Provider reliability with interventions for knee impairments: a preliminary investigation to facilitate development of an MDT-based knee intervention taxonomy

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ABSTRACT

Objectives: The lack of a standardized intervention taxonomy in comparative effectiveness research trials has led to uncertainty regarding the management of individuals with knee impairments. Inconsistently and poorly defined interventions affect frontline-care providers' abilities to understand and assimilate research findings into practice. An intervention taxonomy could help overcome the lack of treatment specificity commonly found in research trials.

Methods: In the present study, we aimed to develop a Mechanical Diagnosis and Therapy (MDT)-based taxonomy and test the levels of reliability between providers who currently manage individuals with knee impairments in a rehabilitation setting. A total of 182 participants accessed the study during the study period, in which 180 consented to participate and 59 completed the survey (98.9% participation rate; 32.7% completion rate).

Results: A total of 89.8% of the participants who completed the survey were physical therapists. Fleiss kappa values for the primary, secondary, and tertiary categories were 0.90, 0.89, and 0.71, respectively. The results of our investigation suggest substantial to almost perfect levels of reliability for identifying diverse MDT-based knee interventions displayed in video and vignette format within a sample population primarily of physical therapists who currently manage individuals with knee impairments in a rehabilitation setting.

Discussion: Our findings show acceptable levels of reliability and provide support for using this standardized MDT-based intervention taxonomy as a way to improve intervention specificity and generalizability in comparative effectiveness research.

Level of Evidence: 5

KEYWORDS

Comparative Effectiveness Research; orthopedic; musculoskeletal; knee; reliability; taxonomy; Mechanical Diagnosis and Therapy; McKenzie

Introduction

Health care stakeholders rely on evidence-based practice when determining best care for individuals with knee impairments. Evidence-based practice seeks to facilitate superior patient outcomes through consideration of patients' values, clinicians' experience, and the best available scientific evidence [1]. The best scientific evidence has been traditionally developed through scientific inquiry – the gold standard being the randomized controlled trial (RCT) [2–5]. RCTs determine causality and inform clinical practice guidelines [2,6]. However, ambiguity exists regarding the utility of RCT results in the management of individuals with orthopedic conditions due to poor treatment specificity and generalizability [5]. The design, development, and implementation of a standardized rehabilitation taxonomy has been suggested to overcome this challenge [7–10].

Clinical practice guidelines encompass many different evidence-based approaches to the assessment and treatment of individuals with knee impairments

[11]. Mechanical diagnosis and therapy (MDT) is an orthopedic patient classification and management system that measures patient response to unidirectional, repeated, and sustained end-range joint movements. The patient's change in symptomatic and mechanical baselines in response to these movements guides treatment and elucidates the expected recovery period [12]. MDT has gained considerable interest relative to the management of orthopedic challenges of the extremities [13–22].

A recent controlled trial randomized patients with knee OA on a waitlist for total knee replacement to an intervention and control group [22]. The intervention group was classified as having either knee derangements or were nonresponders. Patients classified as having a knee derangement received intervention based on directional preference. Nonresponders received evidence-based exercise aligned with current guidelines, and the control group received no exercise intervention. Patients prescribed exercises based on an MDT assessment had superior outcomes compared

to the waitlist control group. Patients classified as derangement and who received directional preference-matched exercise experienced outcomes superior to those classified as nonresponders who received evidence-based exercise. The article by Rosedale et al. includes a list of MDT-based assessment procedures and interventions. However, McKenzie describes further test movements and interventions for the knee that have not been included in this list [23]. Furthermore, the study was not able to determine if the type of intervention (e.g., Knee Flexion Unloaded) affected outcomes. The authors suggested that additional research must be conducted to understand whether the choice of intervention affects outcomes. An RCT was proposed by the authors to discern differences between outcomes for patients given directional preference-matched and nonmatched interventions. Future comparative effectiveness studies need a platform to measure and report intervention type through the use of a standardized MDT knee intervention taxonomy to improve treatment specificity, maximize generalizability, help frontline clinicians assimilate research findings into practice, and facilitate comparability between future investigations.

Several criteria have been proposed to develop a suitable intervention taxonomy. Our study addresses one of these requirements by examining interrater reliability [24] and serves as a platform for further development of a comprehensive intervention taxonomy for MDT-interested providers who manage individuals with knee impairments. The purpose of this study was to develop an MDT-based taxonomy and test the reliability of identifying knee interventions through video demonstrations and clinical vignettes between providers who currently manage individuals with knee impairments in a rehabilitation setting. This study aimed to initiate the development of a complete, accurate, and precise data documentation system for comparative effectiveness research trials via an MDT-based knee intervention taxonomy.

Methodology

A prospective, interrater reliability study was conducted. We analyzed data collected from health care providers recruited via the McKenzie Institute USA's e-mail blast service from March 2015 to August 2015. The e-mail repository included various allied health professionals, chiropractors, physicians, athletic trainers, and students. The Florida State University Institutional Review Board for Protection of Human Subjects approved the project. All participants signed an informed consent form prior to participating in this study. The study had three stages including the creation of the taxonomy, the establishment of the software, and conduction of the reliability testing (Figure 1).

Figure 1. Phases of the knee reliability study.

The study's knee intervention taxonomy was developed by a focus group of three orthopedic subject matter experts during 2014. The developers were physical therapists who had advanced training in orthopedic diagnostics (mean age: 33; mean years of clinical experience: 6; two held their orthopedic clinical specialist (OCS) certification, diploma in mechanical diagnosis and therapy (Dip. MDT), and doctorate of physical therapy; one held a certification in mechanical diagnosis and therapy (Cert. MDT)) and were current providers working in an outpatient, orthopedic physical therapy setting. The hierarchical taxonomy framework consisted of 7 primary categories, 7 secondary categories, and 67 tertiary categories.

