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Evaluating the Efficacy of Acupuncture for the Treatment of Intervertebral Disc Disease: A Systematic Review and Meta-analysis of Canine and Human Clinical Studies

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ABSTRACT

Intervertebral disc disease (IVDD) in dogs and humans causes pain and limits movement. This systematic review and meta-analysis analyzed published literature to determine the efficacy of acupuncture treatment to enhance outcomes for these patients. Literature was obtained through the following search engines: Library & Information Resources Network, Google Scholar, PubMed, and China National Knowledge Infrastructure. The following keywords were used for the literature search: “Intervertebral disc disease”, “Intervertebral disc herniation”, “Acupuncture”, and “Treatment” (and/or “therapy”). Inclusion criteria for meta-analysis required canine or human controlled studies reporting treatment outcome data that evaluated acupuncture’s efficacy. Fifty-five articles underwent in-depth review, with 12 studies (5 canine, 7 human) identified for meta-analysis. In canine studies, findings demonstrated combining acupuncture with conventional treatment was significantly more effective than conventional treatment only, both for treatment success rate ($p=0.0006$) and shorter recovery time ($p=0.0012$). In human studies, findings also demonstrated combining acupuncture with conventional treatment was significantly more effective than conventional treatment alone in terms of treatment success rate ($p=0.008$), as well as better scores on visual analog scale ($p=0.0001$), Japanese Orthopedic Association scale ($p=0.0038$), and pain score ($p=0.0103$). In addition, acupuncture treatment alone in human studies had a significantly improved treatment success rate when compared to conventional treatment only ($p=0.014$). Despite promising early results, the current body of evidence is limited by the small number of controlled studies available for review. Further well-designed clinical trials are essential to determine the validity of these findings and establish effective evidence-based acupuncture treatment protocols.

Keywords: acupuncture, canine, human, integrative treatment, intervertebral disc disease, traditional Chinese medicine, traditional Chinese veterinary medicine

ABBREVIATIONS: AP: acupuncture; EAP: electro-acupuncture; IVDD: intervertebral disc disease; IVDH: intervertebral disc herniation; JOA: Japanese Orthopedic Association scale; PPI: present pain intensity; QOL: quality of life scale; SMD: standardized mean difference; TCM: traditional Chinese medicine; TCVM: traditional Chinese veterinary medicine; VAS: visual analog scale

The intervertebral discs act as cushions, providing structural support to the spine; hence, the degeneration of intervertebral disc material, with or without herniation into the vertebral canal, can lead to varying degrees of injury to the spinal cord and is labeled intervertebral disc disease (IVDD). When the herniated disc exerts compression on the spinal cord, it subsequently precipitates a range of neurological manifestations. Dogs with disc herniation have a high incidence of spinal cord disease, reaching up to 72%.^{1,2} Clinical signs of canine IVDD can be markedly different. They can develop gradually or be unexpectedly acute. Pain, persistent ataxia, and paresis are three hallmark clinical signs that are most frequently linked to IVDD.³⁻⁶ Presentation will depend on the extent of the damage and

which portion of the spine is involved. Other signs include, but are not limited to: neck and back discomfort, aversion to movement, clenching paws, shaking/swaying owing to pain and impaired ability to urinate or defecate. Early intervention is crucial to preventing the disease from worsening or causing irreparable harm.

Conventional treatment for canine IVDD includes conservative non-invasive treatment and surgical treatment. Strict exercise constraints, sedatives to relax, and painkillers

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are three essential elements of non-invasive therapies, which are preferred to surgery during the early phase of the disease when clinical signs are mild; however, with conservative treatments, recurrence rates of 15-66% have been documented.^{6,7} Surgery is recommended when rest and medication are not effective in reducing pain or presentation includes severe neurological deficits/paresis. Discectomy, laminectomy, and hemilaminectomy can be used to remove the herniated disc and relieve compression. Both the possibility of recurrence and high cost can be discouraging to dog owners. One study demonstrated recurrence rate following IVDD surgery in French bulldogs reaching as high as 52.7%, and the cost of surgery averaging \$3,000 to \$8,000 US dollars.⁸ There is a need, therefore, for alternative treatment options with fewer side effects and more acceptable costs for dog owners presented with these limited choices.

Acupuncture is a traditional Chinese medicine that has been evaluated in both canine and human medicine as a treatment option for IVDD. Through insertion of needles into acupoints, it allows access to regions of the body via the peripheral nervous system and its connection to the central nervous system (CNS).⁹ It has been shown to have local, segmental (spinal) and suprasegmental (brain) effects with enhanced release of endogenous pain-relieving substances such as opioids and reduction of pain-inducing inflammatory cytokines.^{9,10} In addition, acupuncture can affect neuroplasticity of the central nervous system, to positively affect mobility, through induction of neurochemical and cytoarchitectural change.⁹ Silva et al. demonstrated in a prospective study using 181 dogs that the use of acupuncture alone or in combination with analgesics reduced pain and improved quality of life in dogs with neurological and musculoskeletal diseases.¹¹ Han et al. looked at effects in paraplegic dogs (n=80) with patients divided into conventional treatment only or a combination of acupuncture with conventional treatment. The combination group showed better recovery of ambulation, faster pain relief, and lower relapse rates than the medication-only group.¹²

Intervertebral disc disease is also a significant clinical problem for humans representing the fifth most common cause of patient visits to medical services.¹³ It presents similar clinical problems to the canine disease with back pain, neurological deficits, reduced mobility and in severe cases, progression to paralysis. Similar to canine IVDD, acupuncture in humans has been shown to modulate pain pathways, enhance local blood circulation, improve limb function and support neurological recovery.^{11,14-18} Human research in this area benefits from a greater number of well-designed randomized controlled trials, while the existing body of literature pertaining to the use of acupuncture in the treatment of canine IVDD is sparse. Studies in dogs are predominantly limited to observational retrospective studies and case reports. Moreover, there is a paucity of systematic meta-analyses investigating the efficacy of acupuncture specifically for canine IVDD.

Given the clinical disease similarities between humans and canines and the notable disparity in the number of studies, the objective of this study was to

conduct a comprehensive systematic literature review and meta-analysis to assess acupuncture's efficacy in treating canine IVDD and add information from human studies to augment the limited number of canine studies. Specifically, this systematic review collected and analyzed published scientific findings comparing treatment outcomes for canine IVDD patients and humans with disc disease between: 1) acupuncture treatment versus sham treatment (placebo or no treatment); 2) acupuncture treatment versus conventional treatment; and 3) acupuncture+conventional therapy versus conventional treatment alone. The hypothesis was that IVDD-affected patients would have better recovery outcomes from acupuncture treatment, either received alone or integrated with conventional treatment, compared to sham treatment or conventional treatment alone. By undertaking this analysis, the aim was to establish a reliable evidence-based foundation for clinical decision-making and treatment strategies for canine IVDD treatment.

MATERIALS AND METHODS

Literature Search Strategy

Four essential subject resources were used: Library & Information Resources Network (LIRN), Google Scholar, PubMed, and China National Knowledge Infrastructure (CNKI). Literature research identified all articles with the following keywords: "Intervertebral disc disease" (including IVDD), "Intervertebral disc herniation" (including IVDH), "Acupuncture", and "Treatment" (and/or "therapy"). Titles and abstracts were examined to narrow down the initial search results.

