Hinderer,1993)

	Criteria	Grade
no movement	No contraction detected	0
	Contraction detected without joint movement	T
test movement	**HORIZONTAL PLANE**	
	< 100% active range of motion	1
	100% active range of motion	2
	100% active range of motion against resistance – OR – completion of 100% active range of motion and then holds position against resistance	3
	“ANTIGRAVITY” POSITION	
	< 100% active range of motion	
test position	Gradual release from test position	4
	Hold test position	5
	Hold test position against slight resistance	6
	Hold test position against slight to moderate resistance	7
	Hold test position against moderate resistance	8
	Hold test position against moderate to strong resistance	9
	Hold test position against strong resistance	10

0

1

2

3

4

5

Potential testing error

lower *moderate* *higher*

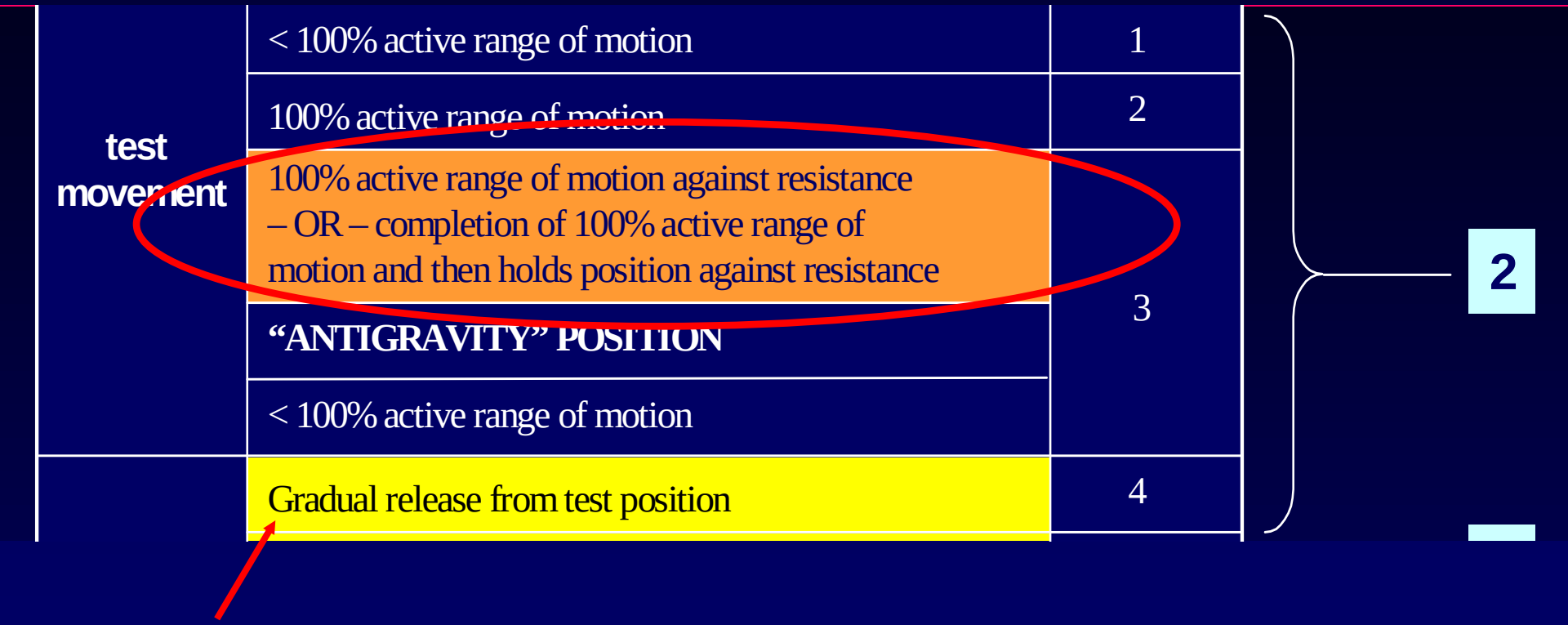
Kendall MMT Scale

	Criteria	Grade
no movement	No contraction detected	0
	Contraction detected without joint movement	T
	HORIZONTAL PLANE	
	< 100% active range of motion	1