Primary categories were adopted with permission from a previous investigation [25]. Primary categories were the least specific level and included Therapeutic Exercise, Manual Therapy Technique, Cognitive Behavior Technique, Modality Technique, Functional Training Technique, Education Technique, and Administrative Technique. Secondary categories were more specific and consisted of interventions grouped by direction of knee movement such as extension or flexion. Tertiary categories were the most specific category and synonymous with the individual intervention (e.g., Knee Extension Loaded). Thus, from most to least specific, categories were labeled from tertiary (e.g., Knee Extension Loaded), to secondary (e.g., Knee Extension), to primary (e.g., Therapeutic Exercise). Each developer tested the taxonomy with

his or her patients with the aim of establishing a provisional, comprehensive, and practical taxonomy, which reflected routine patient care.

In order to examine interrater reliability between providers, our team developed a novel data collection instrument through electronic, Web-based survey software. We programmed the knee intervention taxonomy, along with the intervention videos and clinical vignettes, within the software. The videos and vignettes were used to test the participant's knowledge of a particular knee intervention relative to the knee taxonomy. To create the videos, two adult males (mean age: 24 years old; mean BMI 25) participated as models during filming. A total of 47 single model interventions were performed and 20 dual model interventions were recorded in an outpatient, orthopedic clinic. The vignettes were developed by one adult male (age: 28; years of clinical experience as a physical therapist: 5; held an OCS certification, Dip. MDT, and doctorate of physical therapy) and were based on routine, orthopedic patient scenarios. The order of the videos and clinical vignettes were randomized via electronic data randomization software in order to minimize provider selection bias. In total, 85% (57 videos) of the interventions were created as videos and 15% (10 vignettes) were written clinical vignettes. All identifying information was deleted from the vignettes, and the videos did not verbally disclose the intervention name.

Participants received an e-mail from the McKenzie Institute inviting them to participate in our study. Participants were eligible to participate if they were 18–65 years old, able to read English, and were currently treating patients with orthopedic impairments of the knee in a rehabilitation setting. We aimed to include health care providers of all disciplines to increase generalizability. Upon entering the electronic survey, participants were asked to complete a consent form. Demographic information was collected prior to allowing participant access to the intervention taxonomy. Next, participants were asked to review the knee intervention taxonomy to facilitate identification of a detailed intervention, based on the presented video or vignette. The videos and vignettes were accessible to the participants from March 2015 to August 2015, and participants were able to save and continue their progress throughout the study period. Each video was approximately 10 seconds long, and each vignette was approximately one short paragraph. Participants completed the study if they selected one intervention for each video and vignette. The collection period ended after 8 weeks, and one reminder e-mail was sent at the fourth week of the collection period irrespective of the participant's progress. The average time for complete and incomplete surveys was 102 minutes.

Results

A total of 182 participants accessed the study during the study period, in which 180 consented to participate and 59 completed the survey (98.9% participation rate; 32.7% completion rate). Participant characteristics can be found in Table 1. A total of 89.8% of participants who completed data collection were physical therapists. Compared to participants with complete data ($n = 59$), participants with incomplete data ($n = 123$) exhibited significant differences based on level of degree, gender, level of MDT training, and practice setting. There were no significant differences between the two groups based on years of clinical experience or age. The majority of the raters who completed the survey were located within the northwest and Midwest regions of the United States and worked in an outpatient setting.

Fleiss kappa values for the primary, secondary, and tertiary categories were 0.90, 0.89, and 0.71, respectively. Almost perfect reliability was found for the primary category Modality Techniques (Kappa = 0.94) and the secondary category Other Procedures within Manual Therapy Techniques (Kappa = 0.86). The highest kappa value was found in Modality Technique (0.94) and the lowest kappa value was found in Administrative Technique (−0.01); this negative value may be interpreted as the reliability less than what would be expected by chance. Lowest kappa values for the primary, secondary, and tertiary categories were Cognitive Behavioral Techniques (0.47), Manual Therapy: Extension Procedures (0.33), and Refer to Another Clinic (−0.01), respectively. Fleiss' Kappa coefficients for detailed categories could be found in Table 2.

We created a matrix that made a pair for each rater between raters 1 through 59 and compared each pair's answers to our video key. The result contained 1711 values and corresponding kappa values with confidence intervals, bias indices, and prevalence indices. Bias indices for each possible pair of raters tested against our video key ranged from −0.68 to 0.67. Kappa coefficients, 95% confidence intervals, prevalence, and bias are displayed in Table 3.

Discussion

Our study suggests substantial to almost perfect levels of reliability for identifying diverse MDT-based knee interventions displayed in video and vignette format among a sample population primarily of physical therapists who currently manage individuals with knee impairments in a rehabilitation setting. Although our inclusion criteria included any health care provider currently treating patients with knee impairments in a rehabilitation

Table 1. Participant characteristics.