Inclusion Criteria

All controlled clinical studies related to canine or human IVDD and acupuncture treatment published in peer-reviewed journals were included in the systematic review. Studies that specifically reported acupuncture's clinical efficacy assessed by the treatment outcomes measured by the degree of neurological deficit, functional numeric scale (FNS) scores, or the time required for recovery of ambulation were included for meta-analysis. Duration of sign, improvement time, recovery time, quality of life scale (QOL), Japanese Orthopedic Association scale (JOA), and visual analog scale (VAS) were also frequently used from the literature to evaluate the effectiveness of the treatment of IVDD; therefore, literature using these methods were also included in the present study.

Meta-analysis

A meta-analysis, using statistical methods on results from 2 or more similar studies to form a pooled estimate of that data, was applied to controlled clinical trials meeting inclusion criteria. This combined data was used to improve the ability of the study to derive a conclusion about the efficacy of acupuncture treatment for IVDD with increased power and accuracy. Forest plots were used to illustrate the pooled estimate outcomes of studies used in the meta-analyses. Effect size was calculated (i.e. value estimating the strength of the relationship between the response and

treatment variables in a population). Different categories were evaluated in canine and human studies; therefore, the meta-analyses were performed separately for studies in dogs and humans. In addition, within each category, a meta-analysis using random effect model was conducted for each outcome measurement, but only for those reported in at least two studies. Level of statistical significance for all tests was set at 0.05. All statistical meta-analyses and graphical presentation of the data were conducted using an open-source public statistical software^a.

Quality Assessment

For each of the articles included in the meta-analysis, the quality of the study was assessed based on the Jadad Scale.^{19,20} The scale, ranging from 0 to 5, is widely used in systematic review studies for assessing the quality of randomized controlled trials. The assessment is based on the following three criteria: 1) “randomization” which scores 1 if mentioned, scores 2 if the method is described; 2) “blinding” which scores 1 if mentioned, scores 2 if the method is described; and 3) “data outcome” which scores 1 if the fate of all subjects in the trial is known (e.g. complete the trial, drop-out, excluded due to protocol deviation).

The risk of bias for trials that met the inclusion criteria were evaluated using the adapted Cochrane Collaboration tool. This tool assesses bias of a randomized controlled trial based on the assigned judgments of “High”, “Low”, or “Unclear” for specific elements within seven domains. These domains included: 1) random sequence generation, 2) allocation concealment, 3) blinding (participants and personnel), 4) blinding (outcome assessment), 5) incomplete outcome data, 6) selective reporting, and 7) other sources of bias.²¹ The trials assessed were evaluated through “risk bias tools” developed by McGuinness and Higgins.^{21,22} If the risk of bias evaluation results of all areas are “Low”, then the overall risk of bias is “Low”; if the risk of bias evaluation results of some areas are “Unclear” and there is no area of “High”, then the overall risk of bias is “Unclear”. Whenever there is an area where the risk of bias is assessed as “High”, the overall risk of bias is “High”.²³

RESULTS

Initial Search and Inclusion

The initial literature search was performed through the search engines using the keywords/terms and methodology described previously, which, based on the relevance of article titles and abstracts, resulted in a total of 55 articles warranted for in-depth review and assessment to determine their inclusion for statistical meta-analysis (Figure 1). Among these 55 relevant articles, 34 were canine studies and the remaining 21 were in human subjects. The 34 canine studies contained 5 controlled studies that qualified for meta-analysis, which included: 3 that compared AP + conventional treatment versus conventional treatment only;^{12,24,25} 2 comparing AP only versus conventional treatment only;^{24,26} and 1 that compared AP versus sham AP;²⁷ while 1 article contained multiple group comparisons. The other 29 were not qualified for inclusion in the meta-

analysis: 2 comparing integrative traditional Chinese veterinary medicine (TCVM) treatment (AP + other TCVM modalities) versus conventional treatment; 1 comparing integrative TCVM+conventional treatment versus conventional treatment, 3 comparing different AP methods, 2 investigating post-surgery pain relief, and the remaining 24 were case-series reports. Conventional treatment in the canine studies predominately included surgery and/or pharmaceuticals to control pain, inflammation and muscle spasms.

Among the 21 human studies, 16 were controlled studies. The 7 controlled studies that qualified for meta-analysis included: 4 that compared AP+conventional treatment versus conventional treatment only;²⁸⁻³¹ 1 that compared AP versus sham AP;³² and 3 compared AP only versus conventional treatment only.^{29,33,34} The other controlled studies included 1 for integrative TCM versus conventional treatment; 1 for integrative TCM + conventional treatment versus conventional treatment; and 7 studies reported comparisons of TCM treatments with other non-conventional treatment (e.g. oblique pulling/*Tui-na* manipulation, integrative Korean medicine treatment, herbal medicine), which are outside the scope of this research. The remaining 5 articles were 4 study protocols and 1 systematic review study. Conventional treatment in human studies predominately included surgery, pharmaceuticals, or physical therapy-based, such as traction, rehabilitation and other similar modalities.

Quality Assessment

Among the 5 controlled trials on canine subjects that met inclusion criteria, only 3 were randomized trials²⁵⁻²⁷ with 2 of these describing the method of randomization^{26,27} (Table 1). Two of the 5 trials were blinded, but neither described the blinding methodology.^{26,27} On study fate during the trial, 2 studies^{25,26} included this information when reporting the results and 1 study did not.²⁷ The overall Jadad Scale scores for the randomized controlled trials were: 1 study scored 1,²⁵ and the 2 others scored 4;^{26,27} therefore, 2 studies would be considered good quality trials (Jadad Scale ≥ 3).^{26,27} Among the 7 controlled human trials that qualified for meta-analysis, all were randomized controlled trials and all described the method of randomization, but only one study mentioned blinding (Table 2). There were 2 studies that described the fate of patients during the trial.^{28,32} On the overall Jadad Scale, 5 studies scored 2,^{29-31,33,34} 1 scored 3,²⁸ and 1 scored 5.³² Therefore, only 2 of the 7 studies would be considered good quality trials (Jadad Scale ≥ 3).

Risk of bias analysis was conducted on all randomized controlled studies which included all human studies (H-1 through H-7)²⁸⁻³⁴ and the 3 canine randomized controlled trials (C-3, C-4, and C-5).²⁵⁻²⁷ These selected studies underwent a comprehensive evaluation using the adapted Cochrane Collaboration tool. The outcomes of the risk of bias assessment based on the Cochrane criterion suggested that all but two studies had unclear overall risk of bias and the remaining two studies (H-1, H-2)^{28,34} were considered to have high risk (Figure 2). Calculation of percentage of randomized controlled studies in each level of risk (7 domains evaluated) as well as overall risk of bias showed the majority were considered unclear risk of bias (Figure 3).

