Beyond Isolated Testing

Integrated Lower Limb Assessment with Isoforce

From Single-Joint Data to Whole-Limb Functional Insights

A Comprehensive White Paper for Evidence-Based Clinical Practice

Executive Summary

The traditional approach of assessing individual joints in isolation has reached its limitations in modern sports medicine and rehabilitation. While single-joint isokinetic testing provides valuable baseline data, it fails to capture the complex interdependencies that drive real-world movement and performance.

This white paper presents a paradigm shift toward integrated lower limb assessment using the Isoforce system, supported by emerging scientific evidence that demonstrates the critical importance of kinetic chain evaluation. Recent research confirms that isokinetics remains the gold standard for objectively determining dynamic muscle strength, power, rate of force development, and endurance, yet the clinical community increasingly recognizes that optimal outcomes require assessment of the entire kinetic chain rather than isolated joints.

The Clinical Challenge

This comprehensive approach addresses the growing challenge of suboptimal return-to-sport rates and re-injury statistics that plague current rehabilitation protocols. By integrating ankle, knee, and hip assessments, clinicians can identify the "weakest link" in the kinetic chain, leading to more targeted interventions and improved patient outcomes.

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1. The Limitations of Isolated Joint Assessment

The Traditional Paradigm

For decades, isokinetic testing has focused on individual joint assessment, providing clinicians with joint-specific insights including torque curves, strength ratios, fatigue indices, and work capacity. While these measurements offer valuable data points, they represent only fragments of the complete functional picture.

Multi-joint isotonic tests like the leg press or squat may demonstrate a performance weakness, but because multiple muscle groups are being used in the movement, the actual point of weakness and degree of deficit within the kinetic chain are difficult to truly isolate.

Why Athletes Don't Move in Isolation

Athletes and patients don't perform in isolation—they function as integrated systems. A knee hamstring-to-quadriceps (H/Q) ratio within normal limits doesn't guarantee safe return-to-sport if hip extensors are weak. Similarly, an ankle plantar flexion deficit can undermine running economy even when knee extension strength appears adequate.

Biomechanical Reality: During sprint acceleration, the hip contributes approximately 45-50% of total limb power, the knee 30-35%, and the ankle 15-20%. A deficit in any single contributor forces compensatory patterns that can overload other segments and predispose to injury.

The Clinical Challenge

Current return-to-sport protocols demonstrate concerning statistics:

44%

Athletes with functional deficits at return-to-sport clearance

↑

Re-injury rates remain suboptimal despite surgical advances

?

Traditional criteria fail to identify complex movement dysfunction

These challenges underscore the urgent need for assessment protocols that capture the interdependent nature of human movement.

2. Scientific Foundation for Integrated Assessment

Evidence-Based Rationale

Recent research emphasizes that it is important to assess the muscle's performance in each link of the kinetic chain to determine if any isolated weaknesses exist. This perspective aligns with mounting evidence that movement deficits rarely exist in isolation.

Kinetic Chain Research

The kinetic chain function demands neuromuscular, sensorimotor, and neurocognitive control. Any blockage or defect in the kinetic chain can develop compensatory patterns, high demands on distal parts, and overuse and overload injuries.

Historical Context: The kinetic chain concept, originally introduced by Franz Reuleaux in 1875, proposed that rigid, overlapping segments were connected via joints, creating a system whereby movement at one joint produced or affected movement at another joint in the kinetic link.

2. Scientific Foundation for Integrated Assessment

Modern Application

The kinetic link principle describe show the human body can be considered in terms of a series of interrelated links or segments. Movement of one segment affects segments both proximal and distal to the first segment. This foundational understanding drives the need for assessment protocols that evaluate these interconnections rather than treating each joint as an independent entity.

Bilateral Asymmetry Considerations

Strength asymmetry, defined as a lack of equality between limbs or muscle groups, has been the topic of interest for various studies over recent years, particularly in strength and conditioning literature, due to the effect of asymmetry on injury and performance.

Research Finding: Recent research identified a significant correlation between lower limb functional imbalance and sports injuries in volleyball players. A bilateral asymmetry exceeding 10-15% was associated with an increased risk of injury.