Status of Survey	Complete (n = 59)	Incomplete (n = 123)
Completion Time (hr:min:sec)	Mean = 1:42:52	Mean = 0:20:21
Age (mean $\pm$ SD)	38.63 $\pm$ 9.68	40.64 $\pm$ 11.35
Practice Location (U.S. Regions)		
Northeast	20.3%	13.8%
Midwest	22.0%	17.9%
South	20.3%	26.8%
West	8.5%	13.0%
Practice Location (International)		
No Location Listed	15.3%	17.9%
Alberta	1.7%	0.0%
Greece	0.0%	0.08%
India	8.5%	8.9%
Israel	1.7%	0.0%
Mexico	0.0%	0.8%
United Kingdom	1.7%	0.0%
Healthcare Discipline		
Physical Therapist (PT)	89.8%	76.4%
Physical Therapist Assistant (PTA)	6.8%	4.1%
Chiropractor (DC)	3.4%	2.4%
Physician (MD or DO)	0.0%	0.0%
Athletic Trainer (ATC)	0.0%	3.3%
Occupational Therapist (OT)	0.0%	0.8%
PT Student	0.0%	0.0%
DC Student	1.7%	0.0%
Other	0.0%	0.8%
Gender		
Male	39.0%	30.1%
Female	61.0%	54.5%
No Response	0.0%	15.5%
Level of Degree		
Associate	6.8%	3.3%
Bachelor	23.7%	30.9%
Master	33.9%	16.3%
Doctorate/PhD	33.9%	33.3%
Other	1.7%	0.8%
No Response	0.0%	15.5%
Practice Setting		
Inpatient	0.0%	0.8%
Outpatient (Hospital-Based)	30.5%	29.3%
Outpatient (Private Practice)	64.4%	51.2%
Other	5.1%	3.3%
No Response	0.0%	15.5%
Level of MDT Training		
Certification in Mechanical Diagnosis and Therapy (Cert. MDT)	50.9%	41.5%
Diploma in Mechanical Diagnosis and Therapy (Dip. MDT)	11.9%	4.1%
Fellowship	1.7%	0.8%
Part A	0.0%	4.1%
Part B	15.3%	4.9%
Part C	5.1%	7.3%
Part D	15.3%	20.3%
None	0.0%	1.6%
No Response	0.0%	15.5%
Years of Clinical Experience (Mean $\pm$ SD):	12.98 $\pm$ 9.39	14.51 $\pm$ 10.75

setting, our recruitment methods attracted participants who were primarily physical therapists. We considered important participant level characteristics such as age, gender, practice location, practice setting, level of degree, level of MDT training, and years of clinical experience. The taxonomy was developed for providers who manage patients with knee impairments by way of MDT methods.

Our primary findings indicate that reliability levels were highest for primary categories. This was an expected finding because this category had the broadest inclusion criteria. Participants needed to discern differences between interventions that were categorized as, for example, Therapeutic Exercise and Manual Therapy. Direct hands-on assistance of a provider characterize Manual Therapy interventions and distinguish this intervention category from

Therapeutic Exercise. Secondary category reliability levels demonstrated similar findings. At this level, participants needed to distinguish between MDT-based interventions, which were mainly characterized by direction of motion (e.g., identification of the intervention as a knee extension or knee flexion-based movement pattern). Participants had the lowest level of reliability among the Tertiary Categories. This level required knowledge of more specific and potentially complex intervention characteristics such as the amount of force used in the intervention (e.g., identification of knee extension in a weight-bearing position), bidirectional movements (e.g., identification of knee extension with tibial rotation), and resistive movements (e.g., knee extension under resistance from elastic tubing).

Table 2. Fleiss' kappa values for all categories.

	Kappa Value
Category 1: Therapeutic Exercise	0.67
Knee Extension	0.65
Knee Extension Unloaded (Knee Ext UL)	
Knee Extension Internal Rotation Unloaded (Knee Ext IR UL)	
Knee Extension External Rotation Unloaded (Knee Ext ER UL)	
Knee Extension Semi-loaded (Knee Ext SL)	
Knee Extension Loaded (Knee Ext L)	
Knee Extension Internal Rotation Loaded (Knee Ext IR L)	
Knee Extension External Rotation Loaded (Knee Ext ER L)	
Knee Sustained Extension (Knee Sus Ext)	
Knee Resisted Extension (Knee Resist Ext)	
Knee Target Zone Extension (Knee TZ Ext)	
Knee Resisted Target Zone Extension (Knee Resist TZ Ext)	
Knee Flexion	0.65
Knee Flexion Unloaded (Knee Flex UL)	
Knee Flexion Internal Rotation Unloaded (Knee Flex IR UL)	
Knee Flexion External Rotation Unloaded (Knee Flex ER UL)	
Knee Flexion Loaded (Knee Flex L)	
Knee Flexion Internal Rotation Loaded (Knee Flex IR L)	
Knee Flexion External Rotation Loaded (Knee Flex ER L)	
Knee Resisted Flexion (Knee Resist Flex)	
Knee Target Zone Flexion (Knee TZ Flex)	
Knee Resisted Target Zone Flexion (Knee Resist TZ Flex)	
Other Knee Resistive Movement	0.64
Knee Isometric Extension (Knee Iso Ext)	
Knee Isometric Flexion (Knee Iso Flex)	
Knee Eccentric Extension (Knee Ecc Ext)	
Knee Eccentric Flexion (Knee Ecc Flex)	
Other Therapeutic Exercise	0.57
General Knee Strength Training	
General Knee Endurance Training	
Proprioceptive Neuromuscular Facilitation (PNF) Techniques	
Balance Training	
Aerobic Conditioning	
Plyometrics	
Category 2: Manual Therapy Technique	0.72
Extension Procedures	0.33
Knee Extension with Clinician Overpressure	
Knee Extension Internal Rotation with Clinician Overpressure	
Knee Extension External Rotation with Clinician Overpressure	
Flexion Procedures	0.42
Knee Flexion with Clinician Overpressure	
Knee Flexion Internal Rotation with Clinician Overpressure	
Knee Flexion External Rotation with Clinician Overpressure	
Other Procedures	0.86
Tibiofemoral Anterior Glide(s)	
Tibiofemoral Posterior Glide(s)	
Patellofemoral Superior Glide(s)	
Patellofemoral Inferior Glide(s)	
Patellofemoral Lateral Glide(s)	
Patellofemoral Medial Glide(s)	
Soft Tissue Mobilization	
Joint Accessory Mobilization/Manipulation	
Category 3: Cognitive Behavioral Technique	0.47
Operant Graded Activity Program	
Graded Exposure <i>In Vivo</i> Program	
Problem Solving	
Positive Thinking	
Relaxation Breathing	
Meditation	
Category 4: Modality Technique	0.94
Heat Modality	
Ice Modality	
Ultrasound Modality	
Electrical Stimulation Modality	
Electrotherapeutic Delivery of Medication	
Dry Needling Modality	
Laser Modality	
Category 5: Functional Training Technique	0.79
Work and Activities of Daily Living	
Sport Specific Training	
On-Site Ergonomic Modification	
Lifting	
Category 6: Education Technique	0.50
Posture	
Rest	
Active Rest in Presence of Healing	
Physical Activity and Self-Exercise Consulting	
McKenzie Booklet	
Category 7: Administrative Technique	-0.01
Refer to Another Clinic	

Table 3. Prevalence and bias index.