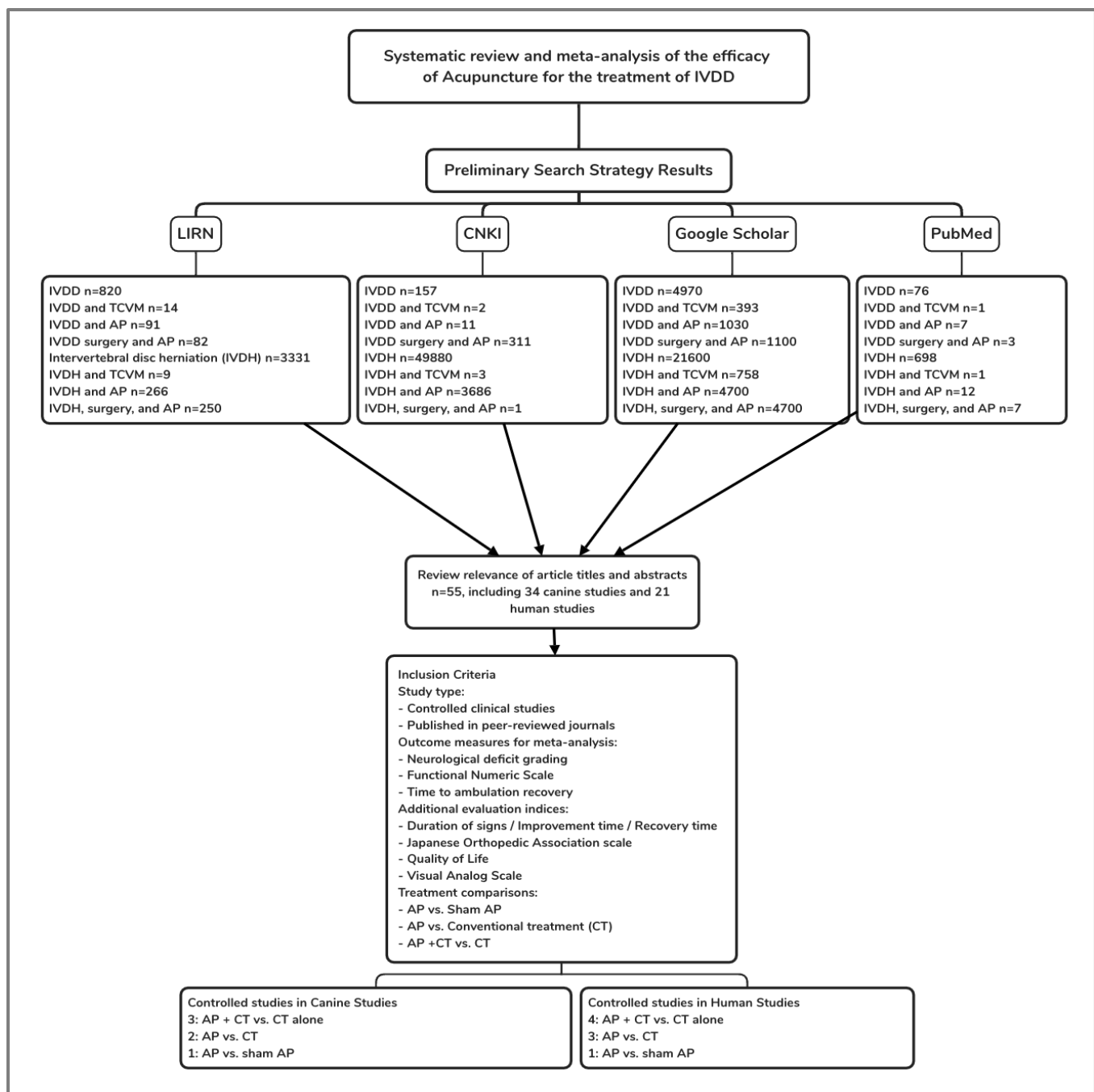


Figure 1: Flow chart of search strategy used to identify viable studies for inclusion in a systematic review and meta-analysis of the efficacy of acupuncture for the treatment of IVDD.

Table 1: Canine studies qualified for meta-analysis

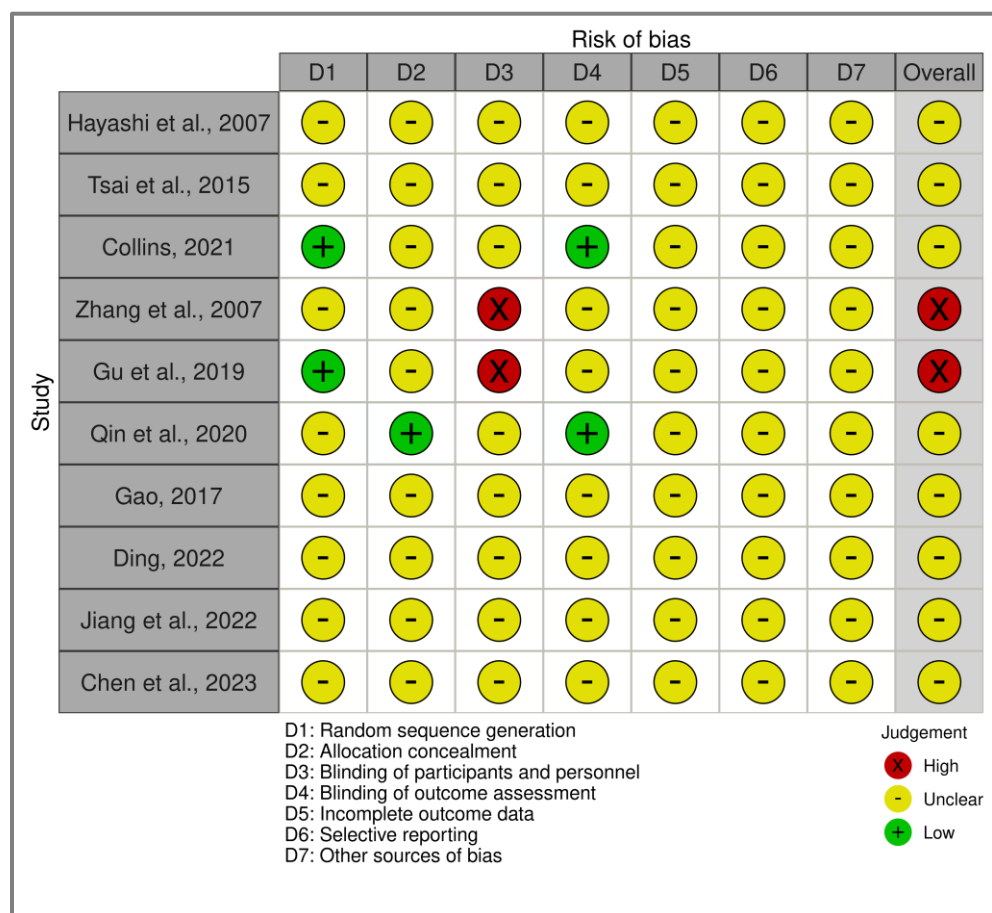
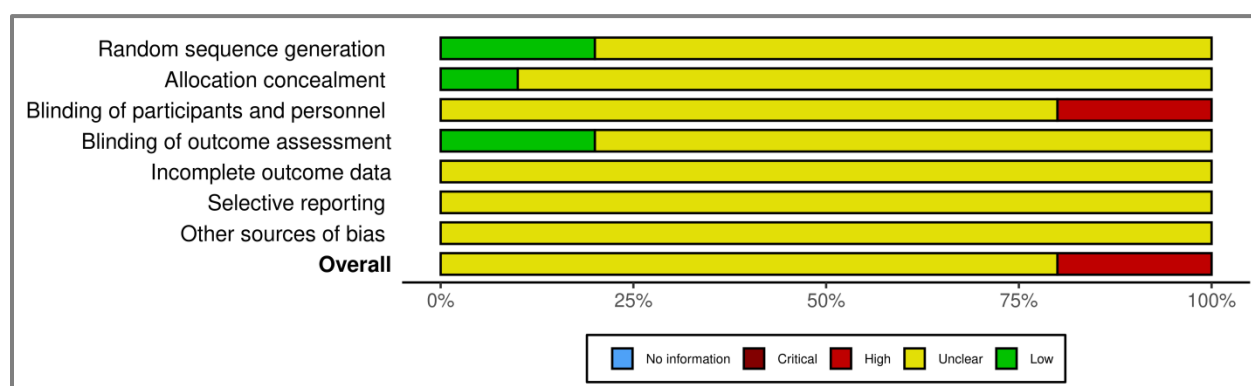
Article No.	Authors (Year)	Treatment Groups	Sample Size
C-1	Joaquim et al., 2010 ²⁴	DSX + EAP (T1) vs. EAP (T2) vs. DSX (C)	T1 = 11, T2 = 19, C = 10
C-2	Han et al., 2010 ¹²	EAP + Conv. (T) vs. Conv. (C)	T = 43, C = 37
C-3	Hayashi et al., 2007 ²⁵	EAP + Conv. (T) vs. Conv. (C)	T = 26, C = 24
C-4	Tsai et al., 2015 ²⁶	Bee venom acupoint injection (T) vs. Conv. (C)	T = 17, C = 19
C-5	Collins, 2021 ²⁷	AP (T) vs. Sham AP (C)	T = 12, C = 12

