# CONFLICTS OF INTEST AND RESEARCHER ALLEGIANCE IN CLINICAL TRIALS OF DRY NEEDLING FOR MUSCULSKELETAL PAIN DISORDERS: A SYSTEMATIC APPRAISAL

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# Conflicts of Interest and Researcher Allegiance in Clinical Trial of Dry Needling for Musculoskeletal Pain Disorders: A Systematic Appraisal

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Abstract

Concerns over potential bias due to conflicts of interest (COI) have gained increased attention in the biomedical and psychotherapy literature in recent years. However, little formal analysis of COI in clinical trials of physical therapy (PT) interventions has occurred. As in psychotherapy, PT interventions are often characterized by complex treatment rituals that influence the clinician-patient interaction and therefore the outcome of treatment. One such intervention that has gained significant popularity among physical therapists is dry needling (DN) to treat pain and disability due to musculoskeletal disorders (MSDs). In the psychotherapy literature, a form of non-financial COI has been described as researcher allegiance (RA), which occurs when a clinician-researcher demonstrates a preference for an intervention based on a belief in its superiority over other treatments. The purpose of this study was twofold: 1) to determine the frequency and methods of COI in published DN trials, and 2) to determine the frequency of RA and the nature of reported COI in DN trials and their association. A systematic search of the literature was undertaken to identify trials of DN published between January 1, 2013 and July 16, 2018. Two independent reviewers extracted COI and RA data from published reports. In addition, authors were contacted to obtain information on funding in reports that lacked this information. Finally, study authors were sent a survey inquiring about the presence of RA, and these responses were compared to RA items identified in those study reports combined with a random subset of 14 reports. Sixteen systematic reviews contained 62 unique trials of DN for MSDs. Only 56% per cent of DN trials had a COI statement and just 37% had information on funding in the report. Just 1 report disclosed a “potential” COI; therefore, no association between COI and RA could be determined. A post hoc analysis showed only 5% of journals in which DN trials were published were members of the International Committee of Journal Editors, which requires comprehensive COI reporting. Authors from 20 (32%) DN trials responded to the RA survey. At least 1 RA item was present in 100% of DN trials according to the surveys but in just half of reports. A nearly 5-fold greater magnitude of RA per trial was found in the survey responses (3.75/5) compared to study reports (0.80/5). The disparities in COI and RA reporting in published trials compared to survey responses suggest that COI and RA might be under-reported in DN trials. Trials of

psychotherapy interventions have found significant effects of RA on outcomes, and the effect increases with the magnitude of RA. Improved reporting of COI/RA in clinical trials of PT interventions may improve trustworthiness of results and help identify the various factors involved in complex interventions provided by physical therapists. Doing so, could help optimize PT treatments.

*Keywords:* conflict of interest, researcher allegiance, dry needling, systematic appraisal

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# Conflicts of Interest and Researcher Allegiance in Clinical Trial of Dry Needling for Musculoskeletal Pain Disorders: A Systematic Appraisal

In the medical,[1–5] dental,[6] and psychotherapy[7–10] research literature, numerous investigators have raised concerns about the influence of conflicts of interest (COI) on the results and conclusions in clinical trials and other empirical studies of interventions in their respective fields. The concern is that various manifestations of COI, both financial and non-financial in nature, may bias the results and conclusions from clinical trials and subsequent systematic reviews,[11–17] which then influence clinicians to adopt treatments that lack an adequate scientific basis or may even be harmful. While the issue of COI has gained wide attention in other health care professions, a similar systematic effort to address the presence and effect of COI in the research of non-invasive, conservative treatments for musculoskeletal pain disorders (MPDs) provided by physical therapists has not been undertaken. Now that the physical therapy (PT) profession has advanced to the clinical doctorate as its entry-level degree, with a commensurate emphasis on evidence-based practice, there's a need to ensure that interventions provided by physical therapists are based on research that can be trusted. Therefore, more systematic and rigorous scrutiny of the potential bias resulting from COI in research relevant to physical therapy practice is needed.

The efficacy and effectiveness of conservative treatments for a wide range of MPDs remains unclear.[18–24] An example of an intervention for MPDs that has gained popularity among non-medical providers, including physical therapists, in recent years is dry needling (DN). However, two recent meta-analyses of DN to treat MPDs, published in the same journal just a few years apart, reached opposing conclusions about the efficacy of this intervention for reducing pain and disability.[25,26] While Kietrys et al[25] ascribed "grade A" evidence to DN and recommended its use in clinical practice to treat neck pain, Gattie et al[26] found less favorable

results for a variety of MPDs treated by physical therapists and did not recommend adoption of DN into physical therapist practice. When research evidence is presented in the form of meta-analyses, which are weighted heavily as a warrant for adoption or rejection of an intervention, clinicians may be less likely to apply evidence to practice if such studies conflict. Investigations of practice patterns in other health care professions show that conflicting results and unclear or ambiguous research reporting are major barriers to implementation of evidence-based practice.[27–29]

Rapid increases in clinical interest and research of DN have occurred in recent years. The increase in clinical interest has contributed to the proliferation of DN continuing education programs. A recent rapid expansion of DN courses for physical therapists has occurred since the late 1990's (**Table 1**), with most of these programs appearing within the last 5 years. A Medline/EBSCO Host search using the terms "dry needling" OR "intramuscular stimulation" from 1947 through 1999 yielded only 48 citations. However, from 2000 through October 2018, the number of citations using the same terms has increased nearly 10-fold in this single database alone. Finally, DN has received endorsements from professional physical therapy organizations in the United States. The Federation of State Boards of Physical Therapy, the American Physical Therapy Association, and the American Academy of Orthopaedic Manual Physical Therapists have published position statements which support the use of DN by physical therapists.[30,31]
In order to have confidence in the reported clinical benefits of DN and minimize the risk of harm, including undue financial burden to patients, we believe it is vital to have a robust and thorough understanding of the validity of the evidence base in terms of the classic risks of bias (i.e., randomization, blinding, allocation concealment, loss to follow-up, intention to treat analysis, etc.) as well as the often overlooked impact of COI. Although previous meta-analyses have

addressed the efficacy and effectiveness of DN, [25,26,32–36] an assessment using a consistent methodology to account for the presence and potential influence of COI on DN trials has not been attempted. Furthermore, assessing only the classical elements regarding risk of bias might be insufficient. According to the findings from a recent series of large-scale Cochrane reviews,[2,37] industry sponsorship of drug and medical device trials led to more favorable results for the drug or device under investigation, suggesting the influence of financial COI on outcomes. However, industry-sponsored studies did *not* have significantly higher risk of bias than non-industry-sponsored studies. The authors concluded that a separate source of bias, not accounted for by the traditional risk of bias domains, must be present in studies that are prone to COI.

The conventional understanding of COI is that potential financial gain unduly influences an investigator's objectivity, which can then result in bias in the design and reporting of results of clinical trials. In pharmaceutical drug and medical device studies, this occurs when the trial is sponsored by the industry that manufactures and markets the drug being investigated.[2,3,38] However, in addition to financial COI, recent methodological analyses of empirical studies show a growing concern over the influence of non-financial COI,[8,11,39–41] and this is reflected in a recently updated definition of COI cited in an Institute of Medicine's committee report for managing COI in clinical practice guidelines[42(p78)]:

> 1) A divergence between an individual's private interests and his or her professional obligations such that an independent observer might reasonably question whether the individual's professional actions or decisions are motivated by personal gain, such as financial, academic advancement, clinical revenue streams, or community standing, and
>
> 2) A financial or intellectual relationship that may impact an individual's ability to approach a scientific question with an open mind."[43(p565)]

In the case of DN, the proliferation of continuing education programs teaching these methods warrants concern of direct financial COI inasmuch as these private business entities may employ faculty who are involved in clinical research of DN. Also, as with drug and device company sponsorship of medical research, funding of DN clinical trials by companies involved in manufacture and sale of needling equipment and supplies constitutes potential financial COI.

A manifestation of non-financial COI has been conceptualized in clinical research of psychotherapies as researcher allegiance (RA). [8–10,14,15,44–46] "Therapeutic allegiance" was the term originally used by Luborsky et[46(p1003)] al in 1975 to describe clinical researchers that are "partisans of a form of treatment who do studies of it." The concept developed out of an increasing awareness that clinical trials of a variety of psychotherapeutic interventions for the same condition showed positive results- the so-called "Dodo bird effect."[45–47] Subsequent analysis has shown that indeed RA has an independent and robust influence on the results of psychotherapeutic treatments.[15,44,48] However, whether positive results reflect an association between researchers' level of training and proficiency with the method or a bias in the design and implementation of the studies has been an ongoing topic of debate among researchers in the field of psychology.[49–51] As of this writing (June 2020), we are not aware of any formal effort to address the issue of RA as a form of non-financial COI and potential source of bias in the efficacy research investigating treatments for patients with pain due to MPDs.

With respect to non-financial COI/RA in DN research, significant growth in studies reporting positive results of DN for a variety of MPDs has taken place over the last decade (**Table 2**). As positive results of outcome trials accumulate, study authors are more likely to over-estimate effects sizes of subsequent meta-analyses of the treatment.[52] The potential for professional investigators and the academic institutions they work in to derive at least indirect

non-financial benefits from DN research makes the investigators and institution susceptible to COI and could therefore bias the studies' results and conclusions. Based on these concerns, the aims of this study are twofold:

1. To determine the frequency and methods of conflict of interest (COI) reporting in published DN trials.

2. To determine the frequency of researcher allegiance (RA) and the nature of reported COI in DN trials and to assess their association.

*Operational definitions*

Conflict of Interest: 1) A divergence between an individual's private interests and his or her professional obligations such that an independent observer might reasonably question whether the individual's professional actions or decisions are motivated by personal gain, such as financial, academic advancement, clinical revenue streams, or community standing, and 2) A financial or intellectual relationship that may impact an individual's ability to approach a scientific question with an open mind."[43(p565)]

Researcher Allegiance: "…in the context of treatment outcomes research, is a belief in the superiority of a treatment [and]…usually also entails a belief in the superior validity of the theory of change that is associated with the treatment."[49(p55)] This allegiance produces an effect separate from any efficacy of the treatment, itself.

Dry Needling: use of a solid, thin filiform needle "to penetrate the skin and stimulate underlying myofascial trigger points, muscular, and connective tissues for the management of neuromusculoskeletal pain and movement impairments."[30(p2)]

Musculoskeletal Pain Disorder**:** a condition characterized by impairments in the neuromusculoskeletal system resulting in pain, reduction in range of motion, and disability.

Common examples include low back pain, shoulder tendinopathy, and knee osteoarthritis. Studies that enroll participants with acute, subacute and chronic MPDs will be included. Conditions treated with DN, such as fibromyalgia, migraine headache, post-operative pain, and medical conditions related to suspected visceral organ disease and psychological disorders were excluded from this investigation.

## Literature Review

Between 1995 and 2011, biomedical research funding tripled in the United States, with similar amounts originating from federal government and private industry sources.[53] With such a prodigious increase in funding opportunities for scientific research, the influence of conflicts of interest (COI) on the reporting and outcomes of research studies has gained increased scrutiny. A recent issue of the *Journal of the American Medical Association* (*JAMA*) was entirely devoted to the issue of COI in medical research, education and practice.[54] Concerns over the influence of COI in other health professions have recently become a topic of formal investigation, as well,[6–10,38] but not nearly to the degree or intensity that has occurred in the medical profession.

Nonetheless, the PT profession has taken notice of growing COI concerns in health care research, practice and education. Prompted by the above-mentioned *JAMA* issue, the editor-in-chief of the American Physical Therapy Association-sponsored journal *Physical Therapy,* Allan Jette, recently penned an editorial addressing the issue of COI in PT research,[16] and he followed that up more recently with another commentary specifically addressing the issue of "spin" in the publication of clinical trials in PT.[17] Prior to this, in 2010, Jette's predecessor as editor-in-chief of *Physical Therapy,* Rebecca Craik, announced the journal's adoption of the COI standards put forth by the *International Committee of Medical Journal Editors*.[55] Both editors addressed financial and non-financial forms of COI. Craik broke down the sources of COI into four major categories:

1. Authors' associations with commercial entities that provided support for the work reported in the submitted manuscript.
2. Authors' associations with commercial entities that have an interest in the general area of the submitted manuscript.
3. Any financial associations involving the author or author's spouse and children younger than 18 years of age.
4. Any nonfinancial associations that may be relevant to the submitted manuscript.[55]

Subsequently, Jette expressed his assessment that concerns of COI have "disproportionately focused" on secondary financial interests, and then he provided a more detailed breakdown of the non-financial conflicts that are also potential sources of bias:

1. Friendships
2. Institutional affiliations
3. Previous work in a given topic area
4. Interest in professional advancement[16]

In the more recent editorial published in *Physical Therapy*, Jette highlighted the issue of "spin" in reports of clinical trials, whereby these incentives produce "an inherent temptation…for researchers to report the findings of their research in the most favorable light."[17] Jette's comments echo the most recent Agency for Healthcare Quality in Research report "Assessing the Risk of Bias of Individual Studies in Systematic Reviews of Health Care Interventions," wherein "spin" is defined as "biased presentation of results" in the discussion and conclusion of individual studies that should be considered a "flag" for potential risk of bias.[56] Jette cited data from multiple studies showing the prevalence of publication spin in clinical research, and then proposed strategies to minimize this source of bias. However, the prevalence data cited was from the biomedical research. To date (June 2020), no formal effort has been undertaken to examine this issue in clinical research specifically relevant to PT practice.

The purpose of this review is to examine the development of the concept of COI within medical ethics, and more particularly in the field of PT and the various ways COI influences the conduct and interpretation of clinical research. In particular, the rapidly expanding and controversial practice of DN in PT will be presented as an object lesson of the influence of COI in producing potential bias in the reporting and conclusions of clinical trials.