	Kappa Value	Prevalence Index	Bias Index
Minimum	−0.23	−0.05	−0.68
Quartile 1	0.03	0.55	−0.08
Median	0.15	0.64	0.00
Quartile 3	0.30	0.71	0.08
Maximum	0.95	0.92	0.67

There is no consensus about what constitutes a clinically acceptable level of reliability [26–28]. Authors have suggested that 0.40 and 0.60 may represent acceptable reliability [29]. Some authorities demand higher values of acceptable levels of reliability such as 0.75 and above 0.85 [30]. According to this reference standard, our results show substantial to almost perfect levels of reliability for identifying MDT-based knee interventions displayed in video and vignette format within a sample population primarily of physical therapists who currently manage individuals with knee impairments in a rehabilitation setting. In order to further validate our findings, we computed and provided prevalence and bias indices (see Table 3) for our kappa coefficient estimates. High prevalence indices, compared to low prevalence indices, will usually exhibit lower kappa estimates.

Inaccuracy and incomparability of study findings is a serious barrier to understanding best practices in health care. Researchers are interested in determining treatment efficacy by examining associations between interventions and outcomes during real-time clinical practice. Use of a standardized, operationally defined intervention taxonomy for clinical documentation is not typically found in RCT study designs. It is not uncommon that RCTs typically compare ambiguous, poorly defined intervention types to one another such as “strength training” and “stretching.” The lack of intervention specificity could drive erroneous study findings and misrepresent intervention efficacy, and an intervention taxonomy could address this critical challenge.

Practice-Based Evidence studies aim to determine intervention efficacy by examining associations between clinical interventions and outcomes through medical record documentation. Charts are typically composed of nonstandardized documentation that may be biased due to incompleteness and inaccuracy. In order to document reliable data, providers must precisely describe what they do during routine care. Training regarding standardized data documentation does not regularly occur during typical practice, which leads to misinterpretation. Furthermore, chart data are usually recorded in a way that disallows for rapid aggregation and analysis due to inconsistent syntax and semantics, missing data, legibility concerns, and manual data entry error. Therefore, results from research trials are disrupted due to slowed data abstraction from paper charts. The implementation of an MDT-based knee intervention taxonomy within

a traditional electronic health record or clinical documentation system could significantly improve speed to analysis and reporting. Future studies are needed to investigate the feasibility of implementation of an MDT-based knee intervention taxonomy among health care providers who manage patients with knee impairments in a rehabilitation setting by way of MDT methods.

It has been proposed that an effective intervention taxonomy must be comprehensive [7–10]. Providers need to be able to document any and all interventions performed in order to enable fluent operational work flows along with accurate representations of clinical scenarios [31–34]. Incomplete and inaccurate documentation does not reflect actual clinical practice and could misrepresent findings regarding intervention efficacy. Therefore, a comprehensive intervention taxonomy that allows for completeness and accuracy in documentation could elucidate which treatments are most efficacious. Our study attempted to develop the framework for a comprehensive MDT-based knee intervention taxonomy by combining common interventions health care providers employ when managing individuals with knee impairments by way of MDT methods. During development of the taxonomy, we recognized that health care providers may consider other intervention types that have not been exclusively described as MDT-based. For example, electrical stimulation is not a typical treatment modality advocated by MDT thought and practice leaders. However, providers may choose to deliver this modality if the patient’s presentations fall outside the scope of MDT management. We recommend that future investigations should be conducted to determine the completeness of our MDT-based knee intervention taxonomy for health care providers interested in the management of patients with knee impairments by way of MDT methods. Investigations could be conducted through the use of focus groups and Delphi studies while considering our current MDT-based knee intervention taxonomy framework. Currently, our research network is utilizing this MDT-based knee intervention taxonomy within an electronic clinical documentation system to determine functionality, both from a clinical and analytical perspective. Our intention is to conduct robust comparative effectiveness analyses to determine associations between intervention characteristics and clinical, humanistic, and cost-related outcomes.

There are several limitations to our findings. The results of this investigation may only be generalizable to our sample. Our participant population consisted primarily of physical therapists, and research needs to be performed to determine if findings would be similar among other health disciplines that manage patients with knee impairments by way of MDT methods. Furthermore, most of our participants had a

certification in MDT, which could have influenced the results. Individuals who are certified in MDT have completed all MDT coursework regarding extremity condition management and have passed a certification examination. Training level could have affected the levels of reliability within our participant population, and future studies should consider levels of reliability among individuals with varying levels of training in MDT methods.

Our study sought to determine if providers could agree on intervention type; however, we did not consider other important intervention characteristics such as timing, dosage, intensity, and mode of delivery. These characteristics are commonly manipulated during real-time clinical practice, and we are uncertain if the same levels of reliability exist when providers modify these characteristics. Actual clinical practice is a complex process and many factors affect how an intervention is delivered. We believe that intervention reliability, relative to treatment type, is the cornerstone for determining overall provider reliability and allows for investigation of other aspects related to treatment processes. Since our results indicated that substantial to almost perfect levels of reliability have been found within our population, future studies are needed to determine if similar levels of reliability are found when providers modify other factors relative to intervention characteristics such as timing, dosage, intensity, and mode of delivery.