DSX = decompressive surgery; EAP = electro-acupuncture; T = Test Group; C = Control Group; Conv. = conventional treatment; AP= acupuncture

Table 2: Human studies qualified for meta-analysis

Article No.	Authors (Year)	Treatment Groups	Sample Size
H-1	Zhang et al., 2007 ³⁴	AP (T) vs. Meloxicam (C)	T = 98, C = 96
H-2	Gu et al., 2019 ²⁸	AP + Traction vs. Sham AP + Traction	30 / group
H-3	Qin et al., 2020 ³²	AP vs. Sham AP	40 / group
H-4	Gao, 2017 ²⁹	AP vs. AP + Rehabilitation vs. Rehabilitation	40 / group
H-5	Ding, 2022 ³⁰	AP + PELD + Rehabilitation vs. PELD + Rehabilitation	46 / group
H-6	Jiang et al., 2022 ³¹	AP + LLNM vs. LLNM	30 / group
H-7	Chen et al., 2023 ³³	AP (T) vs. Drug-traction (C)	T = 34, C = 33

AP = acupuncture; T = Test Group; C = Control Group; PELD = percutaneous endoscopic lumbar discectomy; LLNM = lower limb neural mobilization

**Figure 2:** Risk of bias assessment in each area of potential bias (7 domains) for each randomized controlled study**Figure 3:** Percentage of randomized controlled studies in each level of risk of bias for each of the 7 domains assessed, as well as for the overall risk of bias

Meta-analysis

Canine Studies

The 5 included controlled canine clinical studies were organized into 3 categories based on type of treatment (Table 3). Category 1 included studies C-1, C-2, and C-3 which reported comparisons between AP + conventional treatment versus conventional treatment only.^{12,24,25} Category 2 included studies C-1 and C-4 which reported comparisons between AP only versus conventional treatment only.^{24,26} Category 3 included only 1 study, C-5, which reported comparisons between AP versus sham AP.²⁷ With respect to the outcome measurements among these studies, only category 1 had multiple studies reporting the same outcome measurement. Category 1 had three studies reporting treatment success rate outcomes;^{12,24,25} and 2 studies reporting time to recover data (Table 4).^{12,25} Only 3 meta-analyses, therefore, were conducted for these 5 canine studies.

Category 1 [(AP + Conventional) vs. Conventional]

1) Based on the treatment success rate, using the random effect model, the relative risk (with 95% confidence interval) from each of the 3 studies (C-1, C-2, and C-3) and the overall relative risk (log-scaled) were calculated (Figure 4).^{12,24,25} Among the 3 studies, all observed that acupuncture + conventional treatment resulted in a better (higher) treatment success rate than conventional treatment alone, but only two of the studies reached statistical significance.^{12,25} The inference of this meta-analysis revealed a significant overall effect ($p=0.0006$) and concluded with statistical significance (at the 0.05 level) that combining acupuncture and conventional treatment can be more effective than conventional treatment only for treating dogs with IVDD.

2) Based on the time to recover, standardized mean difference [(SMD), with 95% confidence interval] from each of the two studies (C-2 and C-3) and the overall SMD were calculated (Figure 5).^{12,25} Both studies showed that acupuncture + conventional treatment resulted in a statistically significant shorter recovery time when compared to conventional treatment only. The inference of this meta-analysis revealed a significant overall effect ($p=0.0012$) and concluded with statistical significance that combining acupuncture and conventional treatment can help IVDD affected dogs recover sooner than conventional treatment only.

Table 3: Study category and lists of studies that qualified for meta-analysis in that category based on type of IVDD treatment

Category	Type of Study	Meta-analysis Canine	Meta-analysis Human
1	AP + Conv. vs. Conv.	C-1, C-2, C-3	H-2, H-4, H-5, H-6
2	AP vs. Conv.	C-1, C-4	H-1, H-4, H-7
3	AP vs. Sham AP	C-5	H-3

AP= acupuncture; Conv. = conventional treatment

Human Studies

Among the 7 studies qualified for meta-analysis, H-2, H-4, H-5, and H-6 reported comparisons between AP + conventional treatment vs. conventional treatment only (Category 1);²⁸⁻³¹ H-1, H-4, and H-7 reported comparisons between AP versus conventional treatment only (Category 2)^{29,33,34} and H-3 was the only study reporting comparisons between AP vs. sham acupuncture (Category 3),³² as listed in Table 3. Due to the number of studies, meta-analyses were only performed for categories 1 and 2. On the outcome measurement(s) reported in each study of categories 1 and 2, category 1 studies (H-2, H-4, H-5, and H-6) had multiple studies reporting the same outcome measurements, including treatment success rate, VAS score, JOA score, and pain score (Table 5).²⁸⁻³¹ Category 2 (H-1, H-4, H-7) had 3 studies,^{29,33,34} 2 reporting treatment success rate outcomes^{33,34} and also 2 studies reporting JOA scores.^{29,33} Therefore, six meta-analyses were conducted for these 6 human studies.^{28-31,33,34}

Category 1 [(AP + Conventional) vs. Conventional]

1) Based on the treatment success rates, the relative risk (with 95% confidence interval) from each of the 2 studies (H-2, H-6) and the overall relative risk (log-scaled) were calculated (Figure 6).^{28,31} Both studies observed that combining acupuncture and conventional treatment resulted in a better (higher) treatment success rate than conventional treatment alone, but only 1 study with statistical significance.³¹ The inference of this meta-analysis using the random effect model revealed a significant overall effect ($p=0.008$), which concluded with statistical significance that AP + conventional treatment can be more effective than conventional treatment only for treating human patients with IVDD.

2) Based on the VAS scores, SMD with 95% confidence interval from each of the three studies (H-2, H-5, H-6) and the overall SMD were calculated (Figure 7).^{28,30,31} All three studies showed that the integrative treatment combining acupuncture and conventional treatment resulted in a better (smaller) VAS with statistical significance over conventional treatment alone. The inference of this meta-analysis revealed a significant overall effect ($p<0.0001$) and concluded with statistical significance that combining acupuncture and conventional treatment is more effective than conventional treatment only.

3) Based on the JOA scores, all 3 studies (H-4, H-5, H-6) showed that the integrative treatment combining acupuncture and conventional treatment resulted in a better (higher) JOA score with statistical significance over conventional treatment only (Figure 8).²⁹⁻³¹ The inference of this meta-analysis revealed a significant overall effect ($p=0.0038$), which also concluded with statistical significance that combining acupuncture and conventional treatment is a more effective treatment than conventional treatment alone when treating humans affected with IVDD.