*Section 1 Development of medical ethics in Western medicine*

It is not surprising that formal analysis of the influence of COI has far and away predominated in medicine and biomedical research. The origin of medical ethics can be traced back to antiquity, most commonly associated with Hippocrates and the Hippocratic Oath, but also with his contemporary, Aristotle. A physician himself, Aristotle provided the basis for modern medical ethics with his descriptions of the character traits of the virtuous practitioner.[57] Aristotle's virtuous traits were summarized into two categories by Pellegrino[57]:

| **Medical Virtues** | **Intellectual Virtues** |
|---|---|
| Fidelity | Science |
| Honesty and truth-telling | Art |
| Compassion | Practical wisdom |
| Effacement of self-interest | Intuitive wisdom |
| Courage | Theoretical wisdom |
| Justice | |

These traits were further advanced by the Pythagoreans in the Hippocratic texts and continued to undergo "metamorphosis" as they were shaped by the Greek Stoics and then primarily, particularly in the West, Judeo-Christian precepts.[58]

However, despite these ancient origins, defining the professional role of the modern physician within a moral framework has by no means proceeded along an incrementally positive course towards the attainment of the virtuous traits described by Aristotle. McCullough[59] recounted how medicine had by the 18th century regressed to "a genuine marketplace of medical practice" in which a hodgepodge of often marginally-trained practitioners vied for a chance at treating illness and injury with poorly evidenced interventions. In a previous paper addressing the ethical challenges facing "physician-leaders" during the advancement of managed health care networks, Chervenak, McCullough's co-author, warned that a modern-day "crisis" was occurring in medicine that "parallel[s] the situation in eighteenth century Great Britain."[60(p880)] McCullough seemed to attribute this deterioration in ethical conduct on the ancient Hippocratic texts themselves, arguing that they promote as a primary goal protection of the self-interests of physicians over the interests of patients.

Furthermore, due to the lack of a formal scientific method acquired during the Enlightenment, McCullough argued that the Hippocratic ethic fundamentally lacked moorings in a clearly defined concept of professionalism.[61] According to these authors, medicine as a profession was not defined in a modern sense until the mid-18th century when John Gregory and Thomas Percival "invented" the concept.[59,61] Orr et al,[62] in contrast, referred to the development of medical professionalism as "a kind of moral archeology"[63(p377)] that evolved out of the same foundational precepts that gave rise to the morals and values of Western Civilization. The results of these investigators' content analysis of medical schools in the United States and Canada showed that nearly half of them continued to use some form of the Hippocratic Oath up to 1993, thus demonstrating the endurance of Hippocratic ideals into the modern era. Jotterand[63(p114)] agreed when she stated, "Clearly, the [Hippocratic] Oath contains moral and ethical obligations, prohibitions, and exhortations that constitute the 'profession's ideology' behind Hippocratic medicine." Moreover, she added that those who have diminished the role of the Hippocratic Oath in shaping modern medical practice "…discount the full force of its power as a document to direct professional conduct."[64(p115)] Regardless of when exactly medical professionalism originated, the rise in the use of some form of the Hippocratic Oath during the last century, and in particular since the 1960's,[62] suggests a general sense that whatever behavior constitutes a moral and ethical practitioner continues to be a major concern among physicians, and this concern has more recently been taken up by other health care professions as well, including PT.

The crisis these authors warn of is a moral one that starts with a threat to the fiduciary relationship between the provider of care and the patient. As Pellegrino stated, "The obligations of physician as physician, *the first step in medical morality*, must depend on what we think of the healing relationship" (emphasis added). The unique nature of the healing relationship is defined by the unwell patient who arrives for care in a "wounded state of humanity" and therefore is "built on vulnerability and a promise." [64] More pragmatically, however, Brody[65(p264)] defined the fiduciary

relationship as one "in which one holds something in trust for another." Brody drew on a legal definition of "fiduciary": the relationship between two individuals wherein one is empowered to act in the best interests of the other. Typically, this definition applies to situations in which fiduciaries exert control over property owned by an individual, or "agent," and therefore "have a duty to be loyal and they must account for their actions;"[66(p347)] although, it fails to explain how the fiduciary relationship differs, if at all, in the caregiver-patient and investigator-study participant roles.

Many other authors in the area of medical ethics and bioethics have referred to the fiduciary relationship between physician and patient.[57,60,61,67–69] Indeed, Chervenak and McCullough[60(p876)] define the concept of medical professionalism as a physician who is the "moral fiduciary of the patient." Erde[68(p188)] defines this relationship in no uncertain moral terms as "a doctor's primary moral virtue…to be trustworthy as the unfailing champion of his patient's life and health." Bion[67(p586)] referred to "the essential fiduciary relationship" between physician and patient as a key element, which "demand[s] that we demonstrate the highest possible standards of objectivity and respect for the truth in scientific research, education and clinical practice."

Bion's[67] definition serves as a reminder that the fiduciary duty is role-based, depending on the social context in which the health care practitioner is operating. Erde[70] described the complex interaction of the various social roles assumed by physicians as they join into a care-provision relationship with a patient. He went on further to break down the features of health care practitioners' social roles that are susceptible to COI:

1. They are socially designed and elected, in contrast to those that seem natural and unavoidable.
2. They exist to serve the welfare or vital interests of others.
3. They involve discretion and judgment as part of the role holder's function.
4. Either the beneficiaries of the role holder's work or society in general must be able to trust the role holder simply because he holds the role. The relationship between…the professional and his client crucially involves the professional's trustworthiness.[70(pp24-25)]

Thus, the various roles held by the health care professional (HCP) can be depicted as a spoked wheel with the clinician-patient role as the hub of the wheel (**Figure 1).** The HCP's duties and responsibilities are assumed within distinct personal and public roles:

- as a care provider for the patient;
- as the member of a health care profession to hold each member accountable for breaches of the public trust via an ethical code of conduct and the legal mechanism of professional practice statutes;
- as the member of the particular health care industry (e.g. the business of providing physical therapy care) in which the clinician makes a living to engage in ethical business practices, including due diligence and honesty in billing and marketing of services;
- as the case may be, the role of clinical investigator to advance scientific knowledge and improve the quality of care through clinical research.[71]

Thus, the fiduciary relationship establishes the ethical grounding upon which the professional role of a health care practitioner is based, which in turn directs moral behavior no matter which role the professional currently occupies. For instance, as an investigator, the "Investigator-Study Participant" role shifts to the hub with the "Clinician-Patient" role becoming peripheral along with the "Profession-Public" and "Industry-Public" roles. However, none of the roles ever becomes irrelevant, as they all encompass what it means to function as a professional practitioner of healthcare. The focus of this review is on the research investigator role, in which researchers serve as fiduciary to both study participants and the public.

Which interests are primary in the context of clinical research, however, remains a topic of intense debate. Those promoting the "difference position" maintain that the roles of clinician-patient and investigator-participant are governed by separate and distinct ethical principles.[72] Essentially, advocates of the "difference position" argue that clinician-investigators do not have the same duty to

optimize therapeutic benefit ("therapeutic obligation") for study participants as caregivers have for patients (i.e. the "similarity position") because the goals are different. In the former case, the goal is to advance medical knowledge to benefit future patients whereas the caregiver's fidelity rests with providing care to the patient that is consistent with the principles of beneficence and non-maleficence.[73] Indeed, Miller and Weijer,[74] proponents of the "similarity position," acknowledged that the goal of clinical research is to advance the public interest for the benefit of future patients, but that this represents a competing interest to the duty of care to the patient-participant. Moreover, they argued that the provision of "optimal" care to study participants is misleading because the duty of care does not require provision of the best care available, only that "competent care," according to the existing standard of care, is required.[74,75] However, as noted by Shamoo,[76] often there is no or scant evidence to support even a standard of care upon which "competent care" can be established. Therefore, the underlying ethical foundation upon which "competent care" is situated, clinical equipoise (a state of honest, professional disagreement in the clinical community regarding the preferred treatment for a given condition),[77] is rendered scientifically invalid because the comparison is made from different levels of evidence, such as randomized control trial (RCT) versus case report, and therefore violates the tenets of evidence-based medicine.[78] London[79] also agreed with Shamoo[76] that as an underlying normative assumption of clinical equipoise, the "therapeutic obligation" does not apply in clinical trials that enroll healthy subjects.

London[80] has attempted to reconcile these divisions by proposing an "integrative approach" that avoids weighing the "common good" (e.g., advancement of scientific knowledge) against the interests of the individual (e.g., maintenance or restoration of good health) based on some utilitarian ethical framework. Indeed, one of the most renowned proponents of the "difference position," Franklin Miller,[81] has expressed the need for "a coherent moral identity" of physician investigators, in which "…[T]he roles of clinician and scientist are integrated to manage conscientiously the ethical

complexity, ambiguity, and tensions between the potentially competing loyalties of science and care of volunteer patients."[81(p1449)] London discussed the need to have "equal regard" for the individual interests of study participants and the societal interests that are served by advancing medical knowledge through scientific research. The "individual good" and "common good" refer to these two distinct sets of interests. Each individual has an interest in health that is not only provided within the caregiver-patient context but is also subserved by advancing scientifically sound medical research.[80] However, London, in agreement with those who are critical of including medical practice and research under the same ethical umbrella,[82–86] stipulated that invoking a formulation of clinical equipoise based on a "therapeutic obligation" to study participants requires a level of individual clinician-researcher intervention that is paternalistic. For example, if an individual decides to forego treatment for side effects during a clinical trial in order to improve medical knowledge for future patients, then it would be a usurpation of that study participant's autonomy to provide a treatment that is known to effectively treat the side-effects. Under a "therapeutic obligation" requirement, a physician would be obligated to provide the current standard of care.

*Section 2.0 COI in the biomedical research literature*

The foregoing discussion lays out the ethical concept of health care as a profession wherein practitioners serve as fiduciaries to patients, study participants and the public in order to advance the two sets of basic interests represented by the individual and common good. The onus, therefore, is on HCPs, both individually and corporately, to first identify and then effectively manage situations that potentially elevate self-interest above their duty to patients and research subjects. Within the context of research, the concern is that the failure to perform one's professional duty due to COI risks bias in the reporting and conclusions of clinical trials.

In fact, increased concerns over COI in biomedical research is supported by an expanding body of empirical evidence showing significant bias resulting from COI,[1,2,5,37,87,88] prompting efforts

to more clearly define and describe COI so that it can be better identified and managed. The ultimate goal is to minimize bias so that reporting of results and conclusions from clinical trials can be trusted to inform and advance practice. The National Academy of Medicine[89] (formerly the Institute of Medicine) recently cited a more comprehensive definition, which was proposed by the American Thoracic Society in 2009: "a relationship that may place primary interests (e.g., public well-being or research integrity) at risk of being improperly influenced by the secondary, personal interests of the relationship (e.g., financial, professional, or intellectual gains)."[43]

This definition, however, has engendered disagreement over what actually constitutes COI. In particular, the inclusion of non-financial secondary interests that, by definition, compete with the primary interests of research integrity, patient care and education of students is an ongoing and at times contentious debate. This debate was featured in a recent *JAMA* series devoted entirely to the topic of COI.[54] Specifically, Bero[90] argued that this category of secondary interests do not constitute a true COI, referring to those as "non-financial interests" and discounting their importance relative to the potentially more insidious influence of financial COI. It's worth noting that the vast majority of the commentaries in the *JAMA* issue focused primarily on COI related to financial incentives and business arrangements. Bero's piece was particularly notable in that she specifically excluded other competing interests (e.g. personal beliefs, intellectual/academic background, desire for professional prestige) that aren't based on a personal relationship or financial motive as capable of producing a COI. Moreover, in a commentary with Grundy, Bero argued that the negative effects of COI from personal relationships "rarely extend beyond the immediate situation" as opposed to the "widespread and harmful source of bias" resulting from financial COI. [91(p4)]

Others have rejected the attempt to separate financial and non-financial COI into distinct categories. Wiersma and colleagues[92] argued that parsing COI into separate categories risks diminishing the potential negative influence they can have on research and clinical practice because

they over-simplify strategies and create artificial parameters to manage them. They referenced the research in psychology and sociology showing that non-financial incentives can influence human attitudes and behaviors at least as much as financial ones. Their definition of COI acknowledges the multi-factorial complexity of clinical practice, including overlapping and intertwined motives, values, incentives and ethical demands of treating patients and advancing clinical practice. Moreover, under the increased pressures of applying evidence-based practice, clinical decisions need to be made according to the complex judgments used to integrate empirical evidence from clinical trials with patient values and preferences.[93] These authors reference and subscribe to Erde's definition of COI, which acknowledges the complex interaction between motives and social arrangements that can unduly influence the responsibilities of HCPs "…to observe, judge, and act according to the moral requirements of their role…".[70(p33)]

An example of this more nuanced definition of COI was provided by Larkin and Loewenstein[94] in the *JAMA* issue devoted to COI[54] wherein the authors described the inherent issues of COI within existing health care business models, which range from a tendency towards over-utilization in fee-for-service models to under-utilization in plans employing capitated payment schemes. However, they noted that the relationship between payment incentives (or disincentives) is hard to disentangle from the complexities of clinical decision-making:

> A complicating factor is the difficulty of assessing whether any individual procedure was influenced by physician incentives; ie, of measuring bias at the procedure level. Medical care involves significant uncertainty and heterogeneity in treatment efficacy, and patients also vary in their needs and preferences. These complexities make it difficult or impossible to identify specific cases in which payments influenced decisions, which both increases the potential for conflicts of interest to occur and makes it impossible to address the problems with remedies such as the threat of malpractice suits for unwarranted procedures.[94(p1746)]

For instance, is an early decision to order diagnostic imaging for a patient with acute low back pain (LBP) based on a direct financial incentive, an indirect one related to concerns of malpractice, or a

particular aspect of the patient's clinical presentation that prompted the clinician to deviate from an established clinical practice guideline? Or, might perhaps even a combination of those factors influence the clinician's decision to order early imaging? While there is a growing body of evidence that early diagnostic imaging for acute LBP results in no better outcomes at higher costs[95–97] and even worse outcomes in the occupational low back population,[98] the reasons for this behavior are not clear. For example, an article published in *The Wall Street Journal* describing a cost-analysis study at Virginia Mason Medical Center found that physicians who had no apparent or structural financial incentive (i.e., they were salaried employees) to order imaging studies for patients with acute LBP had simply "gotten in the habit" of ordering magnetic resonance imaging for these patients.[99] As Larkin and Loewenstein[94] suggested, structural elements within the business models that dominate health care delivery may be driving the "habit" of choosing low-value care. Moreover, since decision-making, even moral decisions involving the care of patients, are subject to automatic/intuitive reasoning processes, which are driven by self-interest, there's always a risk that even a seemingly minor COI can result in the escalation of unethical behavior. Deliberative/ controlled processes are more likely to be associated with ethical judgments.[100] This might explain how even nominal gifts from pharmaceutical salespeople, like pens and notepads, can have a significant influence on the prescribing behavior of physicians.[101]