Conclusion

Our primary objective was to test the levels of reliability between providers currently treating patients with orthopedic impairments of the knee in a rehabilitation setting using a standardized MDT-based knee intervention taxonomy. Our study suggests substantial to almost perfect levels of reliability among a sample population primarily of physical therapists for identifying diverse MDT-based knee interventions displayed in video and vignette format. A standardized intervention measurement system could improve the accuracy and generalizability of comparative effectiveness research findings that offer insight into best orthopedic management practices for individuals affected by knee impairments.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Richard Yarznbowicz obtained his doctor of physical therapy from the University of the Sciences in Philadelphia in

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Appendix: MDT Knee Intervention Taxonomy

Category 1: Therapeutic Exercise

Knee Extension

Knee Extension Unloaded (Knee Ext UL) – The patient is in a seated, standing, or lying position. The patient actively moves the knee into an extension direction toward end range. The patient is asked to move further into end range with each repetition.

Knee Extension Internal Rotation Unloaded (Knee Ext IR UL) – The patient is in a seated, standing, or lying position. The patient actively moves the knee into an extension direction with the tibia in an externally rotated position (foot facing outward) toward end range. The patient is asked to move further into end range with each repetition.

Knee Extension External Rotation Unloaded (Knee Ext ER UL) – The patient is in a seated, standing, or lying position. The patient actively moves the knee into an extension direction with the tibia in an internally rotated position (foot facing inward) toward end range. The patient is asked to move further into end range with each repetition.

Knee Extension Semi-Loaded (Knee Ext SL) – The patient is in a seated position with the heel and/or foot resting on the floor. The patient passively moves the knee into an extension direction toward end range. The patient is asked to move further into end range with each repetition.

Knee Extension Loaded (Knee Ext L) – The patient is in a standing position with the heel and/or foot resting on the floor and the tibia in a neutral position. The patient passively moves the knee into an extension direction toward end range. The patient is asked to move further into end range with each repetition.

Knee Extension Internal Rotation Loaded (Knee Ext IR L) – The patient is in a standing position with the heel and/or foot resting on the floor and the femur positioned in external rotation (foot facing outward). The patient passively moves the femur into internal rotation and then the knee into an extension direction toward end range. The patient is asked to move further into end range with each repetition.

Knee Extension External Rotation Loaded (Knee Ext ER L) – The patient is in a standing position with the heel and/or foot resting on the floor and the femur in internal rotation (foot facing inward). The patient passively moves the femur into external rotation and then the knee into an extension direction toward end range. The patient is asked to move further into end range with each repetition.

Knee Sustained Extension (Knee Sus Ext) – The patient is in a seated, standing, or lying position. The patient positions the knee so that gravity or an external weight forces the knee into an extension direction over a period of time.

Knee Resisted Extension (Knee Resist Ext) – The patient is in a seated, standing, or lying position. The patient actively moves the knee with external resistance (e.g., ankle weight, tubing, etc.) into extension. The patient is asked to move further into end range with each repetition.

Knee Target Zone Extension (Knee TZ Ext) – The patient is in a seated, standing, or lying position. The patient actively moves the knee into an extension direction to the point of maximal pain being provoked. The patient is asked to consistently move within that concentrated area with each repetition.

Knee Resisted Target Zone Extension (Knee Resist TZ Ext) – The patient is in a seated, standing, or lying position. The patient actively moves the knee with external resistance (e.g., ankle weight, tubing, etc.) into an extension direction to the point of maximal pain being provoked. The patient is asked to consistently move within that concentrated area with each repetition.

Knee Flexion

Knee Flexion Unloaded (Knee Flex UL) – The patient is in a seated, standing, or lying position. The patient actively or passively moves the knee into a flexion direction toward end range. The patient is asked to move further into end range with each repetition.

Knee Flexion Internal Rotation Unloaded (Knee Flex IR UL) – The patient is in a seated, standing, or lying position. The patient passively moves the knee into a flexion direction toward end range with the femur positioned in internal rotation relative to the tibia (the tibia is manually externally rotated). The patient is asked to move further into end range with each repetition.

Knee Flexion External Rotation Unloaded (Knee Flex ER UL) – The patient is in a seated, standing, or lying position. The patient passively moves the knee into a flexion direction toward end range with the femur positioned in external rotation relative to the tibia (the tibia is manually internally rotated). The patient is asked to move further into end range with each repetition.

Knee Flexion Loaded (Knee Flex L) – The patient is in a standing or kneeling position. The patient passively moves the knee into a flexion direction toward end range against an external object such as a chair or kneeling. The patient is asked to move further into end range with each repetition.

Knee Flexion Internal Rotation Loaded (Knee Flex IR L) – The patient is in a standing or kneeling position. The patient passively moves the knee into a flexion direction toward end range against an external object such as a chair with the femur positioned in external rotation relative to the tibia (the tibia is manually internally rotated). The patient is asked to move further into end range with each repetition.

Knee Flexion External Rotation Loaded (Knee Flex ER L) – The patient is in a standing or kneeling position. The patient passively moves the knee into a flexion direction toward

end range against an external object such as a chair with the femur positioned in internal rotation relative to the tibia (the tibia is manually externally rotated). The patient is asked to move further into end range with each repetition.

Knee Resisted Flexion (Knee Resist Flex) – The patient is in a seated, standing, or lying position. The patient actively moves the knee with external resistance (e.g., ankle weight, tubing, etc.) into a flexion direction. The patient is asked to move further into end range with each repetition.

Knee Target Zone Flexion (Knee TZ Flex) – The patient is in a seated, standing, or lying position. The patient actively moves the knee into a flexion direction to the point of maximal pain being provoked. The patient is asked to consistently move within that concentrated area with each repetition.

