Review

Network Meta-Analysis of the Effect of Different Modalities of Exercise on the Treatment of Non-Specific Neck Pain

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Network Meta-Analysis of the Effect of Different Modalities of Exercise on the Treatment of Non-Specific Neck Pain

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Abstract: Exercise therapy is an effective means of relieving neck pain. However, the effectiveness of various exercise therapy interventions is currently inconsistent. Therefore, this study aims to use network meta-analysis to investigate the effectiveness of exercise therapy in treating non-specific neck pain (NSNP) and the differences between different exercise interventions, providing insights into the application of exercise therapy in NSNP management. Randomized controlled trials (RCTs) of NSNP exercise therapy were collected by searching the databases of CNKI, Wanfang, Vipshop, Web of Science, Pubmed, Elsevier, and EBSCO. Stata software was used to assess the quality of the literature, and Stata software was used for network meta-analysis. The results showed that 1919 studies were jointly included, and 30 papers were remaining after screening.The results of the study showed that Ba duan jin, Pilates, Resistance, Stretch, Stability, Yoga, Qi gong, Endurance, and Tai chi, all 9 exercise modalities, could reduce the level of pain in patients with NSNP, of which Stretch, Stability, Resistance, Pilates, and Ba duan jin improvement had significant differences, and Stability training was the best modality to significantly improve neck pain in NSNP patients (Surface area under the cumulative ranking curve (SUCRA) = 74.5). Pilates, Resistance, Stretch, Stability, Yoga, Qi gong, and Tai chi. All 7 exercise modalities can improve neck dysfunction in patients with NSNP, Yoga, Stretch and Resistance had significant improvement, the best modality was Yoga (SUCRA=84.4). Ba duan jin, Resistance, Stretch, Qi gong, and Tai chi. these 5 exercise modalities can all improve the quality of life of NSNP patients, among which Ba duan jin has effectiveness, and the best modality to improve neck dysfunction in NSNP patients is Ba duan jin (SUCRA=91.1).Exercise therapy is an effective rehabilitation treatment for NSNP, with significant effects in relieving NP, improving neck dysfunction, and enhancing quality of life. Among them, stability training had the best effect in relieving NP, yoga training had the best effect on neck dysfunction, and Ba duan jin had the best effect on life quality improvement.

Keywords: non-specific neck pain; exercise therapy; network meta-analysis

1. Introduction

Neck pain (NP), abbreviated as neck pain, refers to pain located in the anatomical region of the neck from the upper neckline to the region of the spinous process of the first thoracic vertebra[1].Non-specific neck pain (NSNP), also known as mechanical neck pain, is a type of neck pain that refers to pain in the anatomical region of the cervical spine (excluding the shoulder) caused by a variety of factors, with or without radiating arm pain, with no or mild to severe interference with activities of daily living, and with no specific pathologic manifestations, characteristic signs and symptoms[2]. With the accelerated pace of society and changes in the living and working environments, more and more people suffer from NSNP. At the onset of NSNP, patients may experience soft tissue pain in the neck muscles or accompanying dysfunction in neck movement, which has a certain adverse impact on the normal life and work of the patients[3]. Patients with NSNP have tense superficial neck

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muscles, while the deep neck muscles are less activated and relatively weak, which is the common muscle recruitment pattern[4]. Epidemiologic surveys have shown that the 1-year prevalence in adult workers is estimated to be between 30% and 50%[5]. The occurrence of NSNP reduces an individual's quality of life and economic productivity and places an economic burden on society. Considering the tremendous burden that neck pain places on individuals, healthcare systems, and industries around the world, it is critical to explore strategies to reduce the prevalence of neck pain[6].