With the inherent complexity and intermingling of various forms of COI in mind, it's important to appreciate that the risks of failing to effectively manage COI can result in impaired judgments by researchers and clinicians (**Figure 2**). Therefore, it is imperative that HCPs take measures pre-emptively to identify, prioritize and limit COI in any forms it may take. The concern that bias will create an impaired judgment in the validity of research claims or clinical decisions has been borne out by empirical research in several health care disciplines.[1,2,38,44,48,52,102,103,5–10,14,15]

Formal, published evidence of harm to subjects or patients as a result of these biases is less clear, with several notable exceptions.[103–106]

*Section 2.1 Historical predominance of financial COI in clinical practice and research*

Historically, financial COI has garnered most of the attention in both the scientific and, perhaps even more influentially, the major news media. The empirical evidence showing the negative influence of financial COI on the impartiality of industry-sponsored clinical trials became so compelling that in 1995, the U.S. government instituted regulations on financial COIs through the Department of Health and Human Services and the Public Health Service. The regulations define both who qualifies as an "investigator" subject to the rules and what constitutes a "significant financial interest,"[53] which is defined as:

> …anything of monetary value, whether or not the value is readily ascertainable, that…
> - Is related to the "Investigator's professional responsibilities on behalf of the Institution including, but not limited to, activities such as research, research consultation, teaching, professional practice, institutional committee memberships, and service panels"
> - Belongs to the investigator or the investigator's spouse or dependent children[53]

The recently published issue of *JAMA*[54] devoted entirely to COI contained only two articles that addressed non-financial forms of COI. The remaining over two dozen articles primarily focused on the problem of financial COI in clinical practice, research and education. It's possible that highly-publicized news media attention to incidents resulting in large-scale harm to the public health or in which research subjects were potentially harmed or killed has directed more attention on the negative influences of financial COI. Analyses of the soft drink industry's influence on the research agenda has produced widespread media attention showing that companies like Coca Cola suppressed data suggesting sugar plays a role in chronic diseases, such as coronary heart disease and diabetes.[108–110] However, the most common target of the media when it comes to reporting on financial COI is the pharmaceutical industry. In recent years, several major news organizations have reported on various forms of payments to physicians to promote a drug or medical device company's products.[111–117]

These news stories recount details of harm caused to study participants and patients while researchers, clinicians and institutions conducting the treatments and investigations received significant payments from the sponsoring large corporation. In addition to news stories, books by highly-regarded and influential physician leaders with provocative titles like *On The Take: How America's Complicity with Big Business Can Endanger Your Health*[118] and *The Truth About the Drug Companies: How They Deceive Us and What to Do About It*[119] promote a narrative that COI is synonymous with dubious financial incentives that are bound to result in compromised clinical judgments.

While there's no question that direct financial incentives often underlie threats to HCPs' primary duty to patients, a sales tactic that has come under scrutiny recently is "white coat" marketing.[116,117,120] In the cases reported, a nurse served dual roles as a marketer of a particular company's pharmaceutical product while at the same time engaging with patients as a medical educator. Such a role would be easy for the nurse to justify on the grounds that a valuable health care-related service is being provided to patients; however, the fact that the fiduciary duty as caregiver competed with the nurse's role as salesperson for the drug company creates a COI. A particular example of "white coat" marketing, however, is instructive of the complexity of over-lapping roles and the incentives associated with them. *Bloomberg Businessweek* reported on a drug that was developed to treat extremely rare kidney disorders, thus earning its inclusion as an "orphan drug."[120] These drugs are typically extremely costly for the person with the rare condition primarily because they are so expensive to develop and the population of people with the condition is so small. Therefore, the drug companies are under tremendous pressure to recoup their investment by finding individuals with the condition and then ensuring their compliance with the treatment protocol, which is why they hire field nurses to directly interact with patients. The story includes the case of a patient who reported feeling highly pressured by a nurse to remain on the drug even though she was not receiving significant benefits. The patient reported that the nurse warned her that she may suffer

lethal blood clots, a common complication of the rare kidney disease, if she discontinued the drug. In this particular case, unlike some other cases of "white coat" marketing, the patient was well-aware that the nurse worked for the pharmaceutical company. The article was unclear about what other financial incentive the nurse may have received by keeping the patient on the drug. However, information was provided that during sales meetings nurses were pressured by the sales team to keep patients on the drug by warning them of potential lethal consequences and, if necessary, helping them find another physician who would put them back on the drug. The obvious conclusion from the interaction with the sales team is that the pressure placed on the nurses was driven by financial self-interests, but certainly the nurses could have also experienced social pressures from their work colleagues to be part of the team. Thus, casting this scenario as simply a "financial COI," in which no other competing interests influenced the nurse's behavior, is an example of Erde's "Artificially Narrow Account": "[COIs] occur when and only when a physician strays or is tempted to stray from his role-mandated duties for the sake of his own economic benefit."[70(p13)] The pharmaceutical company's solution for managing COI was to have their nurses report to medical affairs instead of sales. While eliminating the avoidable financial COI from direct contact with the sales force, it is possible that nurses who are reporting to medical colleagues, particularly physicians, will experience a different sort of social, role-related pressure that could compete with their duty to the patient.

*Section 2.2 Non-financial COI in health care research*

The broader definition of COI offered by Erde[70] promotes a more subtle and complex, but important potential source of bias that could impede efforts to advance clinical practice, research and education. These more subtle and varied competing interests may pose more threats to unbiased clinical judgements in the context of treating complex health conditions due to the fact that they can be so difficult to identify and then manage.[11,67,92,121] Moreover, as several have noted, financial and non-financial COI are often so intermingled that they are scarcely distinguishable.[67,92,100,101] For

instance, in addition to the direct financial benefit in the event the physician owns the imaging equipment, the example of ordering early imaging for acute low back pain (LBP) could be motivated by an earnest and clinically important desire to reduce the anxiety of a distressed patient or caregiver, despite the fact that early imaging has failed to show improved outcomes.[95–97] Alternatively, that decision could also be motivated by a combination of conscious and/or unconscious competing interests, such as the clinician being pressed for time and therefore not being able or willing to spend the extra time needed to reduce the patient's or caregiver's anxiety by providing a more thorough explanation of the favorable natural history of acute LBP. Other competing interests based on the clinician's values, such as her sense of duty to waiting patients, or practical concerns (e.g. fatigue) could also influence the ultimate decision to order imaging. This practical example shows that making a determination of which "incentive"- an aversion to rudeness or the increased revenue from a superfluous imaging study- drove the clinician's behavior in any given clinical decision-making scenario consists of the interaction of often several over-lapping factors. How could these possibly be disentangled without imputing the clinician's motive? Wadman[122] warned that when a charge of COI narrowly directs attention to financial arrangements and incentives, which then leads to an imputation of the physician-investigator's motive, "this can plunge public debates into moralistic 'blame games' and lead to the withholding of information that could inform the debate."[123(p3)]

Numerous studies in the biomedical and health care-related research have investigated the presence and influence of non-financialCOI.[3,7,46,48,52,123,124,8–10,13–15,44,45] Unsurprisingly, the growth of empirical data showing undue influence of non-financial competing interests has promoted this form of COI as a general topic of concern on the editorial pages of many HCP journals.[3,50,67,91,107,121,125–138] However, both large and subtle differences remain in how various types of non-financial COI are defined.

Guyatt et al[125] defined "intellectual COI" as "academic activities that create the potential for an attachment to a specific point of view that could unduly affect an individual's judgment about a specific recommendation."[126(p739)] However, it is important to note that this definition was made in the context of clinical practice guideline (CPG) development, which consists of a panel of experts in the particular field of academic study or clinical practice that is tasked with the development and recommendation of the guideline. Due to the normative implications of CPGs, they are having a broad and increased influence on clinical practice[4,139] and can also impact reimbursement patterns.[140] Therefore, to the extent CPG development and implementation includes a variety of individuals with differing interpretations of the evidence, those individuals may be subject to closer scrutiny for COI by a variety of stakeholders than other forms of evidence, such as clinical trials and systematic reviews. Since CPGs are developed from a systematic review of best evidence, most notably the efficacy and effectiveness research, it would make sense to obviate undue influence of COI by managing it effectively at the individual study level before the data is evaluated by the CPG panel and preventing the problem of "garbage in, garbage out."

There is evidence that CPGs are subject to COI and that CPG recommendations have been negatively influenced by forms of COI that could not be defined as strictly financial in nature. A 2012 survey[141] found that less than half of the 37 organizations that frequently issue CPGs even had a COI policy in place, and of those that did about half of them failed to meet any of the National Academy of Medicine's COI standards.[42] A study of 456 World Health Organization CPGs found that a majority of strong recommendations were based on low- or very low-quality evidence,[142] and a subsequent qualitative analysis of panelists' reasons for making strong recommendations showed that "political considerations" and unwarranted certainty of benefits from an intervention influenced some panelists' decisions.[143]

Empirical evidence over a period of several decades has shown that a particular form of intellectual COI, referred to as "researcher allegiance," has resulted in measurable bias in the outcomes of psychotherapy trials.[8–10,14,15,44–46] "Therapeutic allegiance" is a term originally defined by Luborsky et al[46] in 1975 to describe clinical researchers that are "partisans of a form of treatment who do the studies of it."[46(p1003)] In that and subsequent research,[9,45] Luborsky and colleagues went on to show that the so-called "Dodo bird verdict," wherein clinical trials comparing interventions by researchers who possessed an allegiance to the method of therapy, showed an independent positive effect on the outcome due to the allegiance. The "Dodo bird verdict" is a reference to the character in Lewis Carroll's classic *Alice in Wonderland*, who at the end of a race that measured only a single dependent variable (clothes drying after running around a lake for various distances and times) announces, "Everyone has won and all must have prizes." The implication being that apart from the therapists' preference for the particular method, the interventions resulted in equivalent outcomes. The concept was first proposed by Rosenzweig[47] about 40 years prior to the initial formal analysis by Luborsky et al[46] Rosenzweig theorized that different psychotherapeutic methods would produce similar results because non-specific effects of the interaction between patient and therapist are more important than any particular attribute of the method itself.[47]

Within the context of the current financially strained U.S. health care delivery system, where care providers are reimbursed according to a system of coding procedural units of treatment, all stakeholders in the health care system, HCPs in particular, should be concerned about the awarding of "prizes" to practitioners. Over the last decade, several commentaries in prominent medical and medical ethics journals have addressed the problem of over-utilization in the U.S. health care system related to procedural reimbursement,[144–146] and recent empirical analyses have confirmed that "offensive" medicine is widespread.[147,148] An analogous situation may be occuring in clinical research, in which grant "prizes" are indiscriminately awarded to those investigators who report

positive results of trials, thereby impeding appropriate allotment of funding resources to the most promising research questions that minimize risks to patient-participants. A plethora of evidence over the last several decades confirms the presence of "publication bias," whereby positive trial results are much more frequently reported than negative trials.[149–152] It is as yet unclear what role the allegiance effect may play on publication bias, but it stands to reason that a clinical researcher who has an allegiance to a certain treatment model- one which she uses to treat patients and experiences clinical success- would be more likely to favorably review a clinical trial of that method thereby increasing its likelihood of publication. There is empirical evidence that indirectly supports this conclusion. Panagiotou and Ioannidis[52] showed that researchers who have published positive trials of an intervention are significantly more likely to believe that a subsequent meta-analysis of that intervention will show stronger effect sizes on the primary outcome than methodologists, who more accurately estimated the effects sizes of the intervention.

The concept of "equipoise" was first articulated by Fried[153] to provide an ethical underpinning for conducting RCTs but also to mitigate the effects of researcher bias, including preference or allegiance to a particular intervention. Freedman[77] refined Fried's concept with the term "clinical equipoise," which he defined as a state of "genuine uncertainty within the expert medical community…about the preferred treatment."[78(p1)] According to this definition, no arm of the trial is accepted by the clinical community as superior to any other nor is one treatment preferred by all expert clinicians in a given area of practice, thereby protecting study participants' interests but also presumably minimizing the effects of a treatment preference or allegiance that could produce bias in the outcomes of clinical trials. If true uncertainty exists regarding optimal care for a particular condition, then a RCT is warranted because the "honest null hypothesis" pre-condition has been met.[86] However, as discussed earlier when contrasting the "similarity" and "difference position", contention over the validity of the concept of equipoise centers on a profound disagreement between

the role of the care provider and clinical researcher. Those who argue that equipoise is a valid concept contend that it is founded on the clinician-investigator's duty to provide competent care during a clinical trial while also ensuring that important clinical questions are addressed.[74,82,154] Whereas those who reject the validity of equipoise counter that the ethics of clinical research and practice are distinct, [72,73,82,86] and the notion that the roles are similar is based on "therapeutic misconception;" that is, the mistaken belief that the primary reason for a patient enrolling in a clinical trial is to gain therapeutic benefit. Opponents of equipoise argue that the primary goal of clinical research is the advancement of knowledge to help future patients while preventing exploitation of study participants.[73,83]

With respect to concerns of COI, the question arises: Does the concept of clinical equipoise, grounded in the duty of care or "therapeutic obligation," effectively protect the interests of study participants as the primary interest of the researcher? As elucidated by London,[79] and consistent with criticisms of equipoise,[76,86] the equipoise condition lacks applicability to research contexts that include healthy volunteers. Perhaps more importantly, however, with respect to guarding against COI, is the problem of paternalism when an individual clinician is *not* uncertain about which treatment a patient should receive for a particular condition. According to a formulation of equipoise that is grounded in the duty of care, the clinician would be required to refuse enrollment of a patient into a clinical trial in which the patient is randomized to an intervention that the clinician is certain is inferior. The problem of paternalism arises because the uncertainty is located in the mind of the individual clinician as opposed to the clinical community (thus a strict interpretation of Fried's "theoretical equipoise"). As van der Graaf and van Delden[155] explain, however, this represents confusion over the dilemma that equipoise is intended to resolve. The individual clinician who lacks equipoise when it exists in the clinical community (as may be confirmed by an Institutional Review Board [IRB]) is in a state of disagreement with clinical experts. There are many reasons why such

conflict could exist between the beliefs of an individual clinician and the expert community, one of which includes the influence of COI producing conscious or unconscious bias on the part of the individual clinician, such as might exist if the clinician researcher has an allegiance to the intervention.