Knee Resisted Target Zone Flexion (Knee Resist TZ Flex) – The patient is in a seated, standing, or lying position. The patient actively moves the knee with external resistance (e.g., ankle weight, tubing, etc.) into a flexion direction to the point of maximal pain being provoked. The patient is asked to consistently move within that concentrated area with each repetition.

Other Knee Resisted Movement

Knee Isometric Extension (Knee Iso Ext) – The patient is in a seated, standing, or lying position. The patient applies a constant, motionless force against external resistance into knee extension for 3–5 s. The patient then relaxes and repeats the exercise.

Knee Isometric Flexion (Knee Iso Flex) – The patient is in a seated, standing, or lying position. The patient applies a constant, motionless force against external resistance into knee flexion for 3–5 s. The patient then relaxes and repeats the exercise.

Knee Eccentric Extension (Knee Ecc Ext) – The patient is in a seated, standing, or lying position. The patient applies a lengthening force throughout the available range with or without external resistance (e.g., ankle weight, tubing, etc.) into knee flexion. Then, the patient does not perform the concentric portion of the exercise. The patient uses external support (e.g., the contralateral extremity) to reposition the limb and then repeats the exercise.

Knee Eccentric Flexion (Knee Ecc Flex) – The patient is in a seated, standing, or lying position. The patient applies a lengthening force throughout the available range of motion with or without external resistance (e.g., ankle weight, tubing, etc.) into knee extension. The patient does not perform the concentric portion of the exercise. The patient uses external support (e.g., the contralateral extremity) to reposition the limb and then repeats the exercise.

Other Therapeutic Exercise

General Knee Strength Training – The load applied to the foot, ankle, knee, thigh, hip, lumbar spine, and/or abdominal muscle(s) must generate at least 60%–80% of 1 MR (maximal resistance) and the patient is able to perform the strengthening exercises for only 8–12 repetitions. When performing strengthening or endurance exercises in the clinic, patients typically use any piece of equipment that places an isotonic, isokinetic, or eccentric load on the targeted extremity muscle group(s) such as, but not limited to, elastic tubing, dumbbell, weight machine, or exercises against gravity. This intervention is not an isolated specific exercise targeted at the ideological or theoretical concept of, for example, derangement or

dysfunction syndrome proposed by McKenzie. This intervention is strictly intended to augment the treatment of these syndromes. For instance, an individual specific exercise used in the treatment of derangement syndrome is typically used solely in isolation from other interventions. This category is reserved for the purpose of traditional, composite groups of common strength training exercises only.

General Knee Endurance Training – A low load is applied to the foot, ankle, knee, thigh, hip, lumbar spine, and/or abdominal muscle(s) and the patient is typically instructed to perform more than 12 repetitions. The load applied is less than 50% of 1 MR. When performing strengthening or endurance exercises in the clinic, patients typically use any piece of equipment that places an isotonic, isokinetic, or eccentric load on the targeted extremity muscle group(s) such as, but not limited to, elastic tubing, dumbbell, weight machine, or exercises against gravity. This intervention is not an isolated specific exercise targeted at the ideological or theoretical concept of, for example, derangement or dysfunction syndrome proposed by McKenzie. This intervention is strictly intended to augment the treatment of these syndromes. For instance, an individual specific exercise used in the treatment of derangement syndrome is typically used solely in isolation from other interventions. This category is reserved for the purpose of traditional, composite groups of common strength training exercises only.

Proprioceptive Neuromuscular Facilitation (PNF) Techniques – Hallmarks of this approach to therapeutic exercise are the use of diagonal patterns and the application of sensory cues – specifically proprioceptive, cutaneous, visual, and auditory stimuli – to elicit or augment motor responses. The patterns of movement associated with PNF are composed of multijoint, multiplanar, diagonal, and rotational movements of extremities, trunk, and neck. Multiple muscle groups contract simultaneously. Flexion or extension of the knee is coupled with abduction as well as external or internal rotation. Motion of the body segments distal to the knee also occur simultaneously during each diagonal pattern. Specific techniques with PNF include the following: rhythmic initiation, repeated contractions, reversal of antagonists, slow reversal, slow reversal hold, alternating isometrics, and rhythmic stabilization.

Balance Training – Patients are prescribed in the clinic exercises targeting different activities that demand rapid and accurate responses to an external challenge or force in order for the patient to maintain balance (e.g., unilateral standing on an unstable surface).

Aerobic Conditioning – The patient is prescribed exercise in the clinic to increase the heart rate to a value determined by Karvonen's formula $\{[(220 - \text{age}) - \text{rest heart rate}] \times 45\% + \text{rest heart rate}\}$ for a sustained period of time. The patient may or may not use equipment for aerobic exercises. Examples of aerobic equipment are bike, treadmill, elliptical, aerobic land, and aquatic classes using hand and feet assistive devices.

Plyometrics – High velocity eccentric to concentric muscle loading, reflexive reactions, and functional movement patterns in which the muscle elongates, immediately followed by a rapid reversal of movement with a resisted shortening contraction of the same muscle. Body weight or an external form of loading, such as elastic bands or tubing, or a weighted ball, are possible sources of resistance.

Category 2: Manual Therapy Technique

Extension Procedures

Knee Extension with Clinician Overpressure – The patient is in a sitting, standing, or lying position and the clinician passively moves the knee into an extension direction until the limb has reached end range. The limb is then returned to neutral resting position.

Knee Extension Internal Rotation with Clinician Overpressure – The patient is in a sitting or lying position and the clinician passively moves the femur into an external rotation (tibial internal rotation) and extension direction relative to the tibia until the limb has reached end range. The limb is then returned to the neutral resting position.