In order to reduce the social burden caused by NSNP, several international guidelines on the treatment of NSNP have been published in recent years, for example, in the United States, Australia, Denmark and the Netherlands[7–10]. The guidelines all suggest the important role of exercise therapy for treatment and rehabilitation. At the same time, the promotion of physical activity appears to be a positive strategy for alleviating the prevalence of musculoskeletal disorders, including neck pain[11]. A large amount of literature shows that exercise therapy has good efficacy in treating the disease of chronic non-specific neck pain. For example, progressive shoulder and neck exercises can improve the strength of the deep and superficial neck muscles of patients with chronic neck pain, increase muscle function, strengthen the muscles of the shoulder and neck, and reduce the probability of chronic neck pain[12,13]. Cervical and shoulder resistance exercise can relieve neck pain and improve cervical joint mobility, and cervical and shoulder resistance exercise has certain advantages in improving the endurance of neck flexors and the strength of shoulder abductors, and Pilates exercise can reduce pain, lower the cervical disability index, alleviate symptoms of depression, and improve the quality of life, and at the same time, the exercise can significantly enhance the thickness of the semispinalis muscle[14]. Most patients with chronic neck pain have decreased activity of the deep cervical muscle groups and increased activity of the superficial cervical flexor muscles, while the patients' flexor endurance was significantly higher than that of the conventional group after being treated with stabilizing exercises. Stability exercises can increase the endurance of the deep neck flexors and decrease the activity of the superficial neck flexors in patients with chronic neck pain, which is beneficial for the treatment of chronic neck pain[15]. Although there have been many randomized controlled trials (RCTs) that have analyzed the effectiveness of exercise therapy in the treatment of NSNP and studies comparing the differences between several therapies, they do not reflect the effectiveness of all exercise intervention programs. It is therefore difficult to draw conclusions about the reliability of the effectiveness of different exercise intervention programs, and therefore guiding scientific and systematic recommendations are lacking.

The primary aim of this systematic review was to specifically examine the improvement of participation in exercises designed to explore movement on the level of neck pain, level of neck dysfunction, and quality of life in adult patients with NSNP. The second aim was to explore the efficacy of different exercise modalities on patients with NSNP and to discover exercise modalities with better results. We anticipate that these findings will inform clinicians who wish to advise their patients regarding participation in fitness or exercise and the potential benefits for neck pain.

2. Methods

Network meta-analysis is performed according to the preferred reporting items in the System Review and Meta-analysis (PRISMA) guide[16]. (PROSPERO: CRD42021285647).

2.1. Literature Search Strategy

The studies search was performed for the related research studies, mainly from the following databases: PubMed, Cochrane Library, Web of Science, EBSCO, CNKI. The search keywords we used were (exercise therapy OR remedial exercise OR rehabilitation exercise) AND (neck pain OR cervicalgia OR cervicodynia OR neckache OR cervical pain) AND (RCT OR random OR random controlled trial). The network meta-analysis is limited to March 2024, and only includes randomized controlled trials.

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2.2. Inclusion and Exclusion Criteria

Criteria for inclusion：(1) experimental studies using exercise therapy to intervene in NSNP; (2) RCTs; (3) no significant differences in basic indicators of the included patients before the intervention; (4) outcome indicators containing neck pain level (visual analogue scale, VAS; numerical pain scale, NPS; neck pain questionnaire, NPQ), neck disability index (NDI; neck pain and disability scale, NPDS), and quality of life (SF-12, SF-36); and (5) relevant data before and after the intervention could be obtained. Criteria for exclusion：(1) observational studies; (2) non-human subjects; (3) history of trauma or surgery to the neck; (4) subjects containing symptoms other than NP; and (5) inability to extract outcome indicators.

2.3. Data Extraction

Two authors independently screened the abstracts and full-text articles of the selected works, extracting and cross-verifying the data. In instances of disagreement, a third party was consulted to mediate and reach a consensus. During the studies screening process, the initial step involved reading the titles and abstracts, followed by a thorough examination of the full texts to determine the studies to be excluded.

2.4. Quality Assessment

The quality of the included studies was evaluated. Then two authors assessed the quality of the included studies. Any disagreement was discussed with a third reviewer. The two authors/It is important to use the Cochrane Handbook for Systematic Interventions to assess the quality of studies. It includes the evaluation of randomization methods, concealment of distribution, blindness of patients and physicians, outcome evaluation, data integrity, selective reporting, and other biased sources.

2.5. Statistical Analysis

STATA (Version 17.0) command'mvmeta' was used to perform a multivariate network meta-analysis within a frequentist framework. The therapeutic effect of each study on NAFLD was calculated by standard mean deviation (SMD) and standard deviation (SD). For studies that provide only median and quartile ranges, we derive SMD and SD to overcome the heterogeneity between research interventions and results[17,18]. The I^2 statistics are used to measure heterogeneity, which is considered high heterogeneity when it exceeds 50%. Consistency means that the treatment effect estimated by direct comparison is consistent with that estimated by indirect comparison. Statistical indicators include pain level, neck dysfunction, quality of life. Subsequently, interventions were ranked using the surface under the cumulative ranking curve (SUCRA). SUCRA is considered to be a more accurate estimate of the cumulative ranking probability. Simultaneously, SUCRA reported the overall probability based on the ranking of all interventions, that is, a given intervention is one of the best treatments[19,20].