4) Based on the Pain Scores, three studies were included in this meta-analysis, where H-4²⁹ used the McGill pain score

and the other two studies (H-5 and H-6)^{30,31} used the Present Pain Intensity (PPI) score. All 3 studies showed that combining acupuncture and conventional treatment resulted in a better (lower) pain score with statistical significance over conventional treatment alone (Figure 9). The inference of this meta-analysis revealed a significant overall effect ($p=0.0103$), which also concluded with statistical significance that combining acupuncture and conventional treatment is more effective than conventional treatment alone when treating human patients with IVDD.

Category 2 [AP vs. Conventional]

1) Based on the treatment success rates, between the 2 studies (H-1 and H-7), one³³ showed that the acupuncture treatment resulted in a significantly better (higher) treatment

success rate over conventional treatment, but the other one³⁴ showed no significant difference between the two treatment groups (Figure 10). The inference of this meta-analysis revealed a significant overall effect ($p=0.014$), which concluded with statistical significance that AP treatment can be more effective than conventional treatment for treating human patients with IVDD.

2) Based on the JOA scores, both studies (H-4 and H-7)^{29,33} showed that the acupuncture treatment resulted in a better (higher) JOA score with statistical significance over conventional treatment; however, the inference of this meta-analysis did not conclude a significant overall difference ($p=0.181$) between acupuncture and conventional treatments, which was mainly due to significant heterogeneity between these two studies.

Table 4: Outcome measurements in each canine study qualified for meta-analysis

Article No.	Treatment Success Rate	Time to Recover	MSS Grade	FNS Score	Thermal Images	Relapse Rate	Side Effect Rate	Pain Relief
C-1	✓	—	—	—	—	—	—	—
C-2	✓	✓	—	—	—	✓	✓	✓
C-3	✓	✓	—	—	—	—	—	—
C-4	—	—	✓	✓	—	—	—	—
C-5	—	—	—	—	✓	—	—	—

MSS = myelopathy scoring system; FNS = functional numeric scale

Table 5: Outcome measurements in each human study (categories 1 and 2) qualified for meta-analysis

Article No.	Treatment Success Rate	VAS Score	JOA Score	Pain Score	ODI	LFR	IF	SF-36	SLR
H-1	✓	—	—	—	—	—	—	—	—
H-2	✓	✓	—	—	—	—	—	—	—
H-4	—	—	✓	✓	—	✓	✓	—	—
H-5	—	✓	✓	✓	—	—	—	—	—
H-6	✓	✓	✓	✓	✓	—	—	✓	✓
H-7	✓	✓	✓	—	—	—	—	—	—

VAS=visual analog scale; JOA=Japanese orthopedic association scale; ODI=Oswestry disability index; LFR=range of lumbar flexion; IF=inflammatory factor; SF-36=36-item short form health survey; SLR=straight leg raising

DISCUSSION

Intervertebral disc disease is a painful disorder associated with nerve damage, loss of mobility and paralysis that commonly affects both dogs and humans. Acupuncture has been considered as a viable therapy for IVDD, either combined with conventional medicine or as a stand-alone treatment. The objective of this study was to conduct a systematic literature review and meta-analysis to investigate the efficacy of acupuncture treatment as supported by well-designed randomized controlled clinical trials. Fifty-five studies were selected for in-depth review, with 12 (5 canine, 7 human) satisfying inclusion criteria for meta-analysis.

Separate meta-analyses were conducted on the 5 canine studies (treatment success rate, time to recover) and then the 7 human studies (treatment success rate, VAS scores, JOA scores, pain scores). In the canine studies, combining acupuncture and conventional treatment was more effective than conventional treatment alone ($p=0.0006$), and with shorter recovery time ($p=0.0012$). In the human studies, combining acupuncture and conventional treatment was more effective than conventional treatment alone ($p=0.008$), and resulted in better VAS scores, JOA scores, and pain scores which were statistically significant ($p<0.0001$, $p=0.0038$, $p=0.0103$, respectively). Of interest,

acupuncture treatment alone (category 2) in humans was more effective than conventional treatment alone ($p=0.014$). These findings support the study hypothesis that individuals with IVDD may achieve better recovery outcomes when treated with acupuncture, either alone or in combination with conventional treatment.

These study findings highlight emerging evidence that acupuncture enhances treatment outcomes for IVDD through multiple mechanisms by targeting all three components of the disc: the annulus fibrosus, nucleus pulposus, and cartilage endplate. Evidence shows beneficial effects on the nucleus pulposus, including reduced levels of pro-inflammatory substances like IL-1 β , modulation of TGF- β 1 signaling in nucleus pulposus cells, regulation of arachidonic acid metabolites (TXB₂ and 6-keto-PGF1 α), inhibition of apoptosis and improved cellular energy processes.³⁵⁻³⁷ Proteins including netrin-1, neurofilament 200, which are involved in nerve and vessel growth, as well as the pro-inflammatory mediator Substance P, have shown decreases associated with AP, resulting in pain relief.^{38,39} Additional studies have found that acupuncture positively influences the integrity of cartilage endplates that have undergone degenerative changes.^{40,41} Disc disease is characterized by collagen changes and loss of proteoglycans and water molecules, but acupuncture has been shown to limit the transformation of collagen types I and II, boost levels of biglycan and decorin, and regulate metalloproteinases, collectively protecting the disc's extracellular matrix and delaying rupture of the annulus fibrosus.⁴²⁻⁴⁷

Acupuncture also benefits water transport via modulation of Aquaporin-4 as demonstrated by EAP at GV-4 and GV-14.⁴⁸ Additionally, EAP stimulation of the GV Meridian in rodent studies promotes mesenchymal stem cell survival and axonal regeneration,⁴⁹ while stimulation at ST-36 and ST-44 enhanced spinal cord blood flow and motor function in disc extrusion models.⁵⁰ These findings collectively highlight acupuncture's multi-level therapeutic potential in IVDD, integrating anti-inflammatory, anti-apoptotic, matrix-preserving, and neurovascular mechanisms.

A major limitation of this study was the small number of published controlled clinical studies investigating acupuncture's efficacy in treating IVDD. This might explain the scarcity of meta-analyses in this research area. To help mitigate this, IVDD studies for both dogs and humans which have similarities in treatment were used, which approximately doubled the number of clinical studies that were evaluated. Another limitation of this study was the low quality of many included studies, as shown by their Jadad scores. Assessment of "risk of bias" based on Cochrane criteria suggested a high percentage of uncertainty (75%) for overall risk of bias. A majority of these studies did not describe allocation concealment, had incomplete outcome data, selective reporting, or other sources of bias.

Acupuncture for IVDD lacks standardized treatment protocols. Specific details such as acupoint selection, treatment duration, total acupuncture dose, and needle manipulation techniques were often poorly described or not

stipulated. Additionally, during the process of screening the literature to satisfy the inclusion criteria, a more meticulous differentiation between back pain and intervertebral disc disease in advance could have potentially furnished more accurate outcomes for this study. Some included studies reported enrolling patients with intervertebral disc disease but did not provide detailed diagnostic information, such as imaging confirmation. For example, C-5 described patients with back pain without specifying imaging-based diagnosis;²⁷ H-2 mentioned cervical disc disease,²⁸ while H-1, H-3, H-6, and H-7 reported lumbar disc disease (e.g. spinal stenosis or herniation), yet none provided detailed imaging data.³¹⁻³⁴ This lack of diagnostic specificity limited the ability to fully assess the patient populations and possibly introduced heterogeneity in the meta-analysis. Finally, some studies were excluded because they did not focus solely on acupuncture.⁵¹⁻⁵³ These included the studies where TCM or TCVM therapy was used. Although these studies contained acupuncture treatment, they also included other modalities, making the contribution of acupuncture to patient outcomes impossible to accurately assess.