3. The Kinetic Chain: Understanding Functional Interdependence

Biomechanical Principles

The lower limb kinetic chain operates as a coordinated system where force generation, absorption, and transfer occur through integrated muscle actions. Understanding these relationships is crucial for effective assessment and intervention.

Sprint Power Distribution

45-50%
POWER

Hip

The powerhouse of athletic performance

→

30-35%
POWER

Knee

Primary shock absorber and force transmitter

→

15-20%
POWER

Ankle

Foundation and final link in force transmission

Hip-Knee-Ankle Interaction

Hip Function

The powerhouse of athletic performance, the hip generates the majority of propulsive force during sprinting, jumping, and cutting maneuvers. Hip extension strength directly correlates with sprint speed, jump height, and change-of-direction ability.

Knee Function

Serving as the primary shock absorber and force transmitter, the knee must maintain stability while allowing controlled motion. The hamstring-to-quadriceps ratio remains critical for ACL protection and functional performance.

Ankle Function

Often overlooked, the ankle provides the foundation for movement and serves as the final link in force transmission to the ground. The calf muscle-tendon unit of the ankle plays an important role in basic human movement activities, such as balance control while standing and the enhancement of walking effectiveness.

Regional Interdependence

Regional interdependence is the concept that seemingly unrelated impairments in a remote anatomical region may contribute to, or be associated with an area of pain. For example, clients who complain of low back pain or discomfort may actually be suffering from dysfunction at the ankle, hip or knee joints.

Clinical Implication: This concept reinforces the necessity of comprehensive assessment protocols that evaluate the entire kinetic chain rather than focusing solely on the site of pain or dysfunction.

4. Isoforce Integration Protocol: Building Blocks

When combining ankle, knee, and hip testing with the Isoforce system, several key parameters provide insight into kinetic chain function:

Core Assessment Parameters

Peak Torque Integration

- **Joint-specific maximum strength** measurement
- **Total limb output calculation:** Hip + Knee + Ankle = Composite Strength
- **Bilateral comparison** with target deficit <10%
- **Joint contribution analysis** to identify strength distribution patterns

Work Capacity Assessment

- **Total energy production measured** in Joules across the testing sequence
- **Endurance profiling** to identify volume-related deficits
- **Fatigue resistance** evaluation across multiple repetitions
- **Cross-joint endurance comparison** to identify rate-limiting factors

Power Output Analysis

- **Peak rate of work production** essential for explosive movements
- **Joint contribution mapping** (Hip dominance in sprinting, ankle efficiency in jumping)
- **Power distribution asymmetries** that may indicate compensation patterns
- **Velocity-specific power curves** across the testing spectrum

Fatigue Index Integration

- **Progressive torque decline** measurement across repetitions
- **Systemic vs. localized fatigue** identification
- **Joint-specific fatigue resistance** comparison
- **Late-stage performance maintenance** assessment

Testing Velocity Protocols

Based on current research and clinical best practices, the following velocity spectrum provides comprehensive assessment:

30-60°/s Maximum strength and load tolerance assessment

120-180°/s Functional speed approximating activities of daily living and moderate sports activities

240-300°/s High-velocity performance simulating sport-specific demands

Research Support: Recent research investigating the relationship between knee flexion-extension strength ratios and lower limb stiffness during jumping utilized velocities of 60°/s, 150°/s, and 240°/s, demonstrating the importance of multi-velocity assessment.

5. Clinical Implementation: From Theory to Practice

The Isoforce Limb Profile Development

The integration of multi-joint assessment data creates a comprehensive "Isoforce Limb Profile" that transforms isolated measurements into actionable clinical insights:

1 Total Torque Symmetry Index

```
(Hip + Knee + Ankle
Peak Torque)
Left vs. Right
```

Target: <10% difference between limbs
Clinical Significance: Identifies global limb strength deficits that may not be apparent in single-joint testing

2 Work Endurance Profile

Assessment: Total Joules per limb across standardized repetition scheme

Analysis: Progressive work decline evaluation (fatigue index)
Application: Identifies endurance limitations that may predispose to late-game or end-of-season injuries

3 Power Contribution Mapping

Distribution Analysis: Relative contribution of each joint to total limb power

Sport-Specific Benchmarks:

Sprint athletes: Hip 45-50% Knee 30-35%, Ankle 15-20%
Jump athletes: More balanced distribution with enhanced ankle contribution
Endurance athletes: Emphasis on sustained power across all joints

4 Fatigue Adjusted Symmetry

Dynamic Symmetry: Assessment of bilateral balance throughout testing sequence
Progressive Analysis: Symmetry maintenance from repetition 1through completion

Clinical Value: Identifies neuromuscular control deficits that emerge under fatigue

6. Case Studies: Real-World Applications

Case Study 1: Post-ACL Reconstruction Elite Soccer Player

Background

22-year-old professional soccer midfielder, 8months post-ACL reconstruction with hamstring autograft.