*Section 2.3 COI in physical therapy research*

Scarce mentions of issues related to COI have appeared in the PT literature. The first article formally addressing COI in PT research appeared in the journal *Physical Therapy* in 2010 by then Editor-in-Chief, Dr. Rebecca Craik.[55] She took that opportunity in an editorial to indicate that the journal was adopting the International Committee of Medical Journal Editors (ICMJE) (www.icmje.org) format for reporting and disclosure of COI. Overall, however, formal study of the topic has been extremely limited.

Moreover, the same level of concern about COI that has occurred in biomedicine has yet to appear in the PT profession on such a wide scale. A recent systematic review by Grundy et al[38] investigated the influence of COI on clinical trials in multiple non-physician health professions, but did not include PT. Moreover, despite several decades of clinical use in PT practice, the effectiveness of conservative interventions for a variety of MPDs remains in question;[156–160] therefore, there's an urgent need to determine if, like in psychotherapy, the "Dodo bird verdict" has rendered all treatments similar in efficacy and effectiveness. If so, then those interventions that result in the least harm to patients and the public health, both in terms of preventing injury and undue financial burdens, may need to be adopted into CPG recommendations. Furthermore, if some treatments are more beneficial for MPDs, are those differences real or are they due to bias resulting from COI- either financial or non-financial?

A recent EBSCO-based search of the MEDLINE and CINAHL databases using the keywords "conflict of interest" AND "physical therapy" yielded 42 citations compared with over 2800 citations

when combining "COI" with "medicine." Of the 42 citations, about 25% are related to the issue of physician ownership of PT practices. Only one of the citations is an empirical study that addressed the influence of COI on outcomes for patients receiving conservative treatment by physical therapists,[161] and in that trial, the COI was related to the comparative drug treatment, not the interventions provided by physical therapists. However, as mentioned earlier, the current Editor-in-Chief of *Physical Therapy*, Dr. Alan Jette, prompted by the previously cited *JAMA* issue,[54] recently reiterated the journal's commitment to effective disclosure and management of COI at both the study and editorial/peer review levels.[16] Jette[16] addressed both financial and non-financial COI in his commentary. Specifically, he expressed concern over the multiple potential sources of COI and identified non-financial sources in particular. He included "friendships, institutional affiliations, previous work in a given topic area, or interest in professional advancement"[56(p775)] as potential sources of non-financial COI that could influence the judgment of investigators and those involved in publishing research. To date, no similar editorial position has been published regarding the issue of COI at the preeminent musculoskeletal journal in PT, the *Journal of Orthopaedic and Sports Physical Therapy*.

The limited amount of empirical study that has been performed in PT research has addressed COI from the standpoint of clinician preferences to a treatment as defined by the concept of "personal equipoise."[135] In these trials, the authors invoke the concept of equipoise to establish the ethical basis for enrolling participants and designing clinical trials to protect patient-participants from harm but also to reduce the risk of biased outcomes to a particular intervention or treatment method. Two clinical trials of manual therapy controlled for the presences of clinician-researcher equipoise on outcomes for patients with LBP.[162,163] In both of these trials, the authors used the term "personal equipoise," which was essentially equivalent to the definition of the converse of "researcher allegiance" (RA) advanced by Munder et al:[10(p670)] "a researcher's preference for a particular

treatment." However, Cook et al[162] made a clear distinction between "clinical equipoise," as per Freedman's original definition,[77] and "personal equipoise." The distinction wasn't as clear in the trial by Bishop et al[163] as they seemed to conflate the definitions of "clinical" and "personal" equipoise: "Another consideration is the state of the clinical equipoise of a provider. Clinical equipoise is defined as genuine uncertainty regarding the efficacy of a particular treatment arm."[164(p966)] The obvious problem with this latter definition adopted by Bishop et al[163] is that a practitioner's lack of preference for an intervention is not necessarily the same as the clinical community's collective uncertainty that one intervention is superior to another, i.e. that an honest null hypothesis exists. As mentioned above, this may simply represent an individual clinician's disagreement with the clinical community, which could be due to a lack of knowledge or because of the influence of a COI resulting in an unwarranted preference for a particular intervention, i.e. RA. For instance, the practitioner may train in an intervention that has not been found to be any better than an alternative, but may prefer the alternative only because of their training. That same clinician may have taught that particular method on the continuing education circuit and therefore have a vested interest in advancing that method or approach to care. Therefore, an attempt to control for "personal equipoise" may more accurately be considered an effort to manage individual researcher's COI.

In the Cook et al trial[162] comparing thrust to non-thrust mobilization of the spine in patients with "mechanical" LBP, no difference was found when the authors presumably controlled for clinical and "personal" equipoise. However, the determination of clinical equipoise seemed to be inconsistent with the actual design of their study. They cited two CPGs as evidence that thrust manipulation "has been lauded to improve outcomes and quicker recovery"[163(p191)] for patients with acute LBP. However, the first CPG by Airaksinen et al[164] only included recommendations for chronic LBP. It should be noted that the average duration of symptoms in the Cook et al trial was >30 weeks, which is considered well-beyond the typical 7 to 12-week duration of symptoms to meet the standard of

having chronic LBP.[165] The second CPG by Laerum et al[166] did not distinguish between thrust versus non-thrust spinal manipulation for LBP (acute, subacute, or chronic). Based on these misinterpretations of the evidence upon which this study was conceived, it is questionable that the authors have even established a basis for the existence of equipoise according to any definition or formulation described in the literature.

As mentioned earlier, the attempt to control for personal equipoise is more accurately identified as an effort to minimize bias related to RA, which Cook et al indirectly acknowledged when, in reference to the pre-study evaluation of personal equipoise, they stated, "This potential bias was controlled within the study…".[162(p196)] The presumption here, however, is that clinicians who preferred one form of joint mobilization for LBP were biased and those who didn't were not. This is a misinterpretation of the concept of equipoise because being agnostic about which intervention is generally more effective for a condition does not necessarily constitute a lack of bias, particularly when that agnosticism is determined *a priori* with respect to a condition like chronic LBP, which is characterized by a high degree of complexity and clinical variability. It is certainly possible that *after* evaluating the patient according to the protocol, some clinicians who were found to be in "equipoise" *prior* to the study chose to use a certain joint mobilization technique based on a preconceived preference for that particular patient presentation. Indeed, the potential to promote such a bias was built into the design of the study since the thrust techniques used included one originally described by Maitland,[167] which presumably targets the spinal segment "pain generator," whereas the other technique is generally considered non-specific to a particular level of the spine.[168] In fact, this latter technique was originally developed to treat "sacroiliac joint dysfunction."[169] The fact that a non-specific thrust technique was utilized in a study protocol that standardized the examination so clinicians would "localize the most comparable response…to a specific level of the lumbar spine"

suggests that clinicians *did in fact* resort to a preference bias since one of the techniques used did not comport with the examination protocol.

Moreover, determining the presence of bias is not the ethical problem equipoise is intended to address. The purpose of invoking equipoise is to confront the ethical problem of randomizing patient-participants to different arms of a clinical trial due to the uncertainty over which intervention is superior, which then leads to a dilemma of what the clinician-researcher owes the patient-participant, i.e. the debate over "best available care" versus "competent care." It is the role of IRBs to make a determination of the epistemological soundness of the state of clinical equipoise. In the case of the Cooke et al trial, the IRB's responsibility was to answer the question of whether the authors have adequately justified that valid uncertainty exists among the clinical community over the superiority of thrust and non-thrust mobilization for subjects with "mechanical" LBP. Ensuring the individual clinician-researcher's "personal equipoise," on the other hand, is not the relevant requirement for guarding against bias. If an individual clinician-researcher possesses a belief in a treatment that is in conflict with the state of uncertainty in the clinical community, then that individual already presumes to know what best care is despite what the clinical community has concluded. In the Cook et al trial, therefore, it would be unethical for that clinician-researcher to participate, or be allowed to participate, in a trial in which patients were randomized to receive what that clinician-researcher believes to be an inferior treatment. Furthermore, IRBs that evaluate such designs that pre-determine levels of "personal equipoise" to control for bias need to consider the ethical implications of utilizing clinician-researchers who have already established a preference. What role may COI play in the formation of that preference?

*Section 3 Dry needling in physical therapy research and practice*

As Jette[16] expressed in his recent editorial, the influence of COI- both financial and non-financial- requires more attention in PT research and practice. He noted in particular that "concerns

have come to be disproportionately focused on financial COI,"[56(p775)] and identified several other potential sources of COI within the presumably "non-financial" category. DN is an area of practice that has gained intense interest in PT in recent years. Many systematic reviews of various forms of needling therapy (NT) efficacy trials published over the last decade have shown favorable results on pain in the immediate to medium-term for patients with a variety of MPDs (**Table 1**). Systematic reviews that included trials of "Western" forms of acupuncture were included in **Table 1** because so-called "Western medical acupuncture"[170] trials are often included in systematic reviews of DN. However, the difference between "Eastern" and "Western" forms of NT continues to be elusive and driven by unresolved theoretical distinctions, practice scope debates, and medico-legal issues.[171–174] Moreover, according to recent analyses, efforts to standardize and improve reporting of NT trials have achieved marginal success in meeting those goals.[175,176] Jia et[176] al found that less than half of English language trials of NT for knee osteoarthritis reported the theoretical rationale and only about 1% of Chinese language trials did so, thus highlighting the ongoing difficulty trialists encounter in making the distinction between "Eastern" and "Western" NT. Although this is not a comprehensive list of NT systematic reviews, **Table 1** reflects a wide range of the NT literature from journals accessed by a variety of clinicians who treat MPDs, including PTs. The table also displays the immediate to short-term results of NT on pain, which is consistent with recent guidelines from the American Physical Therapy Association[30] stating that NT should be used as "part of a broader physical therapy approach"[28(p5)] progressing to active interventions once pain is better managed.

Despite the generally favorable- at least in the short- to medium term- results on pain reported in these systematic reviews, several commentaries have recently appeared in the PT literature shedding questions on the validity of these results and the underlying theory,[177] misreporting of reliability data in trials of DN for trigger points,[178] and the need to question the efficacy of DN;[179] all of which could be a reflection of bias in the design, publication and/or reporting of DN trials, as has

been reported in the biomedical literature. Specifically regarding the misreporting of data, in two published clinical trials of DN,[180,181] the reliability coefficients for myofascial trigger point diagnosis were erroneously reported indicating much higher levels of agreement than were found in the original study cited by the authors. Each of these studies was approved by the IRBs of different universities, but included two of the same authors and the corresponding author was the same individual in both studies.

Rapid increases in clinical interest and research of DN have occurred in recent years. The increase in clinical interest has contributed to the proliferation of DN continuing education programs. Using the Google search terms "dry needling continuing education" a list was generated of North American DN courses open to physical therapists since the late 1990s, with most of these companies opening within the last 5 years (**Table 1**). Each course is offered over 3 or 4 days, and the costs reflect more or less typical rates for onsite continuing education courses offered to physical therapists. Although no current standards exists for determining a physical therapist's competency in DN based on number of credit hours,[182] the amount offered may in part reflect state PT board requirements for licensees. For example, one continuing education company (Mississippi Dry Needling) explicitly references the 50-hour minimum "face-to-face" requirement to legally utilize NT,[183] which is a requirement of both the Mississippi and neighboring Louisiana physical therapist practice acts.

The predominant theoretical underpinning for use of DN in PT practice is for treatment of myofascial pain syndrome, or more specifically to "inactivate" myofascial trigger points.[30,184–188] However, as described above, other "Western" science-based mechanisms of action have also been proposed over the course of several decades.[189–199] Rickards,[172] from an osteopathic perspective, attempted to reconcile the most popular forms of NT with the various explanatory models available. However, notably, his analysis[172] did not include a reference to the more recently introduced "mechanotransduction" theory proposed by Langevin,[194] which is cited in the APTA Educational

Resource Papers[30,200] and in a popularly-cited narrative review by a PT clinical education group.[190] Rickards[172(p3)] made a distinction between "Eastern acupuncture systems and modern Western acupuncture systems," and only addressed the latter systems in his analysis since they are based on modern theories of evidence that can be tested through scientific methods of inquiry. That is, they are based on evidence of prior plausibility using the principle of parsimony, and any hypothesis that is generated is compared to the null hypothesis using operationally-defined terms and reliable and valid methods of measurement.

Rickards[172] identified three treatment models: myofascial trigger point dry needling, neurosegmental acupuncture, and medical acupuncture. These models are largely consistent with other descriptions in the Western literature.[179,190,191,195,197,198,201–204] Each of the DN continuing education providers listed in **Table 2** subscribes to at least one of these explanatory models, in some form. For example, Myopain Seminars strictly adheres to the myofascial trigger point model,[186] whereas the Spinal Manipulation Institute invokes all three models plus the more recently proposed theory of mechanotransduction as valid rationales for NT.[190] Without question, the term "Dry Needling" predominates in PT; however, as Rickards and others have pointed out,[172–174,201] the use of this term has as much to do with medicolegal and practice scope-related issues as any underlying theoretical distinctions. The only published systematic review with meta-analysis of DN performed strictly by physical therapists to date included trials utilizing the myofascial trigger point model.[26] Although the results were somewhat mixed, the sensitivity analysis showed that DN was more effective than a validated sham procedure, at least in the short to intermediate (12 weeks) term. However, lower quality evidence showed no difference between DN and other treatments used by physical therapists; including manual therapy, exercise and transcutaneous electrical nerve stimulation.