3. Result

3.1. Literature Selection

A total of 1919 studies were assembled in various Chinese and English databases through subject term search, and 1,801 studies were remaining after de-weighting using EndNoteX9, 166 studies were obtained through the initial screening of titles and abstracts; 30 studies were finally included by reading the full text to exclude incomplete data studies, and duplicate publications, and the process of studies screening is shown in Figure 1.

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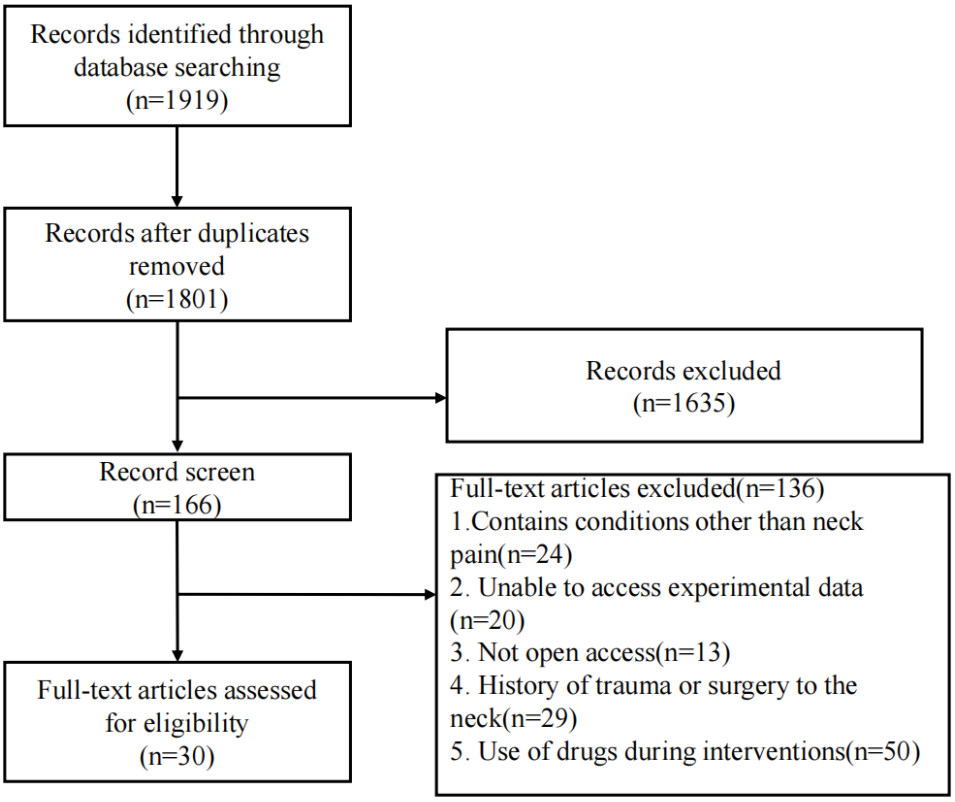

Figure 1. Study flow diagram.

3.2. Characteristics of the Included Studies

30 studies were included in this study, totaling 2,291 subjects[21–50]. 9 exercise modalities were included in the 30 papers in this study, including: Ba duan jin, Pilates, Resistance, Stretch, Stability, Yoga, Qi gong, Endurance, and Tai chi. The length of the single exercise intervention included in the study ranged from 10-90 min; the frequency of the exercise intervention ranged from 1-7 times per week; and the intervention period ranged from 3-24 weeks. (Table 1)

3.3. Result of Assessment

According to the Cochrane Handbook for Systematic Reviews of Interventions, the quality of the included studies was evaluated using the quality assessment method specific to randomized controlled trials (RCTs). The Cochrane Risk of Bias Assessment Tool highlighted the risks of various biases across 30 studies(Figures 2 and 3). The highest risks were identified in relation to performance bias due to lack of blinding and detection bias in outcome evaluation when assessing new concepts. Conversely, other biases, such as attrition bias, reporting bias, and biases related to random sequence generation, were assessed to be of low risk.

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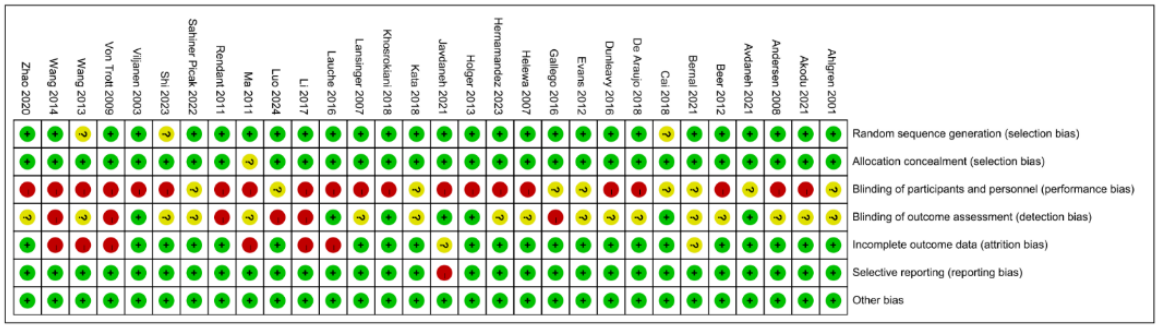

Figure 2. Schematic of Cochrane bias risk assessment.