Overall, despite study limitations, the findings from this systematic review and meta-analysis suggest that including acupuncture when treating IVDD offers better treatment outcomes in both canine and human patients. The evidence indicates faster recovery and higher treatment success rates in canine patients, as well as improved pain and functional scores in human patients. This study, however, brings into focus the paucity of well-designed clinical trials investigating acupuncture treatment of canine and human IVDD and the need for more clinical data to further understand and validate the efficacy of this treatment modality for disc disease.

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Declaration of Interest and Funding

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FOOTNOTES

^a R version 4.2.1. The R Foundation for Statistical Computing Vienna, Austria; <http://www.R-project.org>

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FOREST PLOTS (Figures 4-10)

Legend for Forest Plots: The solid horizontal lines represent 95% confidence interval. Each horizontal line within the plot represents a separate study being analyzed; the vertical line represents a risk ratio of “1” (i.e. no association). A point estimate of the study result is represented by a square. The size of each square is the relative weight (%) of each study to the overall meta-analysis (combining all studies). The diamond shape represents the pooled results calculated from all studies in the plot (the meta-analysis), with the two ends of the diamond representing the (lower and upper) limits of the 95% confidence interval.

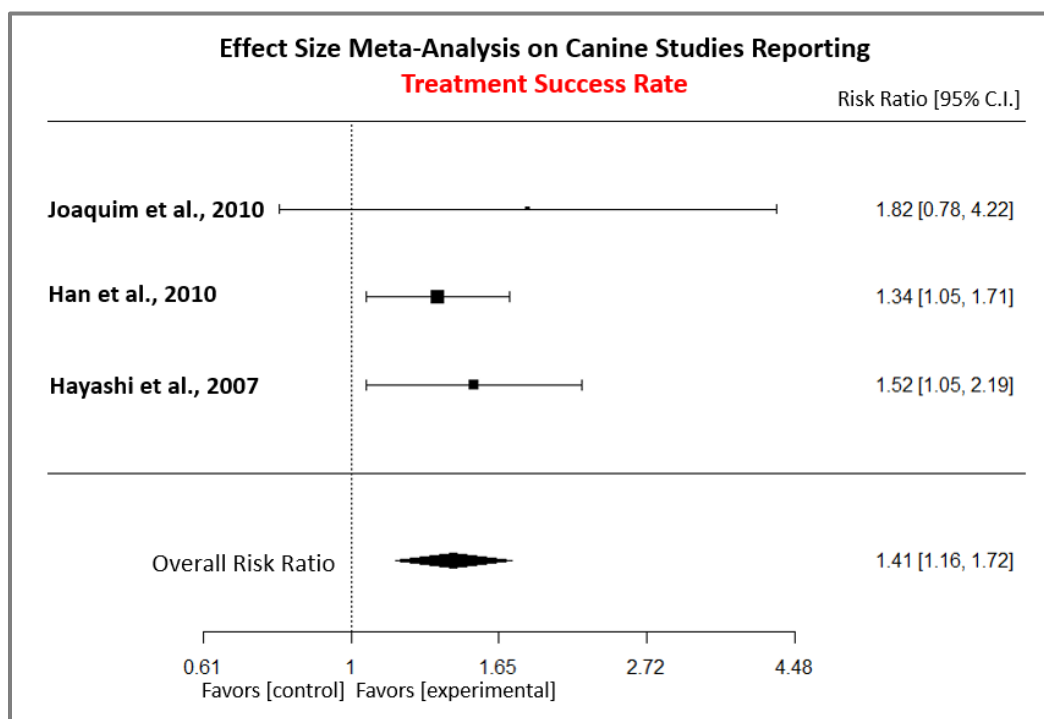


Figure 4: Effect size meta-analysis with forest plot from 3 canine studies (C-1, C-2, C-3) reporting treatment success rate for acupuncture + conventional treatment compared to conventional treatment only (category 1); note the diamond shape which represents the pooled results of the meta-analysis and sums up study results which equals 1.41, which is greater than 1 and falls within the “favors experimental” result. Conclusion from this comparison demonstrates a significant overall effect ($p=0.0006$) that combining acupuncture and conventional treatment can be more effective than conventional treatment alone for treating dogs with IVDD.

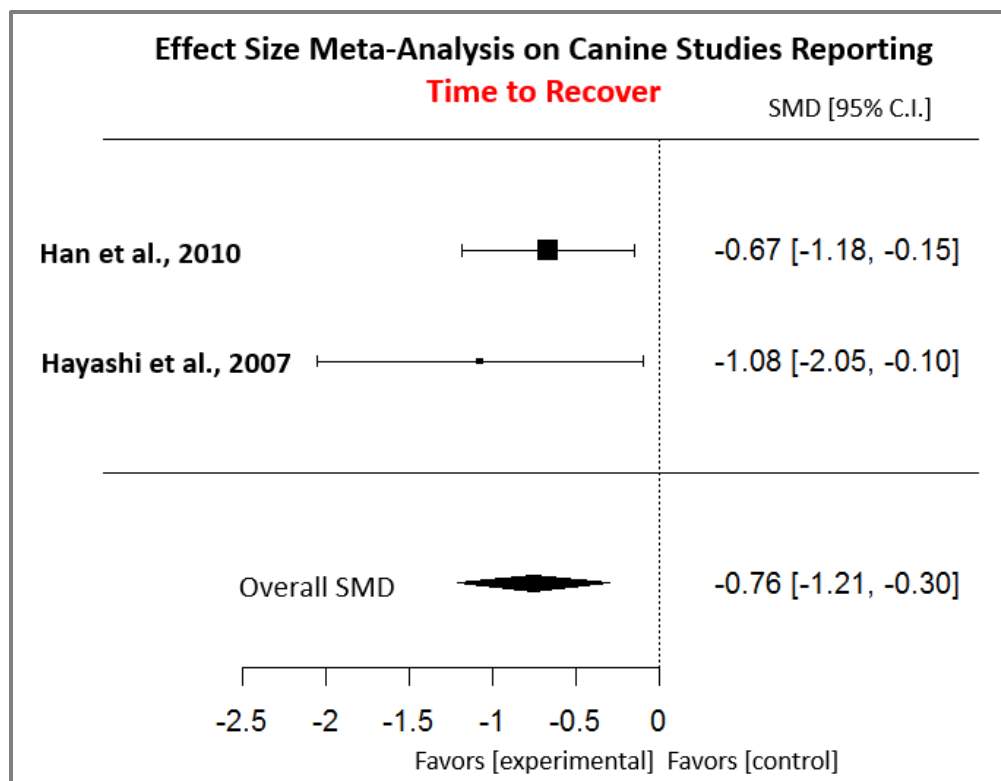


Figure 5: Effect size meta-analysis with forest plot from 2 canine studies (C-2, C-3) reporting time to recover for acupuncture + conventional treatment compared to conventional treatment only (category 1); note the diamond shape which represents the pooled results of the meta-analysis and sums up study results equals -0.76 which is less than 0 and falls within the “favors experimental” result. Conclusion from this comparison demonstrates a significant overall effect ($p=0.0012$) that combining acupuncture and conventional treatment can help IVDD dogs recover sooner than conventional treatment only. SMD=standardized mean difference.