Traditional Assessment: ✓ Cleared

- Knee extension torque: 95% of uninvolved limb
- H/Q ratio: 72% (within normal limits) ✓
- Cleared for return-to-sport based on isolated knee assessment

100%

Uninvolved Limb

Integrated Isoforce Assessment: ✗ Significant Deficits

- Total LimbTorque: Involved limb showed 18% deficit
- Power Distribution: Hip contribution reduced from expected 45% to 35%
- Fatigue Analysis: Accelerated decline in hip extensor work after repetition 6

82%

Involved Limb

18% deficit

Clinical Insight: Despite adequate knee strength recovery, significant hip weakness remained undetected by traditional assessment, creating compensatory patterns that increased re-injury risk.
Intervention: 6-week hip-focused strengthening protocol with progressive loading.
Outcome: Re-assessment demonstrated restoration of normal power distribution and total limb symmetry before return-to-sport clearance.

Case Study 2: Chronic Ankle Instability in Distance Runner

Background

28-year-old recreational marathon runner with history of recurrent lateral ankle sprains and current medial tibial stress.

Traditional Assessment

- Ankle plantarflexion strength: 88% of uninvolved side
- Ankle dorsiflexion: Within normal limits
- Lower legpainattributed to overuse

Integrated Isoforce Assessment

Work Endurance: Ankle plantar flexor work capacity decreased 25% after 10 repetitions

Compensation Pattern: Increased knee flexor contribution (+8%) and hip flexor work (+12%)

Bilateral Asymmetry: 15% total limb work deficit on involved side

Clinical Insight: Ankle plantar flexor endurance deficit created kinetic chain compensation, increasing stress on the tibialis posterior and contributing to medial tibial symptoms.

Intervention: Progressive ankle endurance training with kinetic chain strengthening

Outcome: Resolution of shin symptoms and normalized endurance patterns within 8 weeks.

Case Study 3: Elite Sprinter Performance Optimization

Background

24-year-old national-level 100m sprinter seeking performance enhancement.

Traditional Assessment

- All individual joint measures within normal limits
- No reported symptoms or functional deficits

Integrated Isoforce Assessment

Power Distribution: Left leg showed altered contribution pattern

- Hip: 38% (expected 45-50%)
- Knee: 42% (expected 30-35%)
- Ankle: 20% (expected 15-20%)

Total Power: 8% bilateral asymmetry

Fatigue Resistance: Premature hip extensor fatigue on left side

Clinical Insight: Subtle but significant power distribution asymmetry explained consistent sprint mechanics asymmetry observed by coaching staff.

Intervention: Unilateral hip strengthening with emphasis on power endurance Outcome: Personal best improvement of 0.08 seconds following 10-week intervention.

Case Study 4: Return-to-Sport Following Hip Arthroscopy

Background

26-year-old professional basketball player, 4 months post-hip arthroscopy for femoroacetabular impingement.

Traditional Assessment

- Hip flexion strength: 92% of uninvolved side
- Pain-free range of motion restored
- Functional movement screen: Normal

Integrated Isoforce Assessment

Hip Power Output: 22% deficit at high velocities (240°/s)

Compensation Pattern: Increased ankle plantarflexor contribution (+15%)

Endurance Deficit: Significant hip flexor fatigue after repetition 8

Clinical Insight: While basic strength had recovered, power endurance deficits remained that would impact late-game performance and increase injury risk.

Intervention: Progressive power endurance protocol with sport-specific velocity training

Outcome: Full competitive return with normalized power endurance profiles.

7. Bilateral Asymmetry: The Hidden Performance Limiter

Understanding Asymmetry in Athletic Populations

Bilateral force asymmetries generally less than10% have been reported amongst individual and team-sport collegiate athletes during a series of tests. However, normative jump height asymmetries of 10-15% have been reported in male and female basketball and volleyball players.