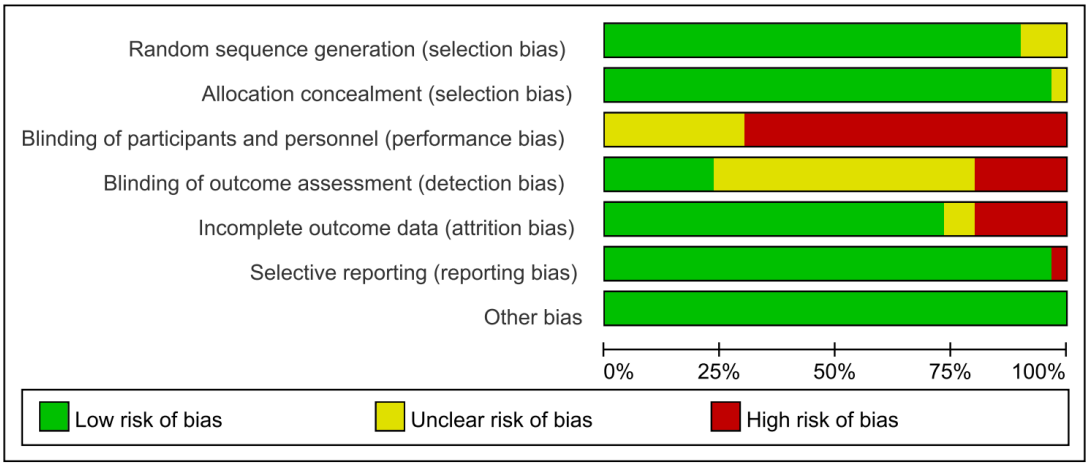

Figure 3. Schematic of Cochrane bias risk assessment.

3.4. Network Meta-Analysis

This study included various types of exercise therapy: Ba duan jin, Pilates, Resistance, Stretch, Stability, Yoga, Qi gong, Endurance, and Tai chi. The effects of 9 different exercises on pain levels, neck dysfunction and in patients with non-specific neck pain were analyzed. Figure 3 shows the network meta-analysis of the effects of different exercise interventions on efficacy. The size of the node is related to the number of participants in the exercise interventions, and the thickness of the lines between different nodes is related to the number of studies compared. In the network analysis, SUCRA is considered to be a more accurate estimate of the cumulative ranking probability. It can use different ranking methods, maximum or minimum, according to the different benefits of sports. (Figures 4–6).

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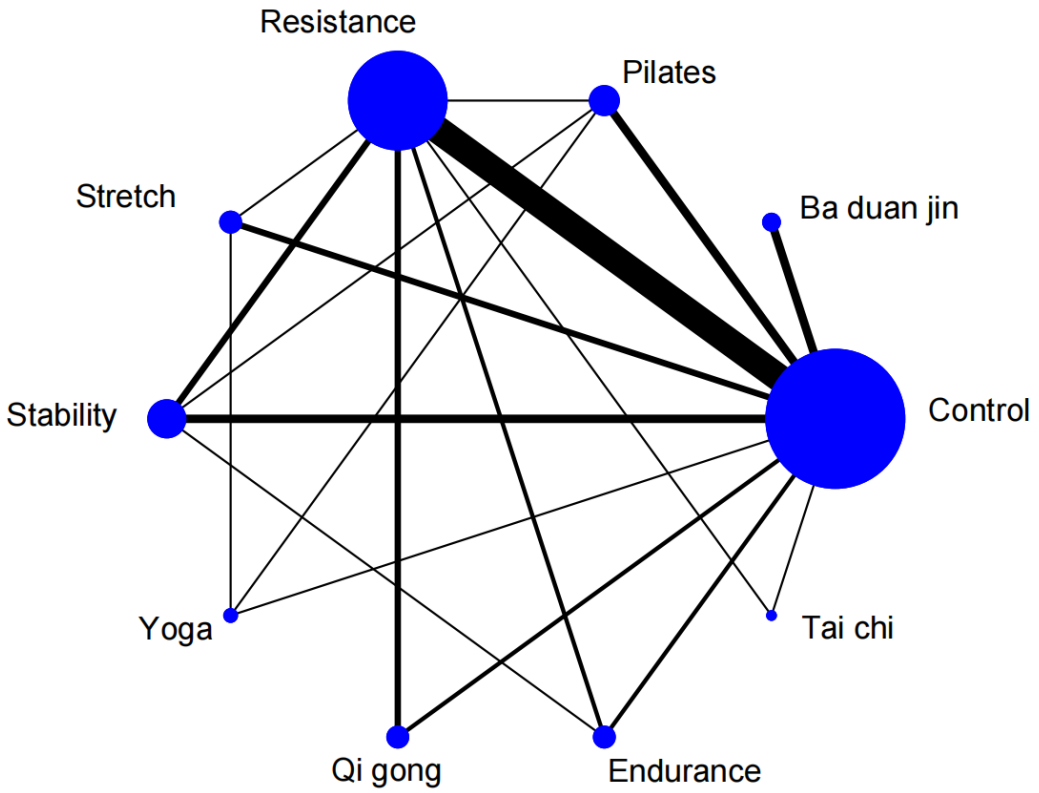