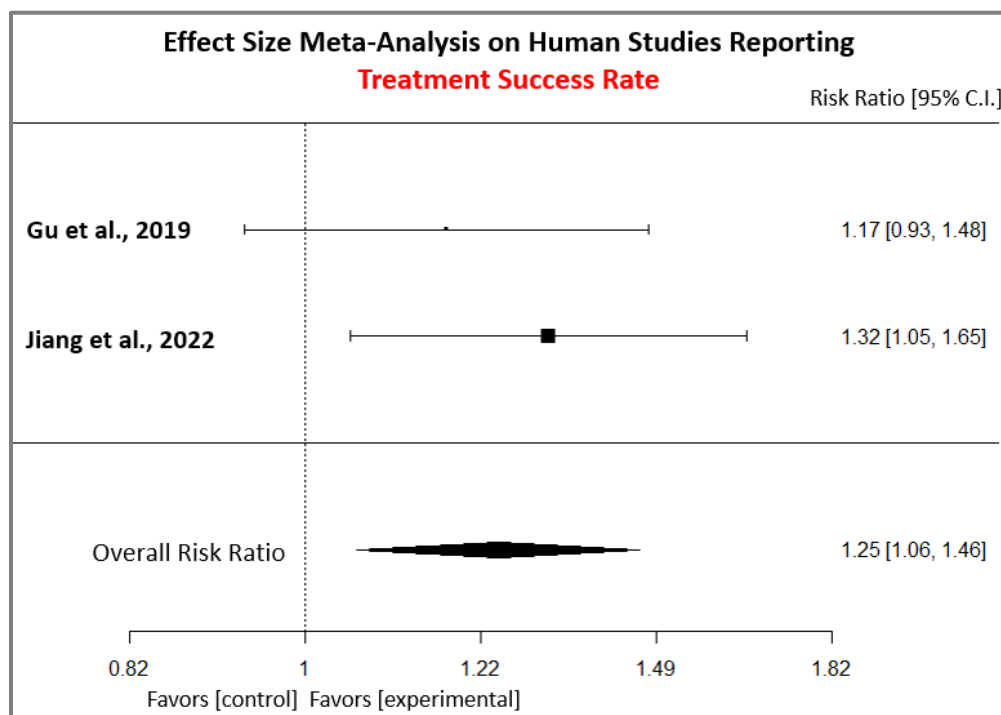


Figure 6: Effect size meta-analysis with forest plot from 2 human studies (H-2, H-6) reporting treatment success rate for AP + conventional treatment compared to conventional treatment only (category 1); note the diamond shape which represents the pooled results of the meta-analysis and sums up study results equals 1.25 which is greater than 1 and falls within the “favors experimental” result. Conclusion from this comparison demonstrated a significant overall effect ($p=0.008$) that combining acupuncture and conventional treatment can be more effective than conventional treatment only for treating human patients with IVDD.

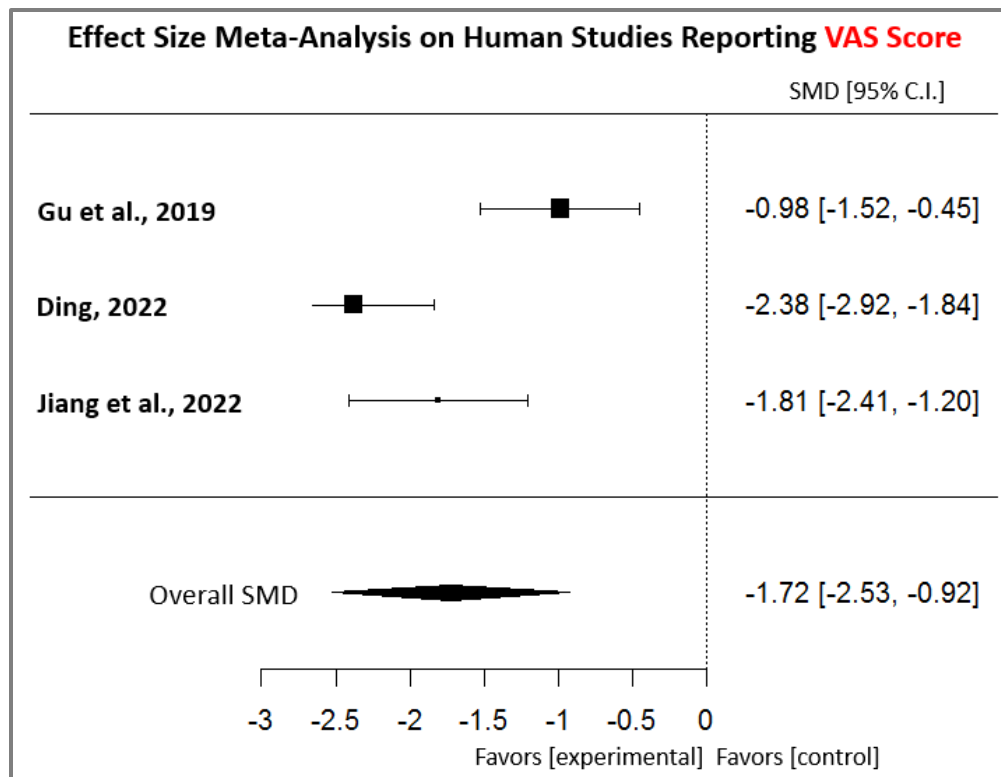


Figure 7: Effect size meta-analysis with forest plot from 3 human studies (H-2, H-5, H-6) reporting VAS scores for acupuncture + conventional treatment compared to conventional treatment only (category 1); note the diamond shape which represents the pooled results of the meta-analysis and sums up study results which equals -1.72, which is less than 0 and falls within the “favors experimental” result. Conclusion from this comparison demonstrates a significant overall effect ($p < 0.0001$) that combining acupuncture and conventional treatment resulted in better (smaller) VAS scores when treating human patients with IVDD.