The Asymmetry Paradox

Recent research challenges traditional assumptions about bilateral asymmetry. Asymmetry is prevalent across several sports regardless of age, gender, or competitive level, and can be verified even in apparently symmetric actions (e.g., running and rowing).

Important Finding: Cross-sectional studies should be taken with a pinch of salt, since the relationships between inter limb asymmetry (magnitude and direction) and performance are not necessarily consistent across a sports season.

Clinical Thresholds and Considerations

Traditional Thresholds

<10%

Generally Acceptable

10-15%

Warrants Attention

>15%

Requires Intervention

Modern Perspective: A more recent perspective questions the use of pre-determined thresholds due to the task-, metric- and population-specific nature of asymmetry.

Integrated Assessment Advantages

The Isoforce integrated approach provides several advantages in asymmetry assessment:

1. **Comprehensive Asymmetry Profiling:** Rather than relying on single-joint measurements, the system evaluates asymmetry across the entire kinetic chain.
2. **Context-Specific Analysis:** Asymmetry patterns are evaluated in the context of sport-specific demands and individual movement patterns.
3. **Dynamic Asymmetry Assessment:** Fatigue-induced changes in asymmetry patterns are captured, providing insight into neuromuscular control under challenge.
4. **Intervention Targeting:** Unilateral plyometric training effectively reduces lower limb asymmetry in athletes, with prioritization of unilateral training to improve athletes' lower limb asymmetry.

Case Example: Basketball Player Asymmetry Management

A 19-year-old collegiate basketball player presented with no symptoms but demonstrated significant asymmetry patterns during integrated assessment:

Findings

- **Total limb power asymmetry:** 12%
- **Hip contribution asymmetry:** 18%
- **Fatigue-induced asymmetry increase:** Progressive worsening to 20% by repetition 10

Intervention Strategy

- Unilateral hip strengthening emphasizing the weaker side
- Progressive fatigue resistance training
- Bilateral movement re-education

Outcome: Asymmetry reduced to 6% with maintained symmetry under fatigue conditions.

8. Return-to-Sport Decision Making

Current Challenges in RTS Protocols

Evidence-based quadriceps femoris muscle strength guidelines for return to sport following ACL reconstruction are lacking. Traditional protocols rely heavily on single-joint criteria that may miss critical functional deficits.

Alarming Statistic: Recent studies show that 44% of athletes had greater than 15% strength deficits compared to the uninjured limb at the time of return to sport clearance.

Integrated Assessment for RTS

The Isoforce integrated approach transforms return-to-sport decision making through:

Comprehensive Strength Assessment

- **Total Limb Strength Index:** ≥90% of uninvolved limb
- **Joint-Specific Criteria:** Individual joint standards maintained within integrated context
- **Power Distribution:** Restoration of sport-specific contribution patterns

Functional Integration Criteria

- **Kinetic Chain Coordination:** Synchronized force production across joints
- **Fatigue Resistance:** Maintenance of strength and coordination under challenge
- **Movement Quality:** Integration of strength with movement patterns

Progressive Return Protocol

Phase 1: Strength Restoration (≥85% total limb strength)

- Basic strength criteria met
- Joint-specific ratios normalized
- No pain or swelling

Phase 2: Power Integration (≥90% total limb power)

- Sport-specific velocity criteria met
- Power distribution normalized
- Fatigue resistance demonstrated

Phase 3: Functional Integration (≥95% total limb function)

- Movement quality assessment
- Sport-specific task performance
- Confidence and psychological readiness

Clinical Decision Tree

Criteria Type	Traditional RTS	Integrated Isoforce
Strength	Knee extension ≥90%	Total limb strength ≥90%
Ratios	H/Q ratio 60-80%	All joint ratios + power distribution
Symmetry	Hop test symmetry ≥90%	Fatigue-adjusted symmetry ≥90%
Timeline	Time-based milestones	Kinetic chain coordination confirmed
Safety	Single checkpoint	Multiple validation checkpoints

Enhanced Safety Profile: The integrated approach provides multiple checkpoints that must be satisfied before clearance, reducing the risk of premature return and subsequent re-injury.