Figure 4. The effect of different exercise methods on neck pain in NSNP patients.

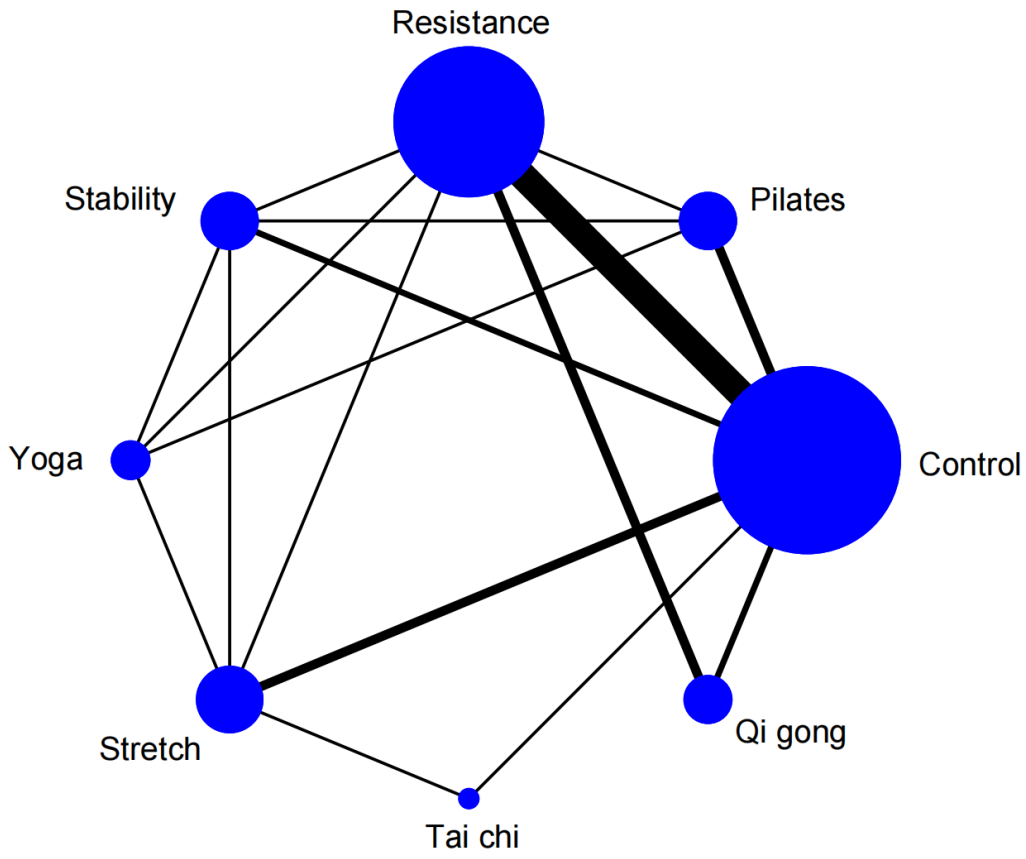

Figure 5. The effect of different exercise methods on in dysfunction NSNP patients.