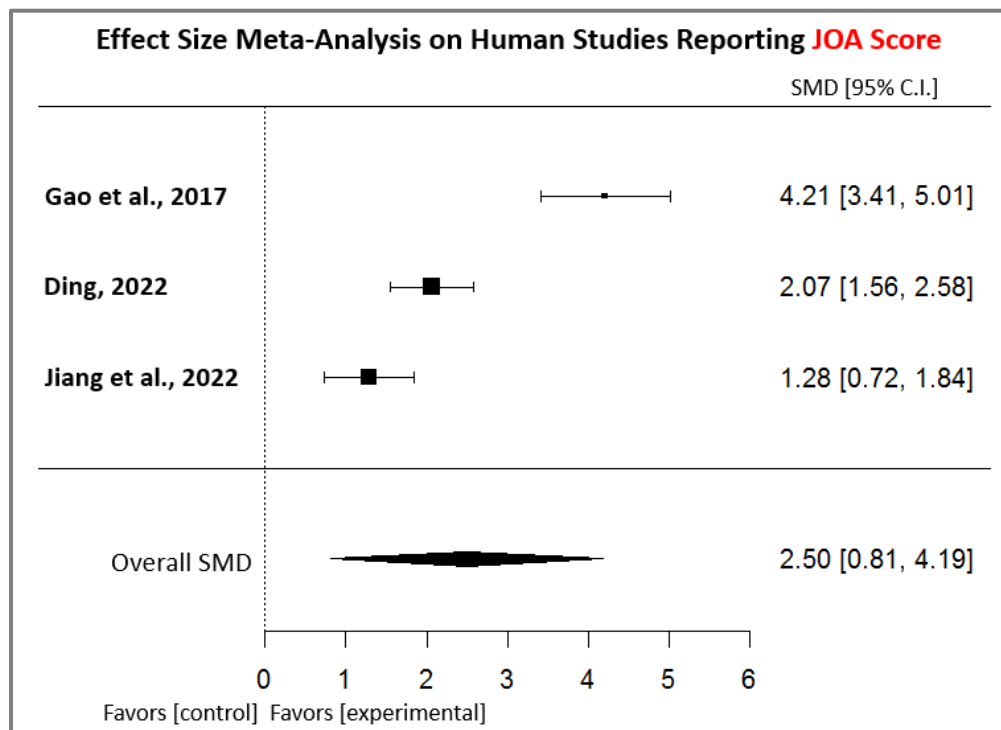


Figure 8: Effect size meta-analysis with forest plot from 3 human studies (H-4, H-5, H-6) reporting JOA scores for acupuncture + conventional treatment compared to conventional treatment only (category 1); note the diamond shape which represents the pooled results of the meta-analysis and sums up study results equals 2.50 which is greater than 0 and falls within the “favors experimental” result. Conclusion from this comparison demonstrates a significant overall effect ($p = 0.0038$) that acupuncture + conventional treatment resulted in better (higher) JOA scores when treating human patients with IVDD.

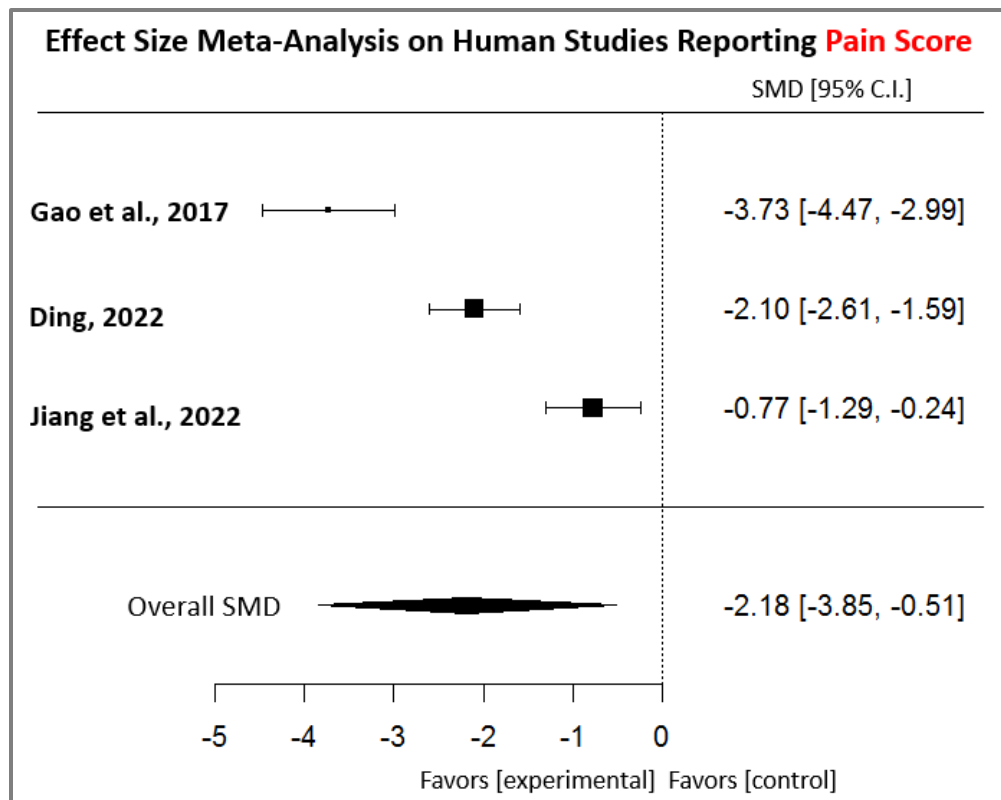


Figure 9: Effect size meta-analysis with forest plot from 3 human studies (H-4, H-5, H-6) reporting pain scores for acupuncture + conventional treatment compared to conventional treatment only (category 1); note the diamond shape which represents the pooled results of the meta-analysis and sums up study results equals -2.18 which is smaller than 0 and falls within the “favors experimental” result. Conclusion from this comparison demonstrates a significant overall effect ($p=0.0103$) that acupuncture + conventional treatment resulted in better (lower) pain scores when treating human patients with IVDD.

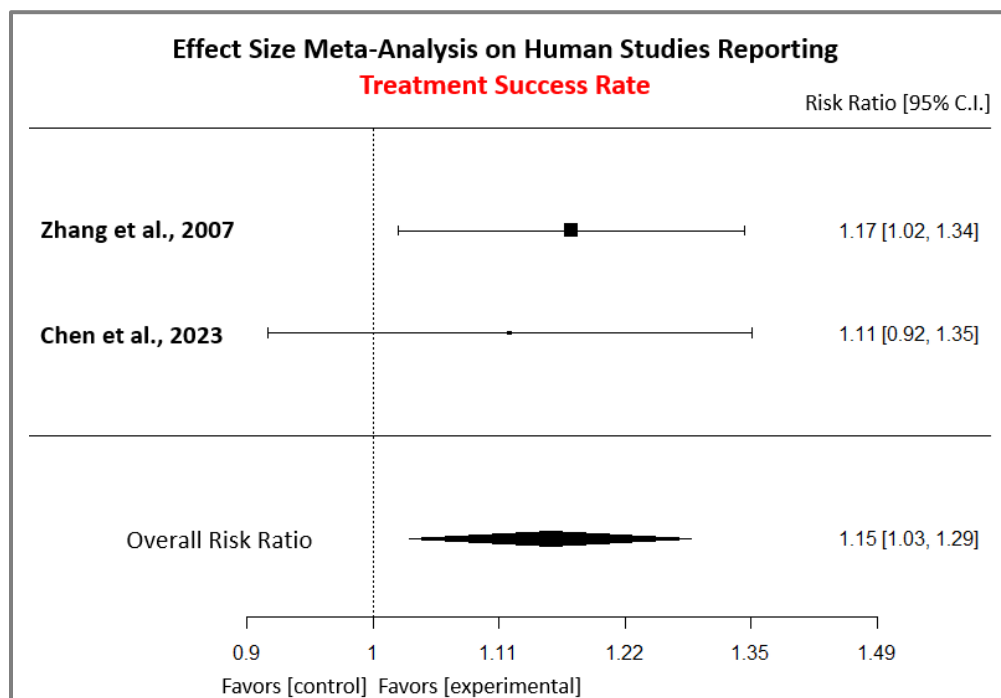


Figure 10: Effect size meta-analysis with forest plot from 2 human studies (H-1, H-7) reporting treatment success rate for acupuncture treatment only, compared to conventional treatment only (category 2); note the diamond shape which represents the pooled results of the meta-analysis and sums up study results equals 1.15 which is greater than 1 and falls within the “favors experimental” result. Conclusion from this comparison demonstrates a significant overall effect ($p=0.014$) that acupuncture treatment only can be more effective than conventional treatment only when treating human patients with IVDD.