Validation Studies

Emerging research supports the superiority of integrated assessment approaches:

Research Finding: Individuals with the largest quadriceps strength deficits demonstrate greater asymmetry in sagittal plane knee joint mechanics during landing compared to those with minimal strength deficits. This finding supports the concept that isolated strength deficits contribute to kinetic chain dysfunction, reinforcing the need for comprehensive assessment protocols.

9. Clinical Implementation Protocols

Standardized Testing Sequence

Pre-Testing Preparation(10 -15minutes)

1 Medical Screening

- Contraindications assessment
- Current pain levels (0-10 scale)
- Recent exercise history (24-48 hours)
- Medication status

2 Warm-up Protocol

- 5minutes stationary cycling at 60-70% age-predicted maximum heart rate
- Dynamic stretching sequence (hip circles, leg swings, ankle circles)
- 3-5 submaximal practice repetitions on Isoforce system

3 System Calibration

- Gravity compensation for each joint
- Range of motion settings verification
- Patient positioning optimization
- Safety parameter confirmation

Testing Sequence Protocol

Hip Assessment (15-20 minutes)

- **Position:** Seated with 90° hip flexion, stabilization straps applied
- **Range of Motion:** 10° extension to 90° flexion
- **Velocity Sequence:** 60°/s (5 reps), 180°/s (10 reps), 300°/s (15 reps)
- **Rest Intervals:** 60 seconds between velocities, 120 seconds between limbs
- **Parameters Recorded:** Peak torque, work, power, fatigue index

Knee Assessment (15-20 minutes)

- **Position:** Seated with. 85-90° hip flexion
- **Range of Motion:** 90° flexion to 0° (full extension)
- **Velocity Sequence:** 60°/s (5 reps), 180°/s (10 reps), 300°/s (15 reps)
- **Critical Ratios:** H/Q ratio calculation at each velocity
- **Bilateral Comparison:** LSI calculation for all parameters

Ankle Assessment (10-15 minutes)

- **Position:** Seated with knee at 0°extension
- **Range of Motion:** 20° dorsiflexion to 50° plantarflexion
- **Velocity Sequence:** 30°/s (5 reps), 120°/s (10 reps), 240°/s (15 reps)
- **Focus Areas:** Plantarflexor endurance, dorsiflexor / plantarflexor ratio

Data Integration Formulas

Total Limb Strength Index (TLSI)

TLSI = (Hip Peak Torque + Knee Peak Torque + Ankle Peak Torque) / Body Weight

Bilateral Asymmetry Index (BAI)

BAI = |(Stronger Limb - Weaker Limb) / Stronger Limb| × 100

Power Distribution Coefficient (PDC)

Hip PDC = Hip Power / Total Limb Power × 100

Knee PDC = Knee Power / Total Limb Power × 100

Ankle PDC = Ankle Power / Total Limb Power × 100

Fatigue-Adjusted Symmetry Index (FASI)

FASI = (Final 3 reps average / Initial 3 reps average) × 100

Normative Reference Values

Sport-Specific Power Distribution Targets

Sport Category	Hip Contribution	Knee Contribution	Ankle Contribution
Sprinting	45-50%	30-35%	15-20%
Jumping Sports	40-45%	35-40%	20-25%
Endurance Running	35-40%	35-40%	25-30%
Team Sports	42-47%	32-37%	18-23%

Age-Adjusted Bilateral Asymmetry Thresholds

Age Group	Acceptable (<)	Monitor (%)	Intervene (>)
16-25 years	8%	8-12%	12%
26-35 years	10%	10-15%	15%

Age Group	Acceptable (<)	Monitor (%)	Intervene (>)
36-45 years	12%	12-18%	18%
45+ years	15%	15-20%	20%

10. Conclusion: Transforming Clinical Practice

The Paradigm Shift

The evolution from isolated joint assessment to integrated kinetic chain evaluation represents a fundamental shift in clinical practice. This transformation is driven by compelling evidence that human movement cannot be understood through the lens of individual joint function alone.

Despite the limitations of cost and availability, isokinetics remains an integral part of the successful formula to assess muscular strength, power, and endurance in an objective manner. The Isoforce system extends this capability by providing the technological platform necessary for comprehensive kinetic chain assessment.