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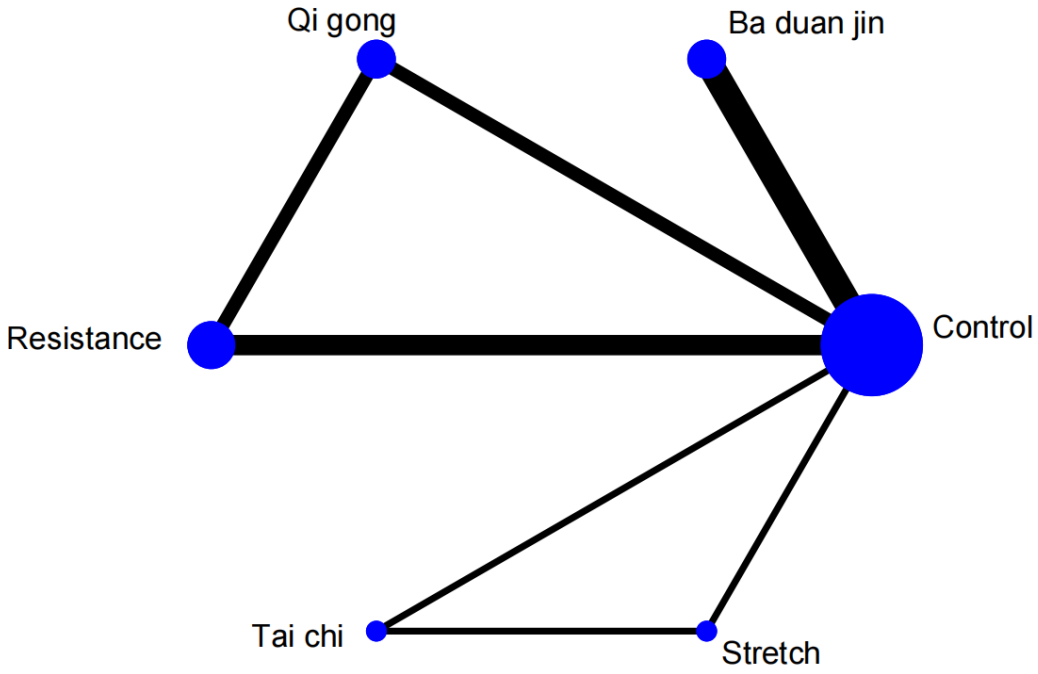

Figure 6. The effect of different exercise methods on in life quality NSNP patients.

3.4.1. Pain Level

In terms of neck pain reduction, all 9 different exercise modalities reduced the level of neck pain in patients with non-specific neck pain compared to the control group. Ba duan jin(-1.79 [-3.55,-0.02]), Pilates (-1.84 [-3.35,-0.34]), Resistance (-1.38 [-2.28,-0.49]), Stretch (-2.18 [-4.02,-0.35]), Stability (-2.15 [-3.55,-0.76]), Yoga (-2.03 [-4.47,0.42]), Qi gong (-1.12 [-2.99,0.76]), Endurance (-0.55 [-2.67,1.57]), and Tai chi (-0.74 [-3.74,2.26]). Among them, Stretch, Stability, Resistance, Pilates, and Ba duan jin had a significant effect on neck pain relief ($p<0.05$). Inconsistency results showed $p=0.9815>0.05$, indicating consistency of results. Calculations by SUCRA show that Stability training (SUCRA= 74.5) provides the best benefits. Stretch (SUCRA= 72.5), Yoga (SUCRA= 65.9), Pilates (SUCRA= 63.7), Ba duan jin (SUCRA= 61.2), Resistance (SUCRA= 48.6), Qigong (SUCRA= 41.6), Tai chi (SUCRA= 35), Endurance (SUCRA= 27.5), Control (SUCRA= 9.4) (Figure 7).