In the context of potential negative COI influence resulting in biased reporting of results and conclusions of DN trials, these findings should be cause for concern. Recalling Miller and Brody's[86] treatise on equipoise and research ethics, they cited the results of psychology trials showing high rates of non-specific, or placebo, effects from treatments for chronic conditions like depression. Non-specific effects are commonly attributed to the results of manual therapy[163,205–210] and NT.[172,191,197,198,211,212] Moreover, patients with persistent musculoskeletal conditions often utilize PT. Generally speaking, the benefits of PT for persistent pain and disability due to MPDs show small effect sizes.[23,156,158,160,213] Therefore, as health care resources become scarcer and pressures increase on clinicians to show value based on the results of the care they provide, it will be imperative that the PT profession design well-controlled trials and systematic reviews with low risk of bias in order to determine the true efficacy and effectiveness of the treatments physical therapists provide. Addressing the scope and influence of COI, as has occurred recently in the biomedical and psychotherapy research, will be a critical part of that process.

## Methods

This study employed a cross-sectional design. The DN trials (and their respective publishers) in this study were identified by use of a systematic literature search. Therefore, Institutional Review Board approval was not required.

### *Literature search and study selection*

A systematic search of the scientific literature using PubMed was undertaken to identify systematic reviews and meta-analyses investigating the efficacy of DN for MPDs. Reviews investigating the effects of DN on pain or disability as the primary outcome was included. Only individual clinical trials of DN drawn from systematic reviews/meta-analyses that utilize a published method of assessing methodological quality/risk of bias, such as the Cochrane risk of bias tool and the PEDro quality scale, were included. Trials that compared DN to another treatment, sham-controlled trials, waiting list controls, and cross-over designs were eligible. Two cohort studies[214,215] that appeared in one review[216] were included in the analysis. The search string consisted of the following terms combined with the recently updated PubMed filter to identify systematic reviews[217]:

*Systematic [sb] AND "dry needling" [ti]*

The original scoping search strategy of NT reviews produced 64 systematic reviews that contained 162 unique trials. Screening of the titles and abstracts of those reports showed that numerous clinical trials investigated forms of NT that a) incorporated Eastern principles, b) the rationale was mixed or unclear between Eastern and Western forms of NT, or c) the review included individual trials that investigated both Western and Eastern forms of NT. Since the main focus of this study was to investigate the presence of COI and RA in DN trials *most relevant to current PT practice*, this targeted and expedited search for systematic reviews of DN was developed. Also, in order to ensure that the DN trials included for analysis were assessed with currently utilized and evidence-based study quality/risk of bias tools, the search was limited to systematic reviews

published since January 1, 2013. Only reviews published in English were included. (See **Appendix 1** for the PRISMA flow chart.)

*Screening procedures*

Two reviewers, the primary author (JWW) and a second reviewer (KV), performed screening of titles and abstracts using online citation screening software (Rayyan QCRI: www.rayyan.qcri.org[218]) according to the inclusion and exclusion criteria below. If the two reviewers did not agree, then a third reviewer (KR) was consulted to reach a consensus.

Inclusion criteria:

- Intervention- DN as operationally defined in the Introduction
- Conditions- MPDs, which is defined as a condition characterized by impairments in the neuromusculoskeletal system resulting in pain, reduction in range of motion, and disability. Common examples include low back pain, shoulder tendinopathy, and knee osteoarthritis.
- Review of efficacy trials using pain or disability as primary outcome
- Use of published methodological quality tool to assess risk of bias (per citation in References section of review)

Exclusion criteria:

- Reviews of conditions that do not meet the criteria of a MPD as above, including reviews of experimentally-induced pain in normal subjects and post-operative pain
- Non-reviews, e.g. review protocols, clinical trials, observational studies, surveys, clinical practice guidelines
- Reviews that investigated aspects of DN other than efficacy for treatment of MPDs, e.g. mechanism of action, cost-effectiveness, adverse events, utilization
- Withdrawn studies

- Studies of non-human participants

The study selection results were depicted in a PRISMA-style flow diagram (**Appendix 1**).[219]

Upon completion of the screening of reviews, the primary author extracted all clinical trials from the eligible reviews, added the citations to reference management software, removed duplicate citations, and acquired full text copies of each individual DN trial for data extraction.

*Data extraction*

Data extraction from the study reports was completed in three steps: 1) study characteristics, 2) presence of absence of defined COI criteria and 3) presence or absence of operationally defined RA criteria. The primary author (JWW) and second reviewer (KV) performed data extraction.

First, the primary author extracted the following study characteristics data from each DN trial report:

- Number of trial authors;
- Type of control: sham, another type of treatment ("comparative" or "active" control); no treatment (e.g. "waiting list" or "inactive" control),
- Number of participants in each group;
- Risk of bias tool(s) used to assess methodological quality with numerical score, and
- Funding source.

A random sample of 10% of study reports (n=6) was checked by the second reviewer and returned to the primary author for verification. In addition, if no funding source information was present in the report, the primary author attempted to contact a corresponding author (CA) to inquire about funding for the study. Two methods were used to contact authors: a) the email contact provided in the study report or, if unsuccessful, b) an attempt was made to contact either the CA or primary author at the ResearchGate website (www.researchgate.net). In cases of reviews that did not report the details of study quality/risk of bias criteria, two methods were used to acquire this data. First, the PEDro

website (www.pedro.org.au) was searched to determine if individual scoring data was available for these DN trials (n=7), 5 of which were available at the PEDro website. The remaining 2 trials, which were cohort studies, were scored by the primary author (JWW) using the PEDro scale.[220] Finally, if a trial registry was identified in the report, the primary author accessed that information online to determine if a funding source or sponsor of the trial was indicated.

Second, both the primary author and the second reviewer independently extracted COI data. After data extraction, the primary author compared results, and a third reviewer was available if needed to resolve any disagreements. The following COI information was extracted from each study:

- Method of COI disclosure, e.g., narrative statement within report, International Committee of Medical Journal Editors COI disclosure form, online document/supplement
- Number of authors that report any type of COI
- Number of authors that report each specific type/subtype of COI (see "Operationalizing COI" below)
- Number of authors providing a rationalization statement, e.g., "This relationship did not influence the investigator's conduct in this trial." (for convenience, the term "loogly," coined by Hakoum et al,[39] will be used to to identify these statements in the data collection tables and in subsequent references to these statements.)
- Number of authors with discrepancy between disclosures in the published report and disclosures in other forms, including those provided upon request
- COI disclosures described as available on request
- Whether there is a reference to COI disclosure statements for individuals other than authors, such as editors, peer-reviewers, medical writers, others

To operationalize COI, the framework established by Hakoum et al[39] was used to initially screen included studies for the various forms of COI that have been shown to unduly influence the reporting of outcomes and conclusions in the empirical research. The table below summarizes this classification framework:

| | Financial | Professional | Intellectual | Advocatory |
|---|---|---|---|---|
| Individual | Individual Financial | Individual Professional | Individual Intellectual | -- |
| Institutional | Institutional Financial | -- | -- | Institutional Advocatory |

Based on a recent extensive literature review in the area of COI by the primary author,[221] this framework is the only published work to date that comprehensively describes the various forms of COI. The definitions are partly derived from the International Committee of Medical Journal Editors' Conflict of Interest Disclosure Form, which is required by each of the six highest impact medical journals for author manuscript submissions. In determining the type of COI present, the definitions developed by Hakoum et al[39] to categorize COI in each DN trial (Appendix 2) was used. A pilot test of the COI classifications was conducted by randomly selecting 10% of the included DN trials (n=6), and both reviewers (JWW and KV) determined which type of COI was present based on the data extracted from the manuscript. No disagreements were found between the primary author and second reviewer on which type of COI was present.

Finally, to determine the presence of RA, the following set of criteria adapted from Wampold et al[48] and Munder et al[10] was employed:

1) developed or provided the intervention,

2) trained the clinicians used in the study,

3) supervised the clinicians used in the study, or

4) advocated for the therapy, which is defined as participating as a principle investigator (first, second or last author[222]) of a previously published positive trial listed in the references section of the article.[223]

5) Any author's involvement in clinical instruction of the NT method used in the study either within a formal academic setting or on a continuing education course for clinicians was also included as a criterion.

The primary author independently reviewed the first 25 trial reports in alphabetical order to determine the presence of any of the RA criteria. A 10% (3 reports) random sample of these 25 studies was created using a random number generator and full-text manuscripts were sent to the second reviewer for analysis. If any discrepancies between the primary author and second reviewer on any RA criterion from the study reports were identified, then the two reviewers met to discuss these differences. A third reviewer was available to consult until agreement was reached on the RA criteria. Additionally, an electronic survey (Survey Monkey©, San Mateo, CA) was sent to the CA of each dry needling study (**Appendix 3**). The survey consisted of questions that address the presence of each of the RA criteria listed above. The survey response period was open from February 21, 2019 until April 23, 2019.

## Results

### *Search results*

The search strategy yielded a total of 17 articles. After title and abstract screening, all 17 articles were selected for full-text screening. The full-text screening resulted in a total of 16 systematic reviews (See PRISMA flow chart in **Appendix 1**). These 16 systematic reviews comprised 62 separate trials of DN for MPDs that served as the basis for this study (**Appendix 6**). Nearly half of the DN studies (47%) had been included in one of the 16 systematic reviews, representing the largest proportion compared to studies that appeared in multiple reviews. An average of approximately 15% appeared in 2, 3 or 4 reviews and 10% were included in 5 or more reviews.

### *Characteristics of DN trials*

The 62 DN trials comprised a total of 3109 patients. The three most studied MPDs were: general myofascial pain syndrome, neck pain, and upper trapezius myofascial pain syndrome. Fifty-nine studies (95%) identified "trigger points" as the target of treatment; although, diagnostic features varied. In one study,[224] the authors referred to "hypersensitive areas" in muscles rather than "trigger points" as the target of treatment. Sample size ranged from 12[225] to 167.[226] Comparators for the DN trials were sham/placebo (34%), active control (34%), no control (26%) and inactive control (6%). Of the 16 trials that did not have a control group, 14 were comparative studies that had between two and four experimental groups and, of these, 3 trials compared DN to DN combined with another intervention (A versus A+B). Ten of the 62 DN trials included a reference to an online registry listing. However, the registry record published in one of these studies[227] was not retrievable. **Table 3** presents the general characteristics of the included DN trials.

*Methodological quality of DN trials*

A summary of quality scores of DN trials in **Table 3** shows that nearly a quarter of studies (23%) met less than 50% of the study quality tool criteria; more than half (53%) scored between 50% and 75%; and 21% exceeded 75%.

A total of seven DN trials were either not assessed by the review authors (n=2[214,215]) or the systematic review report did not include a listing or table of the study quality/risk of bias criteria (n=5[228–232]). A breakdown of study quality/risk of bias scores by criteria judged to be unclear or lacking shows that the most commonly missing criterion was blinding of subjects or clinicians (94%) followed by allocation concealment (52%), blinding of assessors (34%), completeness of data (29%) and, lastly, random allocation (23%).

*Funding information in DN trials*

Forty-four DN trials (71%) included a statement either in the report or from a CA regarding whether funding was provided for the study. Thirteen DN trials (21%) reported that the study did not receive funding. Thirty-one DN trials (50%) were funded, either internally (n=15), externally (n=15) or both (n=1). The study with both internal and external funding was included in the external funding category in **Table 4**. Eighteen trials (29%) did not have a statement about funding, and neither a corresponding or primary author could be contacted to retrieve this information. Of the 18 DN trials categorized as "not reported," 17 (94%)[215,227,231,234–246] provided an email address for either a CA or primary author in the report; although, one email address was no longer valid.[243]

In **Table 4** the characteristics of the included DN reports stratified by source of funding (internal, external, non-funded, or not reported) are presented. Nearly half (48%) of funded trials had sample sizes ≥30 compared to 31% of trials with no funding. Sample sizes <30 occurred in 46% of non-funded studies compared to 19% of funded studies.

The most commonly used control group across DN trials, sham/placebo, was used in 39% of funded studies and 23% of those not receiving funding. Among funded trials, 44% of those with external funding used a sham/placebo compared to 20% of internally-funded trials. Active controls were utilized in 52% of funded trials compared to 38% that were not funded. Active controls were used about twice as frequently in internally-funded DN trials (35%) than those receiving external funding (16%). Thirteen per cent of funded studies compared to 23% of those that were not funded lacked a control group.

Eighty-seven per cent of funded DN trials had a study quality score ≥50% compared to 77% of non-funded studies. No externally funded studies scored <50%, whereas 4 studies receiving internal funding scored <50%, representing 13% of funded trials and 6% overall.

A breakdown of study quality/risk of bias criteria by funding source indicates that failure to blind subjects/clinicians occurred most often across funding-source types (ranging between 87% and 100%). Also, lack of subject or clinician blinding occurred with similar frequency in funded (94%) and non-funded (100%) studies. The next most common quality criterion, lack of allocation concealment, occurred in 35% of funded trials compared to 38% of non-funded studies. Among funded studies, nearly twice as many internally funded DN trials (23%) lacked a clear description of allocation concealment compared to those that were externally funded (12%). The third overall most reported quality criterion, non-blinded assessors, occurred in 26% of funded studies and 38% of non-funded studies. Of those that received funding, internally funded studies had an approximately eight-fold greater frequency of non-blinded assessors (23%) than externally funded studies (3%). Incomplete data reporting was the fourth most overall reported study quality criterion, including about one-third of funded studies and 8% of those that were non-funded. Incomplete data reporting occurred with about twice the frequency in internally funded studies (23% of funded studies) compared to those that were externally funded (10%). The least reported overall study quality

criterion, lack of random allocation of study participants, occurred in 19% of funded DN trials compared to 15% of trials that were not funded.

*Conflicts of interest reporting in DN trials*

Thirty-four DN trials utilized a narrative statement to disclose COI in the published report resulting in a total of 55% of the DN trials including some form of COI disclosure. The remaining 28 (45%) trials did not include any form of COI disclosure statement in either the published report or online protocol. One study[247] made reference to "financial disclosure statements" within the narrative statement that were obtained from each author; however, no information was included about how to acquire these disclosures. One out of the 34 studies with a COI disclosure made reference to a "potential COI or source of funding" and listed the funding source in the narrative statement.[248] The author was contacted for clarification, and he stated that there was "no conflict."

