THE NEED FOR STANDARDIZED PAIN MEASUREMENTS IN ORTHOPAEDIC BIOMECHANICS RESEARCH: A Systematic Review of the Hand Osteoarthritis Literature

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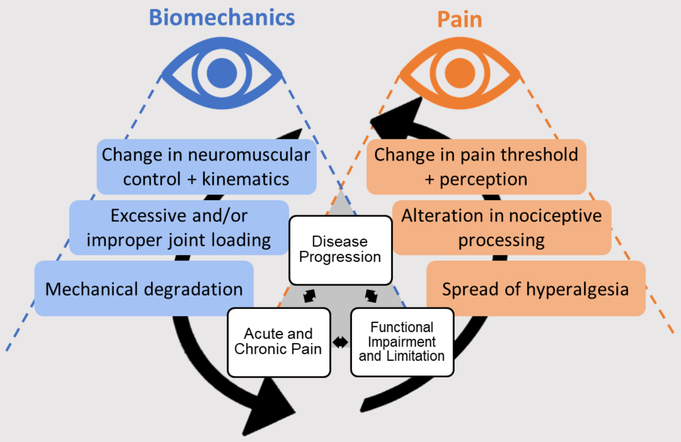
Motivation

Musculoskeletal research is multidisciplinary, with biomechanists and pain scientists comprising the majority.

Biomechanics studies:
- ✓ Focus on understanding movement adaptations
- X Fail to acknowledge and address the key role pain plays in modulating movement

Pain studies:
- ✓ Assess and monitor somatosensory neuropathies and other pain disorders
- X Do not routinely include movement and force analyses

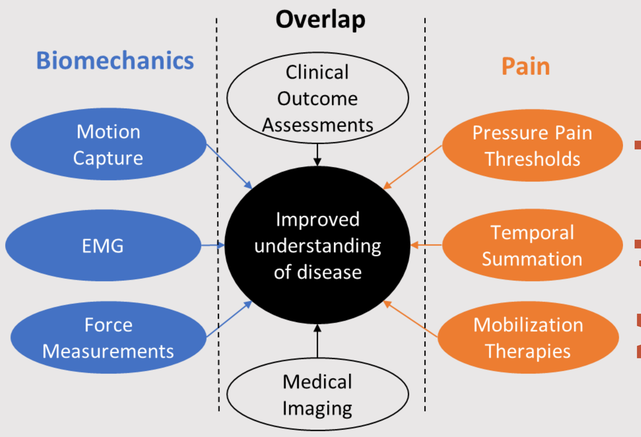


Merging biomechanics and pain measurements can provide insight into:
- (a) effect of pain sensitization on treatment responses[1]
- (b) mechanisms of postoperative pain[2]
- (c) differences between pain at rest and movement-evoked pain[3-4]

Osteoarthritis (OA) is a widely studied musculoskeletal disease in both fields with an overarching consensus that structural changes in musculoskeletal system do not correlate directly with pain or function[5-6]

Hand OA was selected as a representative field of study as methodology to characterize pain and biomechanics is similar across joints; hand OA also presented a feasible scope for capturing relevant articles

OBJECTIVE: This review aims to provide background on current quantitative pain methods, describe the need for standardization within and across the biomechanics and pain fields, and provide suggestions for using pain research methods to elucidate the complex mechanisms behind diseases such as hand OA.



Methods

Inclusion Criteria

Each study had to:
(a) Be written in English in a peer-reviewed publication

Biomechanics
(b) Measure muscle activity, kinematics, or a kinetic parameter other than clinical metrics of strength (i.e., grip or pinch strength)

Pain
(c) Include quantitative pain measurement (e.g., quantitative sensory testing)

Search Term Categories

(a) "osteoarthritis" or "OA", AND
(b) Joint type (e.g., "carpometacarpal", "trapeziometacarpal"), AND
(c) Methods (e.g., "motion capture", "pressure pain threshold")

Electronic Database Search

PubMed and Web of Science

Identification

Biomechanics
Web of Science(*n = 249*)
PubMed (*n = 209*)

Pain
Web of Science (*n = 139*)
PubMed (*n = 112*)

Screening

Biomechanics
Duplicates removed (*n = 290*)
Excluded based on abstract (*n = 138*)
Excluded based on full article (*n = 10*)

Pain
Duplicates removed (*n = 165*)
Excluded based on abstract (*n = 58*)
Excluded based on full article (*n = 2*)

Literature Grouping

Biomechanics
Grouped based on experimental methods and the extent to which pain was measured and/or discussed

Pain
Grouped based on the purpose of the study, pain measurements performed, and inclusion of strength measurements

Included

Biomechanics
Total (n = 20)
Kinematics (*n = 15*)
Kinetics (*n = 7*)
EMG (*n = 3*)

Pain
Total (n = 26)
Treatment (*n = 15*)
Characterization of Pain (*n = 11*)

Data Extraction

(a) Patient demographics
(b) Joint affected by OA
(c) OA diagnostic method
(d) Strength measurements and type (e.g., grip, tripod pinch, tip pinch, etc.)
(e) Pain screening scores (e.g., visual analog scale or numeric rating scale)
(f) Other types of clinical outcome assessments used

Results and Interpretation

Patients included in the biomechanics studies were younger and healthier than the patients in the pain studies