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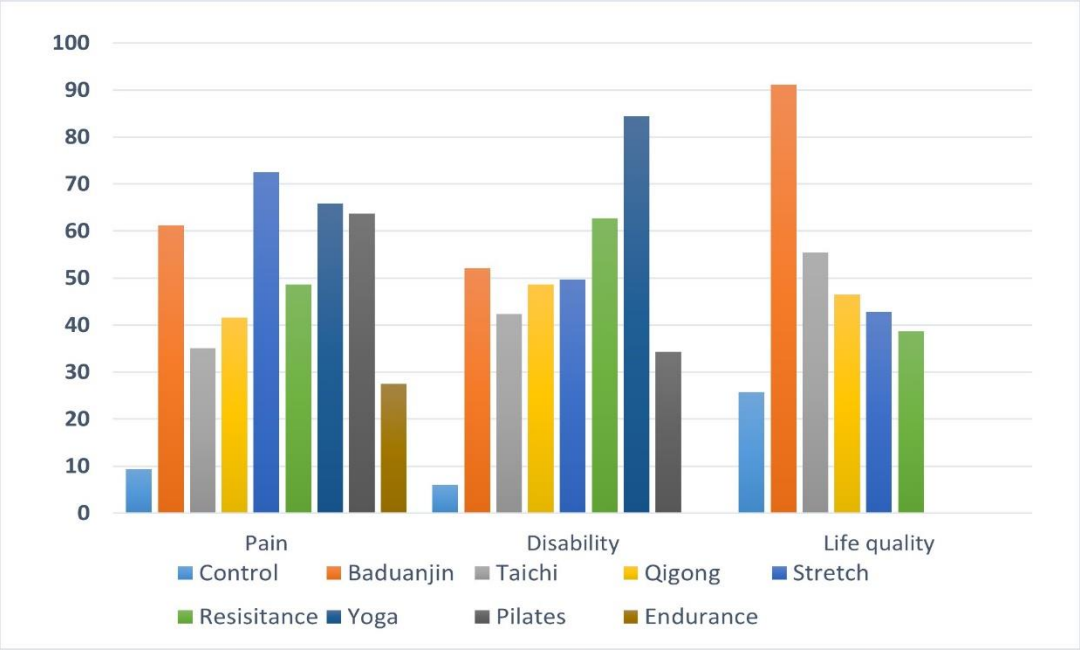

Figure 7. Efficacy of different exercise modalities.

3.4.2. Neck Dysfunction

In terms of enhancing quality of life, all seven different exercise modalities reduced the level of neck dysfunction in patients with non-specific neck pain compared to the control group. Pilates (-0.72 [-1.86,0.42]), Resistance (-1.32 [-2.05,-0.59]), Stretch (-1.06 [-2.17,0.04]), Stability (-1.59 [-2.79,-0.38]), Yoga (-2.00 [-3.36,-0.37]), Qi gong (-1.02 [-2.30,0.27]), and Tai chi (-0.86 [-2.92,1.21]).Among them, Yoga, Stretch and Resistance had a significant effect on neck dysfunction relief ($p<0.05$). Inconsistency results showed $p=0.4043>0.05$, indicating consistency of results. Calculations by SUCRA show that Yoga (SUCRA= 84.4) provides the best benefits. Stability (SUCRA= 72.1), Resistance (SUCRA= 62.7), Stretch (SUCRA= 49.7), Qi gong (SUCRA= 48.6), Tai chi (SUCRA= 42.3), Pilates (SUCRA= 34.3), Control (SUCRA= 6) (Figure 7).

3.4.3. Life Quality

In terms of life quality enhancement, all five different exercise modalities enhanced the level of quality of life in patients with non-specific neck pain compared to the control group. Ba duan jin(1.60 [0.57,2.63]), Resistance (0.21 [-0.94,1.35]), Stretch (0.33 [-0.94,1.35]), Qi gong (0.37 [-0.94,1.35]), and Tai chi (0.64 [-1.36,2.63]). Among them, Ba duan jin had a significant effect on life quality enhancement ($p<0.05$). Inconsistency results showed $p=0.9976>0.05$, indicating consistency of results. Calculations by SUCRA show that Ba duan jin (SUCRA= 91.1), provides the best benefits. Tai chi (SUCRA= 55.4), Qigong (SUCRA= 46.4), Stretch (SUCRA= 42.8), Resistance (SUCRA= 38.6), Control (SUCRA= 25.7) (Figure 7).

4. Discussion

NSNP, as a chronic pain with no clear etiologic source, should follow a multimodal treatment principle in which exercise therapy plays a crucial role [36]. The aim of this study was to systematically review the RTCs related to different exercise interventions for NSNP, analyze the changes in neck pain, neck dysfunction, and quality of life of patients after the intervention of different exercise regimens, and explore the effects of different exercise regimens in intervening NSNP. From a general point of view, exercise therapy is effective in improving neck pain, neck dysfunction and quality of life in patients with NSNP, but there are some effect differences between exercise intervention programs of different modalities.