*Researcher allegiance rating in DN trials*

After contacting CAs or PAs via the email address provided in the report or through the ResearchGate portal, 20 survey responses (32% response rate) were collected. The first 25 DN reports, in alphabetical order, were assessed for RA by the primary author (JWW), which included 11 studies for which survey responses had been received. Therefore, the sample of RA data consists of 34 DN trials, of which 20 includes data from both the author survey and the report.

**Table 5** presents the data on rating of RA in the DN studies. The presence of at least one RA criterion was identified in 50% of study reports, and the average number of RA criteria extracted from the reports was 0.80 per study. In contrast, among the 20 studies represented by the survey respondents, 100% reported the presence of at least 1 RA criterion, and the average number of RA criteria was 3.75 per study.

For the first RA criterion "developed/provided DN" it was found that this item was present more often than not according to the study report (41% to 6%). According to the answers by the survey respondents, 90% of studies had a major author (1st, 2nd or last) provide DN to participants in their study. For the second and third RA criteria "trained clinicians" and "supervised clinicians", the study reports showed that each of these RA factors was present in 3% of DN trials. Based on the survey data, 65% and 80% of these criteria, respectively, were present.

For the fourth RA criterion "advocated for DN" 23% of study reports met this RA criterion. The survey respondents indicated that in 65% of studies a major author was also an author of a previous positive DN clinical trial that was cited in the references of the current study. For the fifth and final RA criterion "taught DN course", no information in the study reports suggesting that any of the major authors taught DN in an academic or continuing education course was found. The survey data showed that 75% of survey respondents indicated that an author of the study taught DN as an academic or continuing education course, or both. Three of the CAs participating in the survey identified an author as teaching in an academic course *only*. The remaining 17 reported that a major author taught in either an academic or continuing education course, or both.

**Discussion**

The aim of this study was two-fold: first, to determine the frequency and methods of COI reporting in published DN trials. In general, low rates of reporting COI in DN studies were found. Forty-five percent of the 62 trials lacked a COI disclosure statement either in the report or at the online registry. Seventy-one percent of the DN trial authors provided information regarding the funding source either in the report itself or through contact with study authors. Of the trials that reported a funding source, 48% were funded internally and 52% externally. The second objective was to determine the frequency of RA, the nature of reported COI in DN trials and to assess their association. Large disparities were found between disclosure of COI (none) and the presence of RA criteria (high). No association could be established due to a potential under-reporting of COI.

Of the DN trials with a COI disclosure statement in the published report, none reported a COI. The CA of one study that disclosed a "potential COI" was contacted via email and stated there was "no conflict." The use of the descriptor "potential" to describe COI has been criticized as misleading and inaccurate because it "reflects the view that a COI only exists when bias or harm actually occurs."[107] Others have taken exception to the use of the term "COI" because it is equated with an accusation of research misconduct, when the evidence suggests this rarely actually occurs,[249] or that it imputes the motives of researchers causing them to defend what they perceive as unavoidable relationships with funding agencies, including industry sponsors.[122] Also, the ongoing debate over what constitutes COI- whether it should be primarily concerned with financial interests related to business and industry relationships [91,94,126,250] or if it should be expanded to include intangible non-financial interests, such as scholarly and ideological positions and desire for prestige and recognition among peers[11,12,16,17,40,67,92,128–130,134,285–288]- likely adds to the confusion and defensiveness. That a majority of DN trial reports did not include a COI disclosure and nearly one-third (n=20) did not respond to a minimum of two requests for identification of a funding source, suggests that

impediments to reporting potential sources of bias may be a problem in clinical research of PT interventions. Alan Jette, the editor-in-chief of *Physical Therapy,* recently expressed his concern that COI is "disproportionately focused on financial COI," and this narrow interpretation may at least partly explain the low rate of COI reporting in this study.[16]

In addition to determining and categorizing COI, RA towards the DN interventions was assessed by two methods: extraction from study reports and solicitation from study authors via a survey questionnaire (**Appendix 3**). Based on the results from the survey, all studies (100%) had at least some form of RA, and at least 65% of studies scored positive on 3 or more of 5 RA items. In contrast, among the published reports, only half had at least 1 criterion and 2 of the RA items were present in only 1 study. This disparity between DN reports and author surveys suggests RA might be an overlooked issue in the DN literature, which is understandable, as the magnitude of RA was less clear if only the published reports of the studies were assessed. These findings compare with a recent investigation of RA disclosure in psychotherapy trials[13] in which about 2/3 of studies were deemed "allegiant," and about 12% as "non-allegiant." In a related study, this research group[8] found a significant effect of RA on study results, and the effect increased with the magnitude of the RA rating. Since RA was first identified as a potential source of bias in psychotherapy trials in 1975,[46] study designs have reflected more sophisticated methods to assess its influence.[8,9,255,10,14,15,44–46,48,123] Given the dearth of RA items present in DN trial reports, it would be difficult to perform similar analyses of the effects of RA on outcomes of DN without the additional step of contacting study authors, which may be subject to errors of author recall and variable interpretation between different authors of the same study.

Ostensibly, the wide disparity between RA criteria extracted from the study reports versus survey responses seems to validate a reluctance of authors to "disclose COI." However, the findings from the survey seem to belie conventional beliefs that clinical researchers are reticent to confront

potential sources of bias when the issue is framed as RA versus COI, at least in this particular area of PT research. The admission by all 20 respondents to the survey that an average of over three RA criteria was present in their DN trials suggests an eager willingness to disclose relationships to the intervention that could affect clinician behavior during a DN trial and thereby influence results. Furthermore, the nearly 5-fold larger magnitude of RA criteria from the surveys compared to study reports suggests that authors may be unaware of RA's influence on trial designs and outcomes and therefore do not directly address it as a potential source of bias. Noting the lack of established efficacy of psychotherapeutic interventions, Ioannidis[51] suggested that "allegiance bias" should be exploited in clinical trials to provide more information about how to properly provide an intervention and to show if it works. He contended that if the developers and promoters of a new, promising intervention perform the early trials, this could provide important details of how the intervention should ideally be performed. Moreover, if no clinically meaningful effect is found by the experts, then it is unlikely that a benefit will be found in studies by non-allegiant investigators. Therefore, by accounting for what Cook et al[162] referred to as "adjunctive processes" associated with complex interventions, study designs that control for RA may help elucidate how mediators of outcomes; such as therapeutic alliance, natural history and regression to mean, differentially influence treatment effects. Clarification of the contents of the "black box" of complex interventions may improve the ability to measure other important outcomes; such as costs, adverse events, and recurrence rates, thus increasing the scope of the potential benefits of PT interventions from a broader healthcare delivery perspective.

The results of this appraisal of COI and RA in clinical trials of DN for common MPDs inform the clinician-researcher dyad in two important ways:

1) they suggest that framing clinician-researchers' treatment preferences in terms of COI may be too narrow a lens to view how these factors influence outcomes. Whereas acknowledging

them in terms of RA, in which clinicians with opposing preferences square-off in well-controlled trials with clear operational definitions of RA factors, may provide insight into the complex interactions between clinicians and patients with MPDs and therefore produce more meaningful and trustworthy results, and;

2) they identify possible impediments in the feedback loop between researchers and clinicians that can prevent the growth of clinical practice and the development of more effective treatments for patients with MPDs.

The most important recommendation for now from the authors' perspective is that journals require authors to clearly and uniformly report COI (including elements comprising RA). Explicit criteria for reporting COI have been provided by the International Committee of Medical Journal Editors (ICMJE). Alas, few of the journals that published DN trials are members. A post hoc analysis to determine the membership status of the journals that published DN trials in organizations that provide guidelines for COI disclosure (**Appendix 3**) showed that just eight (20%) journals in which DN trials were published are members of ICMJE, and only three of those were members when the DN trials were published. Therefore, presumably only four sets of DN trial authors were required to complete the ICMJE form, which clearly defines the various types of both financial and non-financial COI.

Finally, the reporting of PT interventions needs to be optimized. Assessments of RA through the screening of the reports showed that this issue was substantially under-reported by DN authors. Half of the studies did not report who developed or provided the intervention. Even more pronounced, under both the "trained clinicians" and "supervised clinicians" criteria, the rate of reporting was less than 25%. In contrast, 75% and 80% of survey respondents indicated that there was training and supervision of treating clinicians, respectively, by a major author. It is possible that these elements were left out of the published reports due to space constraints imposed by the journal. The inclusion

of online supplements that describe details of both the treating clinicians and the treatment itself, perhaps based on STRICTA[256] or an extension of the TIDieR checklist,[257] would provide more opportunities for higher quality investigations into this area of clinical research.

Our study has a number of strengths and weaknesses. A strength of our study is that the search strategy yielded a representative sample of DN trials that have been used by physical therapists to inform clinical practice in treatment of MPDs. The 62 trials spanned nearly three decades of DN research, with two-thirds being published since 2010. Half of the DN trials appeared in multiple reviews with about one-third appearing in more than two reviews. Ten (62%) of the systematic reviews, comprising nearly three-fourths of the DN trials, included a physical therapist as a major investigator (first, second or last author). The three most common MPD diagnoses- general myofascial pain, neck pain, and upper trapezius myofascial pain- are commonly treated in PT clinics, and therefore this body of evidence accurately reflects the types of patients that physical therapists treat with DN in current clinical practice. A limitation was the low response rate to the survey. Despite the survey period being open for 3 months with three additional weekly email reminders sent to CAs after the original notice, the response rate from the online RA survey was only 32%. However, 90% of survey respondents were authors of DN trials that were published since 2010, which represents 43% of DN trials analyzed in systematic reviews published since January 1, 2013. Therefore, the survey response data is weighted towards the more recent body of DN clinical research and likely provides a more accurate reflection of the presence of RA in DN trials. Another limitation was that, due to time limitations, only the first 25 DN trial reports in alphabetical order, which included 11 trials from which survey responses were collected, were assessed for RA. Assessment of the entire sample of 62 DN trials may alter the findings, although the alphabetical order likely resulted in a random subset. Finally, a priori modification to one of the RA criteria was made ("developed DN" was combined with "provided DN"), and another criterion was added

("taught DN") based on the assumption that providing and teaching an intervention is likely to represent a degree of enthusiasm or endorsement of the treatment. More formal efforts to operationally define RA are needed.

*Conclusion*

This systematic appraisal of COI and funding source reporting in clinical trials of DN found that these elements had relatively low rates of reporting. The results of this appraisal suggest that authors of DN trials are quite willing to provide additional details of RA elements in their study designs. However, there seems to be a "no one asked about that" mindset among authors. Modification or expansion of existing guidelines for ensuring study quality of complex interventions, such as STRICTA[256] and TIDieR[257], with RA criteria included in online supplements, should be considered to provide a full measure of study methods and then the data used to drive additional research to determine the effects on study quality and results. Furthermore, the inclusion of this data may drive more precise investigations into the mediators of effect sizes of the complex interventions used by physical therapists to treat MPDs. Finally, as the PT profession moves forward with creating a relevant and trustworthy body of clinical research evidence, accurate and complete reporting of COI and RA in clinical trials will improve clinicians' understanding of the various factors that can influence study results. More detailed reporting of factors that can influence outcomes will enhance the ability of physical therapists to identify higher quality studies and apply that research to practice. Doing so will promote deepening and strengthening physical therapists' fiduciary roles in both the clinic and research labs.

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**Table 1.** Characteristics of meta-analyses of randomized clinical trials investigating effects of needling therapy on pain for musculoskeletal pain disorders

| Study | Journal | Type of NT | Condition(s) treated | Follow-up Time point(s) for meta-analyses | Reported results in immediate to short/medium term | Study Quality/ Risk of Bias Assessment Tool |
|---|---|---|---|---|---|---|
| Gattie et al, 2017[26] | Journal of Orthopaedic & Sports Physical Therapy | DN | Post-op SP, chronic NP, MPS, LBP, chronic ankle sprain, WAD, TPs in neck mm | Immediate to 12 wks (short term), 6 to 12 mos (long term) | ↑↑ compared to sham | PEDro[258] |
| Rodriguez-Mansilla et al, 2016[32] | Journal of Traditional Chinese Medicine | DN | NP, MPS, SP, LBP, posterior thigh pain, HA, lateral elbow pain | Immediate, 3 to 4 wks | DN>placebo or control immediate to 3-4 wks | PEDro[258] |
| Trinh et al, 2016[259] | Cochrane Library | AC* | NP, WAD, MPS, NP and HA, NP w/ radicular symptoms | Immediate, 1d-3 mos (short term), 3 mos to 1yr, >1yr | ↑↑ compared to sham | Cochrane Back Review Group[260] |
| Liu et al, 2015[33] | Archives of Physical Medicine and Rehabilitation | DN** | Chronic MPS, TPs in neck muscles, WAD, SP | Immediate to 3d, 9-28d (medium term), 2-6 mos (long term) | DN more effective than sham/control in medium term | PEDro[258] |
| Kietrys et al, 2013[25] | Journal of Orthopaedic & Sports Physical Therapy | DN | MPS, NP, UE pain, SP | Immediate, approx. 4 wks | DN superior to sham/control immediately and approx. 4 wks | MacDermid[261] |
| Ong&Claydon, 2013[34] | Journal of Bodywork & Movement Therapies | DN | NP due to TPs, MPS | Immediate, 1-4 wks, 3-6 mos | No difference between DN and INJ | PEDro[258]/ Cochrane Handbook[262] |
| Tough et al, 2009[35] | European Journal of Pain | DN | NP, posterior thigh pain, LBP, TPs in neck muscles | (pooled) | n/a | Jadad[263] |
| White et al, 2007[264] | Rheumatology | MA† | Knee pain due to OA | 2-12 wks (short-term) | MA superior to sham | Cochrane Back Review Group‡[265] |
| Furlan et al, 2005[36] | Spine | AC & DN | Acute LBP, Chronic LBP | Immediate, <3mos (short term), 3-12mos (intermediate) | DN: ↑ immediate time point only compared to placebo | Cochrane Back Review Group[260] |

Abbreviations: DN-Dry Needling, AC-acupuncture, MA- Western medical acupuncture, SP-shoulder pain, NP-neck pain, MPS-myofascial pain syndrome, LBP-low back pain, WAD-whiplash associated disorder, TPs-trigger points, HA-headache, UE-upper extremity, TMD-temporomandibular disorder, INJ-injection of various medications (e.g. anesthetics, botulinum), RHB-multidisciplinary rehabilitation, ROM-range of motion, PPT-pressure pain threshold, PEDro-Physiotherapy Evidence Database

*Combined results from trials of both MA and Eastern acupuncture.