Clinical Impact

The integrated assessment approach addresses critical gaps in current practice:

Enhanced Injury Prevention

- Identification of subtle kinetic chain dysfunction before injury occurs
- Comprehensive asymmetry assessment across multiple parameters
- Fatigue-resistant movement pattern evaluation

Improved Rehabilitation Outcomes

- Targeted intervention based on kinetic chain analysis
- Objective monitoring of functional restoration
- Evidence-based return-to-sport decision making

Performance Optimization

- Sport-specific power distribution analysis
- Identification of performance-limiting factors
- Data-driven training modifications

Economic Considerations

While the initial investment in comprehensive assessment capabilities may appear substantial, the long-term benefits include:

Reduced Re-injury Rates

Lower healthcare costs through more effective initial rehabilitation

Enhanced Performance

Improved competitive success and career longevity

Patient Satisfaction

Evidence-based care with objective monitoring

Professional Edge

Advanced capabilities that distinguish clinical practice

Implementation Recommendations

For Clinical Practitioners

1. **Training Investment:** Comprehensive education in kinetic chain principles and assessment interpretation
2. **Protocol Development:** Standardized assessment procedures for consistent results
3. **Integration Planning:** Incorporation of kinetic chain assessment into existing workflows
4. **Outcome Monitoring:** Systematic tracking of improved patient outcomes

For Healthcare Administrators

1. **Strategic Planning:** Long-term investment in advanced assessment capabilities
2. **Staff Development:** Support for clinician education and certification
3. **Quality Metrics:** Tracking of return-to-sport success and re-injury rates
4. **Market Positioning:** Leveraging advanced capabilities for competitive advantage

Future Opportunities

The field of integrated kinetic chain assessment continues to evolve rapidly. Healthcare providers who invest in comprehensive assessment capabilities position themselves at the forefront of evidence-based practice.

Emerging Opportunities

Research Collaboration

Participation in multi-center outcomes studies

Technology Development

Partnership in advancing assessment methodologies

Education Leadership

Training the next generation of clinicians

Standard Setting

Contributing to clinical guidelines development

The TUR Isoforce Advantage

TUR's commitment extends beyond providing advanced technology to supporting clinicians in transforming their practice. The Isoforce system provides:

- **Technological Excellence:** State-of-the-art hardware and software for comprehensive assessment
- **Educational Support:** Comprehensive training programs and ongoing education
- **Clinical Integration:** Seamless incorporation into existing practice workflows
- **Research Platform:** Participation in advancing the science of kinetic chain assessment

The Bottom Line

Athletes don't move in isolation, and neither should our assessments. The integrated Isoforce approach transforms rehabilitation from guesswork into evidence-based precision —identifying the hidden deficits that traditional testing misses and protecting athletes from preventable re-injury.

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Important Disclaimers and Limitations

Commercial Disclosure

This white paper is prepared and published by TUR, the manufacturer and distributor of Isoforce isokinetic dynamometry systems. TUR has a commercial interest in promoting the use of isokinetic assessment technology. While this document is based on peer-reviewed research and evidence-based practice principles, readers should consider this commercial relationship when evaluating the recommendations presented.

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This document is intended for educational purposes only and does not constitute medical advice, diagnosis, or treatment recommendations. The information presented should be used by qualified healthcare professionals as part of their clinical decision-making process, in conjunction with their professional judgment, patient assessment, and adherence to institutional protocols.

Individual clinical decisions should always consider:

- Patient-specificfactors and medical history
- Current symptoms and functional status
- Institutional protocols and guidelines
- Professional scope of practice limitations
- Contraindications and safety considerations

Research and Evidence Limitations

While this white paper cites peer-reviewed research and established clinical practices, readers should note:

- Research findings may not apply to all patient populations
- Individual variations in response to assessment and intervention exist
- Emerging research may modify or contradict current recommendations
- Clinical outcomes cannot be guaranteed
- Additional research is needed in many areas discussed

Professional Responsibility

Healthcare professionals using this information are responsible for:

- Ensuring appropriate training and competency before implementing protocols
- Adapting recommendations to their specific clinical context
- Maintaining current knowledge through continuing education
- Following institutional policies and procedures
- Obtaining appropriate informed consent from patients
- Recognizing limitations of their scope of practice

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