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4.1. Pain Improvement

Symptoms of neck pain are basically similar to those of cervical spondylosis, and are characterized by localized pain, discomfort, and limitation of movement in the neck. There are many causes of neck pain, including degenerative diseases of the cervical spine, developmental cervical spinal stenosis, etc., which cause neck muscle injury, cervical spine stability disorder, nerve root compression, and vertebral artery stimulation, etc., and can easily lead to the occurrence of cervical spondylosis. Neck pain can impact motor control, leading to co-contraction of agonist muscles, increased activity of superficial flexor and extensor muscles, delayed onset of neck muscle activation, and weakness in the deep muscles[51,52]. In recent years, stability training has become a popular form of fitness activity and has begun to be widely used in rehabilitation programs and sports medicine[53]. The results of this study found that Ba duan jin is one of the best ways to enhance the quality of life of NSNP patients. Stability training controls the balance and stability of the body through fixed or slow dynamic body posture control and activates the core, deeper smaller muscle groups, therefore, through stability training or movement control training, deep neck muscle strength and endurance can be exercised, which may have a potential therapeutic effect on NSNP. Wu found through systematic review and Meta-analysis that stability training has a significant role in the treatment of NP disorders with certain effects[54]. The clinical guidelines of the American Physical Therapy Association state that exercise is part of the therapeutic intervention for NSNP[7], and advocate active exercise aimed at strengthening neck muscle strength or endurance, in addition to movement exercises related to neck muscle stretching, coordination, and control. Similarly in the Chinese expert consensus on exercise therapy for the treatment of NP, neck muscle strength training, stability training, and yoga are also included as strongly recommended exercise treatments for NP treatment[55]. Therefore, stability training can be considered a preferred approach for exercise intervention.

4.2. Neck Dysfunction

Chronic injuries caused by neck injuries, incorrect posture, etc., cause strain and laxity of neck muscles and ligaments, and produce chronic pathological changes in the neck, all of which can cause neck dysfunction. Yoga is a mind-body training program that integrates strength, flexibility, coordination, stability, and cardiorespiratory function, which has positive therapeutic effects on chronic musculoskeletal disorders[56]. Relevant scholars at home and abroad have also proved that yoga has good effects in treating NSNP through the method of systematic review and Meta-analysis. The results of this study also further proved that the effectiveness of yoga in improving neck dysfunction is best. Yoga originally means "integration" and is a philosophical idea. Nowadays, yoga for sports is also an exercise method that keeps the practitioner physically and mentally healthy through the combination of asana, breathing and meditation. The results of this study found that yoga is one of the best ways to improve neck dysfunction in NSNP patients. Yoga helps identify and modify habitual posture patterns, thereby correcting poor body posture and muscle tension in daily life[57]. Consequently, patients with chronic neck pain report an enhanced awareness of posture in their daily activities after practicing yoga[58]. Additionally, yoga has been shown to improve proprioception and range of motion in the neck for those with chronic neck pain. Furthermore, potential nonspecific factors may include environmental and attentional effects, participants' responses to meaning and beliefs, and social influences generated by group interventions.

4.3. Life Quality

In the studies dealing with life quality enhancement for people with NSNP, the majority of exercise interventions are physical and mental training. Ba Duan Jin is a traditional Chinese method of physical and mental training, which is profound and has a long history, is an important part of Chinese culture, and in recent years has been widely recognized around the world. Traditional Chinese physical and mental training is a low-cost form of exercise that involves the musculoskeletal

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involvement of the whole body through changes in body posture and control of movement speed, which can enhance the qualities of strength, agility, balance and flexibility, strengthen the function of the motor nervous system, improve cardiorespiratory endurance, and have the effects of health care, body nourishment, and treatment of diseases[59]. The results of this study found that Ba duan jin is one of the best ways to enhance the quality of life of NSNP patients. Ba duan jin is believed to invigorate and nourish qi, relax muscles, strengthen the body, promote blood circulation, remove blood stasis, enhance metabolism, and harmonize internal organs. It is said to regulate cardiac function and respiration, unblock meridians to alleviate cardiac pressure, maintain calmness, and balance mental state[60]. The results of this study found that Ba duan jin is effective in alleviating neck pain and improving neck dysfunction. Additionally, the improvement in quality of life highlights Ba duan jin's holistic approach, embodying the traditional Chinese practice's dual focus on physical fitness and mental well-being.

Some of the outcome indicators included in the literature were not comprehensive enough, especially the literature containing quality of life evaluation indicators was insufficient. According to the elements of exercise prescription development, in addition to exercise modality, exercise intensity, exercise duration, exercise frequency, and exercise cycle are included, but due to the limitations of the amount of literature, these factors could not be considered comprehensively.

5. Conclusion

Exercise therapy is an effective rehabilitation treatment for NSNP, with significant effects in relieving neck pain, improving neck dysfunction, and enhancing quality of life. Among them, stability training had the best effect in relieving neck pain, yoga training had the best effect on neck dysfunction, and Ba duan jin had the best effect on life quality improvement. Therefore, in the future exercise prescription design, physical therapy programs can be better designed for NSNP patients based on these findings.

There is no conflict of interest among all authors.

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