**Included trials that combined both Eastern and Western theoretical frameworks of needling therapy

†Authors investigated MA within "Western scientific" framework and defined an "adequate dose" using strict criteria.

(↑) limited, (↑↑) moderate evidence that needling therapy is more effective than control treatment

‡Slightly modified by authors

**Table 2.** Needling therapy companies offering courses to physical therapists

| Company | Year Est. | Course Title | Course Fee | Contact Hours |
|---|---|---|---|---|
| Kinetacore | 2006 | Functional Dry Needling Level 1<br>Functional Dry Needling Level 2<br>Advanced Functional Dry Needling Level 3<br>Functional Therapeutics<br>Functional Dry Needling of Pelvic Floor | $1250<br>$1250<br>$1000<br>$1000/1250<br>$1000 | 29/37*<br>25/33*<br>18<br>19/27<br>16 |
| Myopain | Late 1990s | DN-1 Foundations I<br>DN-2 Foundations II<br>DN-3 Advanced | $995<br>$995<br>$1095 | 34<br>34<br>32 |
| Spinal Manipulation Institute | 2007 | DN-1: Dry Needling for Craniofacial, Cervicothoracic & Upper Extremity Conditions<br>DN-2: Dry Needling for Lumbopelvic & Lower Extremity Conditions | $795<br>$795 | 27<br>27 |
| IAOM-US (Optimal Dry Needling Solutions) | 2014 | Dry Needling I<br>Dry Needling II<br>Dry Needling for Hand Therapists<br>Dry Needling Pelvic Rehab | $1095<br>$1095<br>$1095<br>$1095 | 26<br>25<br>26<br>26.5 |
| IAMPT | 2011 | Trigger Point Dry Needling Level 1<br>Trigger Point Dry Needling Level 2<br>Trigger Point Dry Needling Level 3 | $1200<br>$1200<br>$900 | 20/27<br>20/27<br>16 |
| Integrative Dry Needling | 2009 | Foundation Dry Needling<br>Advanced Dry Needling | $1295<br>$1295 | 27<br>27 |
| Systemic Dry Needling | 2015 | Foundations in Dry Needling<br>Advanced Dry Needling<br>Anatomical Dissection and Dry Needling | $1295<br>$1295<br>$2000 | 25<br>25<br>27 |
| Benchmark Rehab | 2015 | DN1: Dry Needling of the Lumbar Region & Lower Quarter<br>DN2: Dry Needling of the Cervicothoracic Region and Upper Quarter<br>DN3: Advanced Dry Needling | $795<br>$795<br>$595 | 25<br>25<br>16 |
| Hands-on Seminars | 2004 | Dry Needling – Basic Program<br>Dry Needling – Intermediate Program<br>Dry Needling – Advanced Program | $795<br>$795<br>$895 | 24<br>24<br>24 |
| The Dry Needling Institute | 2008 | DN Level 1<br>DN Level 2 | $1199<br>n/a | 21<br>21 |
| Master Dry Needling | 2017 | Master Dry Needling Level-1<br>Master Dry Needling Level-2 | $995<br>$995 | 27<br>27 |
| Dr. Trinh's Dry Needling Course (McMaster Univ.) | 2015† | Dry Needling Program-<br>An Evidence-Based Approach | $1495 | up to 50 |
| Mississippi Dry Needling‼ | 2018 | Course One<br>Course Two | $800<br>$800 | 54<br>(27 each) |

*2- and 3-day courses list for same fee
†Based on information provided online indicating course offering in Florida open to PTs (http://www.dryneedlingprogram.com/about.html). Accessed on 8/17/2017.
‡Not offered in North America
⁺Approximate course fees converted from Euros to U.S. dollars as of 4/29/2018
‼Courses offered on consecutive weekends at single course fee of $1600

**Table 3.** General study characteristics (N=62)

| | | | | |
|---|---|---|---|---|
| Funding source, n(%) | Overall* | Report | CA/PA | Registry |
| Internal | 15(24) | 6(10) | 7(11) | 2(3) |
| External[^] | 16(26) | 15(24) | 1(2) | 0(0) |
| Non-funded | 13(21) | 2(3) | 11(18) | 0(0) |
| Not reported[#] | 18(29) | - | - | - |
| Publication year, n(%) | | | | |
| ≥2010 | 42(68) | | | |
| ≥2000,<2010 | 15(24) | | | |
| <2000 | 5(8) | | | |
| Number of participants, n(%) | | | | |
| <30[‼] | 16(26) | | | |
| ≥30,<60 | 27(43) | | | |
| ≥60 | 19(31) | | | |
| Type of control group, n(%) | | | | |
| Active | 21(34) | | | |
| Sham/Placebo | 21(34) | | | |
| Inactive | 4(6) | | | |
| No control | 16(26) | | | |
| Study quality score range,‡ n(%) | | | | |
| <50% | 15(23) | | | |
| ≥50%,<75% | 33(53) | | | |
| ≥75% | 14(21) | | | |
| Unclear or lacking study quality criterion, n(%)** | | | | |
| Random allocation | 14(23) | | | |
| Allocation concealment | 32(52) | | | |
| Blinded subjects/clinicians | 58(94) | | | |
| Blinded assessors | 21(34) | | | |
| Complete data | 18(29) | | | |
| Trial registration,[+] n(%) | | | | |
| Reported | 9(15) | | | |
| Not reported | 53(85) | | | |

Abbreviations: CA-corresponding author, PA-primary author.

*Three studies had the same funding information included in both the report and online registry. The report data is included in the Table.

[^]One trial had both internal and external funding and was categorized as "external."

[#]Two methods were used to contact CAs/PAs for funding information: a) via email address provided in study report and, if no response, b) attempt to contact author on the ResearchGate platform (www.researchgate.net).

‼11(18%) of DN trials had <20 participants

‡For studies assessed in >1 review with the same study quality tool, the lowest score was used. For studies that were assessed using >1 tool, an average score was calculated using the lowest score on each tool.

**Total number of studies with quality criteria listed in report=55. An overall score only, without individual scoring of individual criteria, was provided for 5 studies that were included in 1 review,[233] and no quality score was determined for 2 studies in the one review[216] they appeared in. The 4 study quality criteria domains common to each tool were used to avoid validity issues.

†Includes Cochrane risk of bias tool, Cochrane Back Review Group tool, and Dutch Cochrane study tool

[+]One study's registry number was not valid and therefore included in the "Not reported" category.[227]

**Table 4**.General characteristics of included dry needling trials stratified by funding source

| | Overall (N=62) | | Internal (n=15) | | | External (n=16) | | | Non-funded (n=13) | | | Not reported (n=18) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | %N | %n | n | %N | %n | n | %N | %n | n | %N | %n |
| Type of control | | | | | | | | | | | | | | |
| Active | 21 | 34 | 11 | 18 | 73 | 5 | 8 | 31 | 5 | 8 | 38 | 2 | 3 | 11 |
| Inactive | 4 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 15 | 2 | 3 | 11 |
| Sham/placebo | 21 | 34 | 3 | 5 | 20 | 7 | 11 | 44 | 3 | 5 | 23 | 6 | 10 | 33 |
| No control | 16 | 26 | 1 | 2 | 7 | 3 | 5 | 19 | 3 | 5 | 23 | 9 | 15 | 50 |
| Publication year | | | | | | | | | | | | | | |
| ≥2010 | 42 | 68 | 10 | 16 | 67 | 10 | 16 | 62 | 9 | 15 | 69 | 13 | 21 | 72 |
| ≥2000,<2010 | 15 | 24 | 3 | 5 | 20 | 4 | 6 | 25 | 4 | 6 | 31 | 4 | 6 | 22 |
| <2000 | 5 | 8 | 2 | 3 | 13 | 2 | 3 | 13 | 0 | 0 | 0 | 1 | 2 | 6 |
| No. of participants | | | | | | | | | | | | | | |
| <30 | 17 | 27 | 4 | 6 | 27 | 2 | 3 | 12 | 6 | 10 | 46 | 5 | 8 | 28 |
| ≥30,<60 | 27 | 44 | 6 | 10 | 40 | 8 | 13 | 50 | 4 | 6 | 31 | 9 | 15 | 50 |
| ≥60 | 18 | 29 | 5 | 8 | 33 | 6 | 8 | 38 | 3 | 5 | 23 | 4 | 6 | 22 |
| Avg. quality score | | | | | | | | | | | | | | |
| <50% | 14 | 23 | 4 | 6 | 27 | 0 | 0 | 0 | 3 | 5 | 23 | 7 | 11 | 39 |
| ≥50%,<75% | 34 | 55 | 8 | 13 | 53 | 10 | 16 | 62 | 7 | 11 | 54 | 10 | 16 | 56 |
| ≥75% | 12 | 19 | 3 | 5 | 20 | 6 | 8 | 38 | 3 | 5 | 23 | 1 | 2 | 6 |
| Unclear or lacking study quality criterion | | | | | | | | | | | | | | |
| Random allocation | 14 | 23 | 3 | 5 | 20 | 3 | 5 | 19 | 2 | 3 | 15 | 6 | 10 | 33 |
| Allocation concealed | 32 | 52 | 7 | 13 | 47 | 4 | 6 | 25 | 5 | 8 | 38 | 13 | 21 | 72 |
| Blinded subj/clinicians | 58 | 94 | 13 | 24 | 87 | 16 | 26 | 100 | 13 | 21 | 100 | 16 | 26 | 89 |
| Blinded assessors | 21 | 34 | 7 | 13 | 47 | 1 | 2 | 6 | 5 | 8 | 38 | 7 | 11 | 39 |
| Complete data | 18 | 29 | 7 | 13 | 47 | 3 | 5 | 19 | 1 | 2 | 8 | 6 | 10 | 33 |

**Table 5.** Rating of Researcher Allegiance in Dry Needling Studies [Report (R) N=34, Survey (S) N=20]

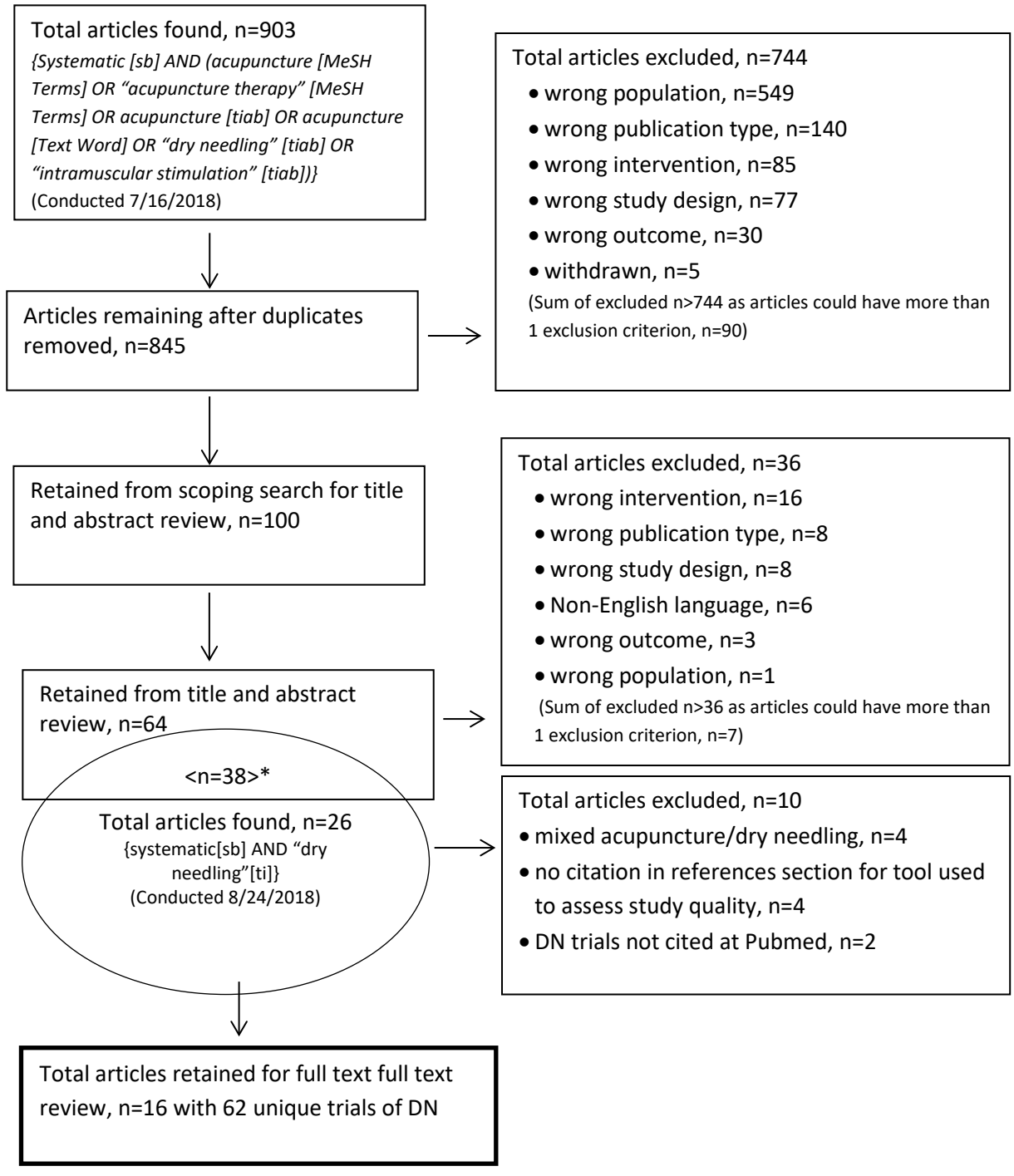
| | Developed/ Provided DN | | Trained Clinicians | | Supervised Clinicians | | Advocated for DN | | Taught DN Course | |
|---|---|---|---|---|---|---|---|---|---|---|
| Response | R | S | R | S | R | S | R | S | R | S |
| Yes n(%) | 14(41) | 18(90) | 1(3) | 13(65) | 1(3) | 16(80) | 8(24) | 13(65) | 0(0) | 15(75)* |
| No n(%) | 2(6) | 2(10) | 7(21) | 7(35) | 7(21) | 4(20) | 26(76) | 7(35) | 0(0) | 5(25) |
| Not reported n(%) | 17(50) | 0(0) | 26(76) | 0(0) | 26(76) | 0(0) | 0(0) | 0(0) | 34 (100) | 0(0) |

*Of the 15 survey respondents reporting teaching DN, 22 major authors in 15 studies taught academic courses and 16 major authors in 11 studies taught in continuing education courses.