Knee Extension External Rotation with Clinician Overpressure – The patient is in a sitting or lying position and the clinician passively moves the femur into an internal rotation (tibial external rotation) and extension direction relative to the tibia until the limb has reached end range. The limb is then returned to the neutral resting position.

Flexion Procedures

Knee Flexion with Clinician Overpressure – The patient is in a sitting, standing, or lying position and the clinician passively moves the knee into a flexion direction until the limb has reached end range. The limb is then returned to the neutral resting position.

Knee Flexion Internal Rotation with Clinician Overpressure – The patient is in a sitting or lying position and the clinician passively moves the femur into an external rotation (tibial internal rotation) and flexion direction relative to the tibia until the limb has reached end range. The limb is then returned to the neutral resting position.

Knee Flexion External Rotation with Clinician Overpressure – The patient is in a sitting or lying position and the clinician passively moves the femur into an internal rotation (tibial external rotation) and flexion direction relative to the tibia until the limb has reached end range. The limb is then returned to the neutral resting position.

Other Procedures

Tibiofemoral Anterior Glide – The patient is prone with the tibiofemoral joint in the loose packed position. The clinician grasps the tibia with the hand that is closer to it and places the palm of the proximal hand on the posterior aspect of the proximal tibia. The clinician applies a force with the hand on the proximal tibia in an anterior direction.

Tibiofemoral Posterior Glide – The patient is supine with the tibiofemoral joint in the loose packed position. The clinician sits on the table with the thigh fixating the patient's foot. With both hands, the clinician grasps around the tibia, fingers pointing posteriorly and thumbs anteriorly. The clinician, with extended elbows, leans the body weight forward pushing the tibia posteriorly.

Patellofemoral Superior Glide – The patient is supine with the patellofemoral joint in the loose packed position. The clinician places the web space of the hand that is closer to the thigh around the inferior border of the patella and uses the other hand for reinforcement. The clinician then glides the patella in a cephalic direction, parallel to the femur.

Patellofemoral Inferior Glide – The patient is supine with the patellofemoral joint in the loose packed position. The clinician places the web space of the hand that is closer to

the thigh around the superior border of the patella and uses the other hand for reinforcement. The clinician then glides the patella in a caudal direction, parallel to the femur.

Patellofemoral Lateral Glide – The patient is supine with the patellofemoral joint in the loose packed position. The clinician places the heel of the hand along the medial aspect of the patella and places the other hand on the femur to stabilize. The clinician glides the patella into a lateral direction.

Patellofemoral Medial Glide – The patient is supine with the patellofemoral joint in the loose packed position. The clinician places the heel of the hand along the lateral aspect of the patella and places the other hand on the femur to stabilize. The clinician glides the patella into a medial direction.

Soft Tissue Mobilization – The patient receives a massage by the clinician for treatment. Massage varies from region to region. Classic Western massage was developed in Europe and the United States during the past two centuries. Western massage is based on the Western medical model disease with mechanical and neurologic rationales supporting its use as a therapy. Typical examples of western massage are effleurage and deep friction techniques. Contemporary massage, bodywork, and Asian bodywork are widely diverse in their rationale, which include myofascial mobilization and lengthening. Practitioners of massage use their hands or other instruments to physically manipulate soft tissue.

Joint Accessory Mobilization/Manipulation – Additional mobilization or manipulation techniques not described above, for example, Cyriax, Maitland, Mulligan, or Kaltenborn mobilization techniques applied to any extremity or spine joint(s). This category would also include manual techniques such as muscle energy.

Category 3: Cognitive Behavioral Technique

Operant Graded Activity Program – A specific treatment program developed for patients with chronic pain and elevated fear-avoidance beliefs. Exercise and/or functional activity quotas are determined by the clinician at the start of the program. The intensity, duration, and frequency of exercise or functional activity selected for the initial quotas are based on the patient's pain intensity and current activity or exercise level. Although the patient's pain intensity is monitored during exercise, pain intensity is not used to make decisions regarding exercise progression. For example, at intake the patient can curl 30 pounds with maximal effort and is capable of lifting 20 pounds of groceries from the floor. The therapist starts the patient's program at 50% of maximal effort and prescribes the following exercise quota: bicep curls at 15 pounds for 15 repetitions and lifting 10 pounds of groceries from the floor for 10 repetitions. When the exercise quota is met, an increased exercise quota of at least greater than 10% is prescribed, for example, 16.5 pounds for bicep curls and 11.5 for lifting groceries. During exercise, the patient interacts with the clinician and receives positive verbal encouragement and praise for reaching an exercise quota.

Graded Exposure *In Vivo* Program – A specific treatment program developed for patients who experience elevated fear-avoidance beliefs. The overall aim of this program is to improve functional ability by reducing perceived harmfulness of activities.

The program requires four sequential steps:

- (1) **Education:** At intake, the patient receives education and reassurance from the clinician regarding the patient's knee and pain problems. The patient is told in an empathetic manner that the knee pain experienced is a common condition and that the knee does not need overprotection. The patient is encouraged to avoid prolonged rest and to return to activity. The clinician addresses the patient's concerns and worries regarding the pain and learning the difference between hurt from exercise or activity and harm to the knee.
- (2) The patient and clinician establish a hierarchy of ordinary movements or activities that the patient is fearful of doing because of pain. The list starts with the least fearful to the most fearful activity or movement. The activities do not go beyond the boundaries of activities that are regularly carried out by the patient.
- (3) The hierarchy of activities forms the basis of the patient's exposure to the feared stimuli. For example, the patient is asked to perform a least limiting task or movement. Afterward, the patient is asked to rate the pain and to determine if the fear or concern regarding the task is warranted. Patients may be asked whether the knee pain limited them from performing the activity. The patient is encouraged to appreciate the difference between hurt and harm and has the opportunity to correct inaccurate predictions about the relationship between activity and harm and to correct perceptions that exaggerate the threat value of pain from performing a task.
- (4) Subsequently, patients are gradually but systematically exposed to more difficult, fear-provoking tasks derived from the hierarchical activity list previously established. The patient continually receives positive feedback from the clinician regarding the patient's increased exposure to perform activities while understanding the difference between hurt and harm.