	Age	Sex	Lateral Pinch Strength (N)	Tip Pinch Strength (N)	Tripod Pinch Strength (N)	Grip Strength (N)	VAS Score	NRS Score
OA Patients	62.2 ± 8.3 (17) * † ◊	F = 20.8 (18) M = 6.6	59.5 ± 16.7 (1)		42.9 ± 14.6 (2)	210.6 ± 98.8 (3)	3 ± 1.5 (3)	2.8 ± 2.4 (1)
Healthy Group	46.2 ± 14.1 (12) *○●	F = 13.0 (16) M = 7.5			65.51 ± 18.7 (1)	270.4 ± 92.9 (2)	0.1 ± 0.5 (1)	
Treatment Group	73.2 ± 6.9 (21) †○	F = 54.5 (26) M = 8.6	33.3 ± 12.7 (1)	21.1 ± 6.1 (9)	26.5 ± 8.6 (7)	114.9 ± 41.5 (7)	3.9 ± 1.5 (5)	4.6 ± 2.3 (7)
Placebo Group	77.2 ± 5.9 (10) ◊●	F = 19.5 (10) M = 4.5		22 ± 10.2 (6)	27.2 ± 12.5 (5)	120.7 ± 60.15 (5)	5 ± 0.2 (1)	6.4 (2)
Healthy Group	67.0 ± 7.7 (7) ▪	F = 12.3 (8) M = 6.8	49.0 ± 12.7 (1)			155.9 ± 78.5 (1)	0.4 ± 0.2 (3)	

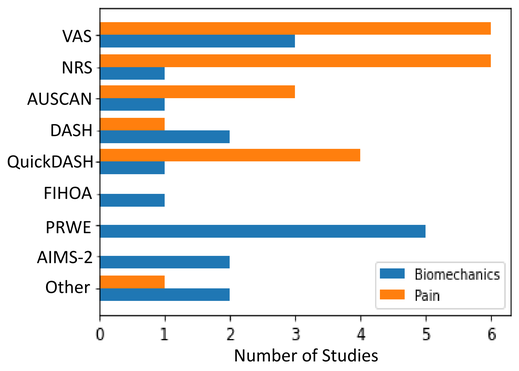
Matching symbols represent significant difference between indicated groups.

Role of clinical outcome metrics in interpreting pain:

The two most common types across fields:
- Patient-reported outcomes
- Performance outcome measures

These methods can assess a patient's physical[7], cognitive, or perceptual function[8-9] during the completion of tasks.

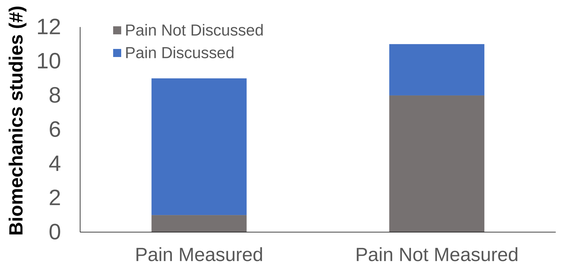
Limitations include:
- Validity between populations and changes within patients[10]
- Lack of consensus on a clinical outcome assessment within either field



Biomechanical outcomes of hand OA:

Studies showed:
- Kinematic changes (e.g., decreased range of motion) at the affected and surrounding joints
- Decreased grip and pinch strength
- Variable muscle activity across studies

Literature varied substantially in their discussion and measure of the influence of pain on movement
- Studies that included self-reported pain questionnaires often missed the opportunity to explore the relationship between movement and pain



Pain outcomes of hand OA:

The primary goal of studies was to either:
- Test the effectiveness of certain pain therapies
- Identify the presence of peripheral and/or central sensitization

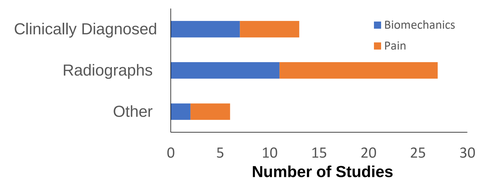
Overall Importance

Advancing our understanding of the complex and dynamic relationship between pain and movement requires shared methodology and greater consensus between the pain and biomechanics fields.

Both fields use clinical outcome measurements and a standard metric of grip or pinch strength, which are important for assessing pain and function.

However, more elaborate pain measurements are infrequent and when taken, lack consensus in both fields, limiting what we can conclude from these measurements

Need for consensus decision-making:
- Hand OA has neither a consistently chosen clinical outcome measure nor one that has been proven to be more reliable
- There is also an underlying lack of consensus with the choice of pain scales (i.e., visual analog scale versus numeric rating scale)
- Even methods used to diagnose and define OA also vary within and across fields



Measuring pain in biomechanics studies using quantitative methods followed by analytical discussion will close the gap between fields and advance our understanding of the relation, both negative and positive, between movement and pain.

References: [1] Woolf, C. J. (2011) Pain, S2-S15 [2] Arendt-Nielsen, L., et. al. (2015) *European Journal of Pain*, 1406-1417 [3] Butera, K. A., et. al. (2016) *Physical* Therapy, 1503-1507 [4] Corbett, D. B., et. al. (2019) *Pain*, 757-761 [5] Bedson, J., et. al. (2008) *BMC Musculoskeletal Disorders*, 116 [6] Finan, P. H., et. al. (2013) *Arthritis & Rheumatism*, 363-372 [7] Callesen, J., et. al. (2018) *NeuroRehabilitation*, 131-142 [8] Taylor, B. A., et. al. (2018) *American Heart Journal*, 166-174 [9] Schiltenwolf, M., et. al. (2014) *Pain Physician,* 9-19 [10] Richardson, E., et. al. (2019) *Therapeutic Innovation and Regulatory Science,* 146-153