**Figure 1:** The Health Care Professional Behavior Cycle


**Figure 2:** Causal Chain of Impaired Professional Judgment[107]

**Appendix 1.** PRISMA Flow Chart




*38 of the retained systematic reviews contained trials with a mix of NT styles; including DN, acupuncture and/or Western medical acupuncture. Therefore, a focused search was conducted with the terms above using the same time frame between 1/1/2013 and 7/16/2018 and then cross-referenced with studies from original title and abstract screening. All 26 systematic reviews were contained within the original screening procedure and 10 of these were excluded for reasons shown.

**Appendix 2.** COI Classifications

*Individual financial COI*: arises from any payment, research funding, consultancy, advisory board membership, and the like from the manufacturer of a drug or device under consideration. This type of COI may involve the individuals themselves, their families or a business they own. Typically, a timeframe of three to five years is considered for these COIs.

*Individual professional COI*: when an individual is "engaged in a specific activity as one's main paid occupation"; this provides no direct benefit however it can result in a COI or increased chance of bias because one's profession eventually provides a financial benefit; when related to the issue under consideration, an individual is expected to not speak against a clinical service/intervention that provides indirect benefit.

*Individual intellectual COI*: arises from scholarly activities by the individual related to the specific issue under consideration.

*Institutional financial COI*: arises when an institution to which an individual belongs has a relationship with the manufacturer of a drug or device under consideration. Such institutions include academic medical centers and professional societies.

*Institutional advocatory COI*: arises when an individual (paid employee or unpaid member) belongs to an institution/organization that: has missions, objectives or strategies that include statements related to the issue under consideration; support the conduct of research to promote a concept related to the issue under consideration; has senior officials who act on behalf of the institution [that] have COI related to the specific questions of interest; has professionals who advocate for clinical services related to the specific question of interest but don't provide those services themselves.

**Appendix 3.** Researcher Allegiance Survey

Researcher Allegiance in Clinical Trials of Dry Needling

Study Identification

**Our sample contains reports that list the same corresponding author for multiple studies. In order that we can accurately identify the study with the survey responses, please copy and paste the study citation that was indicated on the email invitation to this survey. You must enter the study citation to continue to the survey questions.**

* 1. Copy and paste citation below.

Researcher Allegiance in Clinical Trials of Dry Needling

Development of Dry Needling Intervention

**"Developed" means an author was directly responsible for the development of the particular style or implementation of dry needling used in the study. This includes formulation of the underlying conceptual model used to rationalize dry needling as used in the study. For example, if a study author has been involved in research investigating the concepts of myofascial pain syndrome and trigger points, and the participants in the study met the criteria for this diagnosis, that author would be a developer of the dry needling intervention used in the study.**

**"Provide" means the author administered the active dry needling intervention during the study.**

**Please choose Yes, No, or Don't know/don't recall.**

* 2. Did any of the authors develop or provide the dry needling intervention used in this study?

- ◯ Yes
- ◯ No
- ◯ Don't know/don't recall

Researcher Allegiance in Clinical Trials of Dry Needling

Development of Dry Needling Intervention

**Please indicate ALL that apply. If none of the author choices applies to your study, then choose "None of the above."**
**If there were less than 3 authors, please limit choices to "1st author" and/or "2nd author."**

* 3. Which author(s) developed or provided the dry needling intervention used in this study?

- 1st author
- 2nd author
- Last author
- None of the above

Researcher Allegiance in Clinical Trials of Dry Needling

Training of Clinicians Who Provided Dry Needling

**"Training" includes providing direct instruction of the dry needling intervention used in the study to the clinicians who provided the intervention to study participants OR conducting the training of any of the research assistants/clinicians used in the study to train those who provided the intervention to study participants.**

**Please choose Yes, No, or Don't know/don't recall.**

* 4. Did any of the authors conduct the training of the clinicians that provided dry needling in the study?

- ◯ Yes
- ◯ No
- ◯ Don't know/don't recall

Researcher Allegiance in Clinical Trials of Dry Needling

Training of Clinician(s) Who Provided Dry Needling

**Please indicate ALL that apply. If none of the author choices applies to your study, then choose "None of the above."**
**If there were less than 3 authors, please limit choices to "1st author" and/or "2nd author."**

* 5. Which author(s) conducted the training of the clinicians that provided dry needling in the study?

- 1st author
- 2nd author
- Last author
- None of the above

Researcher Allegiance in Clinical Trials of Dry Needling

Supervision of Clinicians Who Provided Dry Needling

**"Supervise" refers to any formal interaction between the authors and the clinicians who provided the dry needling intervention used in the study.**

**Please choose Yes, No, or Don't know/don't recall.**

* 6. Did any of the authors supervise the clinicians who provided the dry needling intervention used in this study?

- ◯ Yes
- ◯ No
- ◯ Don't know/don't recall

Researcher Allegiance in Clinical Trials of Dry Needling

Supervision of Clinicians Who Provided Dry Needling

**Please indicate ALL that apply. If none of the author choices applies to your study, then choose "None of the above."**
**If there were less than 3 authors, please limit choices to "1st author" and/or "2nd author."**

* 7. Which author(s) supervised the clinicians who provided the dry needling intervention used in the study

- 1st author
- 2nd author
- Last author
- None of the above

Researcher Allegiance in Clinical Trials of Dry Needling

Advocacy for Dry Needling

**"Advocated" for dry needling refers to an author that participated as an investigator in a previously published trial (RCT, pilot RCT, quasi-experimental study, case series, or case report) that was cited in the references section of this study.**

**Please choose Yes, No, or Don't know/don't recall.**

* 8. Has any author advocated for the dry needling intervention used in the study at any time in the past?

- ◯ Yes
- ◯ No
- ◯ Don't know/don't recall

Researcher Allegiance in Clinical Trials of Dry Needling

Advocacy for Dry Needling

**Please indicate ALL that apply. If none of the author choices applies to your study, then choose "None of the above."**
**If there were less than 3 authors, please limit choices to "1st author" and/or "2nd author."**

* 9. Which author(s) advocated in the past for the dry needling intervention used in the study?

- 1st author
- 2nd author
- Last author
- None of the above

Researcher Allegiance in Clinical Trials of Dry Needling

Academic Instruction in Dry Needling

**"Teach" refers to providing BOTH clinical and didactic instruction in dry needling in an academic setting, including in an entry-level professional or a post-graduate residency training program.**

**Please choose Yes, No, or Don't know/don't recall.**

* 10. Did any of the authors teach dry needling in an academic course prior to or during implementation of the study?

- ◯ Yes
- ◯ No
- ◯ Don't know/don't recall

Researcher Allegiance in Clinical Trials of Dry Needling

Academic Instruction in Dry Needling

**Please indicate ALL that apply. If none of the author choices applies to your study, then choose "None of the above."**
**If there were less than 3 authors, please limit choices to "1st author" and/or "2nd author."**

* 11. Which author(s) taught dry needling in an academic course prior to or during implementation of the study?

- 1st author
- 2nd author
- Last author
- None of the above

Researcher Allegiance in Clinical Trials of Dry Needling

Continuing Education in Dry Needling

**"Teach" refers to providing clinical and didactic instruction in dry needling as part of a continuing education course, such as a weekend certification course in dry needling.**

**Please choose Yes, No, or Don't know/don't recall.**

* 12. Did any of the authors teach dry needling in a continuing education course prior to or during implementation of the study?

- ◯ Yes
- ◯ No
- ◯ Don't know/don't recall

Researcher Allegiance in Clinical Trials of Dry Needling

Continuing Education in Dry Needling

**Please indicate ALL that apply. If none of the author choices applies to your study, then choose "None of the above."**
**If there were less than 3 authors, please limit choices to "1st author" and/or "2nd author."**

13. Which author(s) taught dry needling in a continuing education course prior to or during implementation of the study?

- 1st author
- 2nd author
- Last author
- None of the above

**Appendix 4.** Membership in Publication Guidelines Organizations of Journals in which Dry Needling Trials were Published

| | | Membership Status | | |
|---|---|---|---|---|
| **Journal Title*** | **# of DN trials** | **ICMJE** | **COPE** | **WAME** |
| Acupuncture in Medicine | 3 | - | - | - |
| American Journal of Physical Medicine & Rehabilitation | 3 | - | + | - |
| American Journal of Sports Medicine | 1 | - | + | + |
| Archives of Physical Medicine and Rehabilitation | 2 | + | - | - |
| British Journal of Sports Medicine | 1 | - | + | - |
| Chiropractic and Manual Therapies | 1 | - | + | - |
| Clinical Journal of Pain | 2 | -(2018)† | + | - |
| Clinical Rehabilitation | 1 | -(2017) | + | - |
| Clinical Rheumatology | 3 | - | - | - |
| Complementary Therapies in Medicine | 1 | - | + | - |
| Dental Press Journal of Orthodontics | 1 | -(2014) | - | - |
| Electromyography and Clinical Neurophysiology | 1 | - | - | - |
| Evidence-Based Complementary & Alternative Medicine | 2 | - | + | - |
| Fisioterapia em Movimento | 1 | - | - | - |
| International J of Clinical and Experimental Medicine | 1 | - | - | - |
| Journal of Acupuncture and Meridian Studies | 1 | - | + | - |
| Journal of Back & Musculoskeletal Rehabilitation | 1 | - | - | - |
| Journal of Bodywork and Movement Therapies | 2 | - | + | - |
| Journal of Geriatric Physical Therapy | 2 | - | + | - |
| Journal of Musculoskeletal Pain | 2 | - | + | - |
| Journal of Oral Science | 1 | - | - | - |
| Journal of Orofacial Pain | 2 | - | - | - |
| Journal of Orthopaedic & Sports Physical Therapy | 2 | - | - | - |
| Journal of Pain | 1 | - | + | - |
| Journal of Rehabilitation Medicine | 2 | - | - | - |
| Journal of Rehabilitation Sciences and Research | 1 | - | + | - |
| Journal of Research in Medical Sciences | 1 | -(2018) | - | + |
| Manual Therapy | 2 | - | - | - |
| Medical journal of the Islamic Republic of Iran | 1 | + | + | - |
| Medicina Oral, Patologia Oral y Cirugia Bucal | 2 | - | - | - |
| Pain | 2 | -(2015) | + | - |
| Pain Research and Treatment | 1 | - | + | - |
| Photomedicine and Laser Surgery | 1 | - | - | - |
| Physical Therapy | 1 | - | + | - |
| PM&R | 1 | + | + | - |
| Rheumatology International | 1 | - | + | - |
| The Journal of Alternative and Complementary Medicine | 2 | - | - | - |
| The Journal of Craniomandibular and Sleep Practice | 2 | - | + | - |
| Turkish Journal of Rheumatology | 1 | - | - | - |
| **Totals** | **59** | **3** | **21** | **2** |

Abbreviations: ICMJE=International Committee of Medical Journal Editors, COPE=Committee on Publication Ethics, WAME=World Association of Medical Editors, (+)=member, (-)=non-member
*None of the three organizations offered membership prior to 1995, therefore no DN trials prior to 1995 are included (n=3).
†Year of journal membership listing shown in parentheses. If (-), DN trial(s) published same or prior year to membership.

**Appendix 5.** In-depth discussion on study quality and funding source

Seventy-one percent of DN trials provided information on a funding source either in the report or by two methods of attempting to contact a study author. However, only 39% of DN trials reported a funding source in the published manuscript. Information on funding from the remaining studies was obtained from a CA via email. In comparison with recent data from various disciplines within clinical biomedical research, the COI disclosure/funding source reporting rates in neuro-oncology trials were 85.9%/83.1% (2010-2015),[266] in breast cancer radiation trials 68%/62.5% (2004-2014),[267] and in critical care 65%/41% (2001-2016).[268] Also, in 657 RCTs published in ten surgical journals between 2005 and 2010, Bridoux et al[269] found COI disclosure and funding source reporting rates of 25.1% and 47%, respectively. However, the COI/funding source data from these biomedical trials are based on unsolicited reporting rates from the trial reports or registry. Since the data include reporting of funding sources from 19 CAs (31% of DN trials) who were contacted by two different methods, a higher reporting rate of funding source would be expected in this study compared to those that relied only on published data in the report or online registry.

An interesting finding of this work was that when study quality was stratified by funding (yes/no), funded studies were generally of higher methodological quality. At first glance, with respect to the three “key domains” of risk of bias,[270] the data suggest the differences between funded and non-funded studies are minimal. However, given that the “not reported” and seven trials classified as “internal” are more likely “non-funded”, the differences in allocation concealment and blinding of assessors became evident. The number of funded trials failing to conceal allocation then is 8 (13%) compared to 21

(34%) non-funded trials. The number of studies that failed to blind assessors then is 6 (10%) for funded trials and 17 (27%) for non-funded trials. Moreover, similar frequencies of funded studies with ≥30 participants as non-funded studies with <30 participants were found, ostensibly suggesting that funded studies are more highly-powered, and therefore able to detect an effect from DN treatment if one exists. These results might either suggest that the funding of DN trials may serve as a “big stick” to comply with important domains of study quality or that more funds are available to ensure a high quality study.

**Appendix 6**. List of Dry Needling Trials


1. Arias-Buría JL, Fernández-de-las-Peñas C, Palacios-Ceña M, Koppenhaver SL, Salom-Moreno J. Exercises and Dry Needling for Subacromial Pain Syndrome: A Randomized Parallel-Group Trial. *J Pain*. 2017;18(1):11-18. doi:10.1016/j.jpain.2016.08.013

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