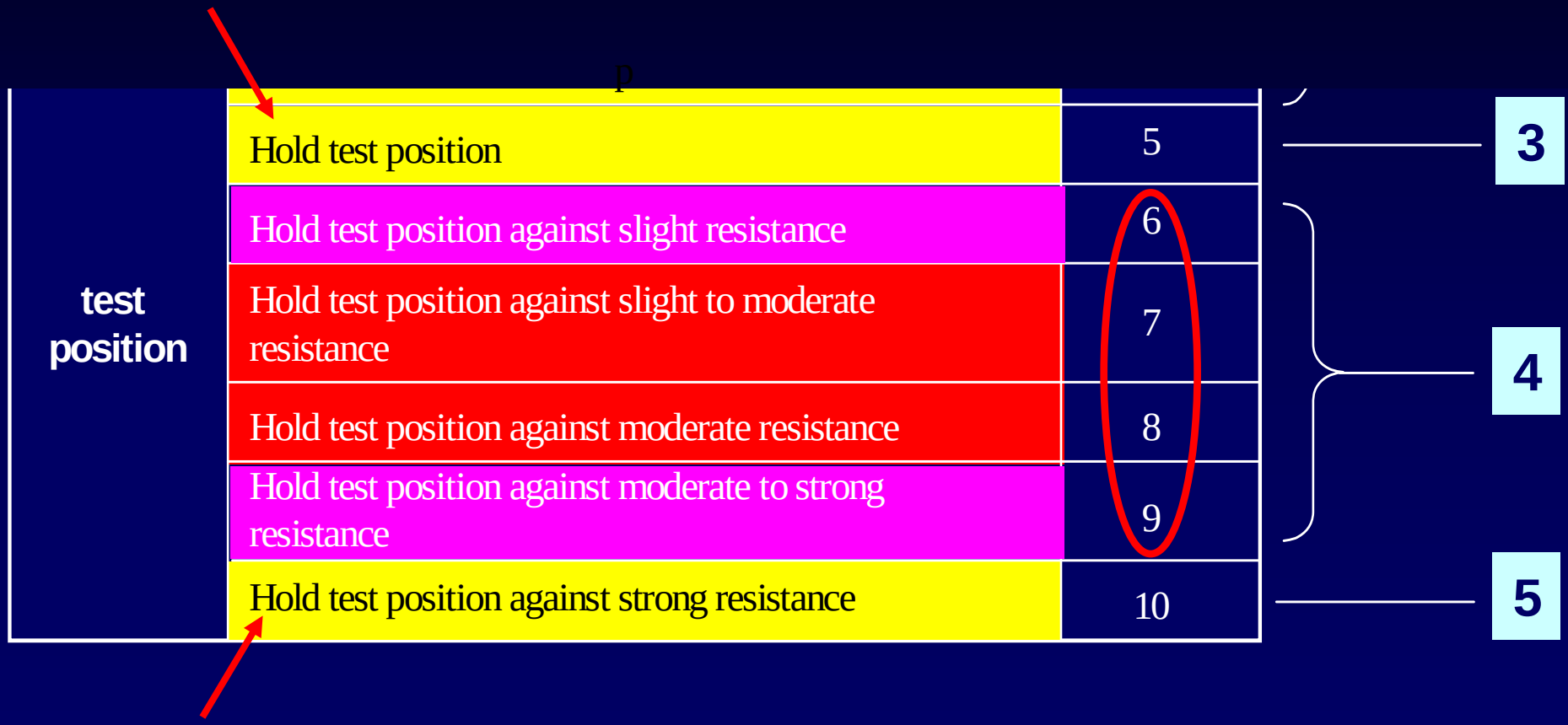
0

1

Kendall MMT Scale



Kendall MMT Scale



Kendall MMT Scale

Moves through complete range of motion	[illegible]	[illegible]	
ANTIGRAVITY POSITION	3	2+	
Moves through partial range of motion			
Gradual release from test position	4	3-	

Kendall MMT Grade Criteria Requiring Modification

- Grade 3: Degree of resistance undefined
- Grade 4: Length of time to hold test position undefined
- Grade 5: Time required to hold test position undefined
- Grades 6 - 10: Length of time to apply resistance undefined

Suggested MMT Modifications

- Grades: 0 – T
  - “Trace” may be assigned as “0” due to palpation skill → use experienced examiners
- Grade: 3
  - Degree of resistance not specified → use of the *antigravity* criterion for this grade is strongly encouraged

Suggested MMT Modifications

- Grade: 4
  - "Gradual release" not clearly defined $\rightarrow$ the descent from *testing position* to *resting position* should last $\geq$ 3 seconds
- Grade: 5
  - Length of "hold" not specified $\rightarrow$ use 3 seconds as criterion

Suggested MMT Modifications

- Grade: 6
  - All grade 5 muscle groups should be retested for grade 6 criterion $\rightarrow$ retest after $\geq$ 1 minute recovery time
- Grades: 6 - 9
  - Increased MMT precision may compromise grade specificity

    $\rightarrow$ use of single examiner strongly encouraged

    $\rightarrow$ strength/stature should be a key factor in determining back-up staff for the primary examiner

(Based, in part, on K. Hinderer and S. Hinderer, 1993)

Suggested MMT Modifications

- Grade: 10
  - MMT grades may be overestimated by examiners of small stature

    → avoid a gross mismatch of examiner and patient stature **(Mulroy, 1997)**

    → <u>all</u> MMT involving resistance should have *force application* lasting 3 seconds

  - Suggested positioning and stabilization for all MMT adapted from the Daniels & Worthingham text (6th ed.)

Suggested MMT Modifications

MMT Considerations to Promote Reliability

MMT Grades (0 – 10 scale)	Comments
0 – T	Palpation skill may confound the distinction between the "0" and "T" score; use trained and experienced clinicians.
1 – 2	Adjust range of motion criterion to accommodate for muscle contractures.
3	This grade can only be assigned to muscles tested in the standard (against gravity) testing position.
4	Gradual descent from testing position to resting position should last at least 3 seconds
5	Test position should be held for 3 seconds
3 – 5	MMT grades in this range should be re-tested for the next highest grade after 60 seconds of recovery time.
6 – 10	MMT grades in this range are heavily influenced by the stature of the subject and tester. Attempt to use back-up testers of a similar stature to the primary tester. All MMT in this range should involve a force application time of 3 seconds.

Summary

- Designations for the MMT score are relatively unimportant – the grading criteria are more critical
- Use of the total MMT score (or subscores) is recommended
- Comprehensive operational definitions for grading criteria need to be refined and validated to obtain reproducible MMT scores