Problem Solving – The patient is specifically instructed by the clinician to apply what he or she has learned regarding posture, movement(s), and body mechanics in the clinic to other tasks usually performed at home but that have stopped because of the pain. If the patient had difficulty performing a task, he or she was encouraged to problem solve by altering or simplifying the task so it could be performed at home. If the patient could not perform the task at home, he or she was asked to discuss the problem with the clinician during the next therapy appointment. Both the patient and clinician would interact and troubleshoot until the patient was able to safely accomplish the activity or physical movement(s) at home with good pain control.

Positive Thinking – The patient is encouraged by the clinician to think and verbally express positive thoughts regarding either (1) prognosis for the patient's knee challenge, (2) the ability to control pain and perform prescribed exercises and functional activities, or (3) be aware of sick or negative thoughts or comments and correct these comments in a positive way. For example, the patient reports he or she has too much pain to perform the exercises. The patient is encouraged to think and talk positively regarding goals for exercise and is encouraged to practice the stretches that are scheduled for that day's visit in the clinic.

Relaxation Breathing – Relaxation breathing is a specific cognitive behavioral technique with the primary goal of enhancing relaxation and decreasing stress. Typically, while sitting or lying on the back, the patient is instructed to place one hand on the abdomen and one hand on the upper chest.

The patient is then instructed to inhale and concentrate on feeling the hand on the abdomen move upward with inhalation. The patient is then told to slowly exhale and feel the hand on the abdomen travel toward the spine. Simultaneously, the patient is told he or she should not feel the hand on the upper chest move at all. Biofeedback EMG devices may be used to assist patient with relaxation breathing.

Meditation – The patient is instructed to close the eyes and focus on inhaling and exhaling for several minutes. The patient is encouraged to empty the mind of any thoughts besides those on breathing. If any thoughts enter the mind, the patient is instructed to gently release them from the mind and bring attention back to intentional breathing. The patient is trained to keep the attention on breathing over a specified time prescribed by the clinician.

Category 4: Modality Technique

Heat Modalities – The patient receives superficial or deep heat using hot pack(s) or infrared equipment.

Ice Modalities – The patient receives a superficial cooling using a cold pack, game ready, or any other agent or device to deliver superficial cooling.

Ultrasound Modality – The patient receives superficial or deep therapeutic ultrasound wave application using different continuous or intermittent waves in various intensities (W/cm^2) and frequencies (MHz).

Electric Stimulation Modality – The patient receives electric stimulation for pain management using various currents (e.g., Russian, pulsating, interferential) delivered by electric stimulation equipment.

Electrotherapeutic Delivery of Medication – The patient receives pain medication using electric stimulation equipment such as iontophoresis.

Dry Needling Modality – The patient receives dry needling for pain management using methods delivered by dry needling equipment.

Laser Modality – The patient receives laser modality for pain management using various settings delivered by laser modality equipment.

Category 5: Functional Training Technique

Work and Activities of Daily Living – This treatment category includes actual training of the patient under the direct supervision of the clinician in the clinic performing and simulating usual activity/activities of daily living at home or at work. Activities may include any usual movements or tasks the patient performs inside or outside of home. For example, the patient is instructed to practice vacuuming, moving furniture, or simulating gardening activities. This category does not include the performance of lifting tasks.

Sport-Specific Training – This treatment category includes actual training of the patient under the direct supervision of

the clinician in the clinic performing and simulating usual sport-specific activities. Activities may include any usual movements or tasks the patient performs within the sport. For example, the patient is instructed to practice running, jumping, throwing, or cutting drills. This category does not include the performance of lifting tasks.

On-Site Ergonomic Modification – Ergonomic modifications to the employee's work area(s) are made by the clinician on-site at the patient's place of employment.

Lifting – The patient practices lifting task(s) under the direct supervision of the clinician in the clinic simulating lifting tasks required at work or home.

Category 6: Education Technique

Posture – The patient is instructed on proper knee and body postures when sitting, lying, or standing assumed during regular activities of daily living (i.e., leisure and work-related activities).

Rest – The patient is instructed to rest as a primary course of treatment. The patient is asked to cease aggravating factors and remove themselves from any activities of daily living. The patient is asked not to perform any exercise.

Active Rest in Presence of Healing – During the acute stage of healing, the patient is instructed in watchful waiting, that is, to control the pain by balancing positions of rest such as lying, with gentle activities such as standing or walking. The patient is instructed to perform gentle activities or movements while being careful not to incur any further injury.

Physical Activity and Self-Exercise Consulting – Physical activity consulting is performed specifically by clinicians who were trained during a postgraduate course to give consultation to patients who need to be involved in physical activity as a part of a treatment of different comorbidities. They are referred to those PT consultants by physicians or physical therapists. During the visits, they construct a specific exercise program and follow up on the patient.

McKenzie Booklet – The patient is specifically given the McKenzie booklet (i.e., Treat Your Own Knee) at the time of the initial evaluation or during a follow-up visit to supplement the patient's treatment education.

Category 7: Administrative Technique

Refer to Another Clinic – The patient is referred by the clinician to another medical clinic, clinician, or physician who specializes in medical evaluation and management of pain. For example, the patient is referred to pain management facility, occupational therapy, lymphatic therapy, hydrotherapy facility, or alternative (complementary) medicine clinic or specialist practitioner(s) such as a neurologist/orthopedic physician.

https://drive.google.com/file/d/19CU2mulAm_cA4wuT0JWhPoNqC-qrS2hd/view