The effectiveness of manual physical therapy interventions in pediatric patients with anterior hip pain: a retrospective study

Mindy Galleher, Briana Crowe and Mitchell Selhorst

Sports and Orthopedic Physical Therapy, Nationwide Children's Hospital, Columbus, OH, USA

ABSTRACT

Objectives: The purposes of this study were to: (1) assess the benefit of adding manual therapy (MT) to physical therapy care in pediatric patients with anterior hip pain; (2) assess the relative risk of adverse reactions when MT is used; and (3) report the types of MT used.

Methods: This study was a retrospective chart review of patients treated in a hospital-based sports medicine clinic. The charts of 201 patients (mean age = 14.23 ± 2.15 years) met the inclusion criteria and were reviewed. Patients were grouped into those who received MT during their episode of care, and those who did not. Pain efficiency (change in pain/number of visits), number and type of adverse reactions, as well as frequency and type of manual therapy interventions used, were the outcomes of interest.

Results: The mean pain efficiency was significantly less if manual therapy was performed (MT = 0.60 [95% CI 0.47–0.72], no MT = 0.80 [95% CI 0.71–0.90] $p = 0.01$). There was no significant difference between groups in risk of adverse reactions (MT = 5, no MT = 5). The number of visits was significantly different between groups (MT = 9.43 ± 3.9 sessions, and no MT = 7.6 ± 5.2 sessions).

Discussion: MT did not increase the risk of an adverse reaction in pediatric patients with anterior hip pain. While it appears to be a safe intervention, it did not improve pain efficiency or patient adherence. Future research should be performed to assess the effectiveness of MT, when performed by skilled therapists, in pediatric patients with hip pain in a controlled manner.

Level of Evidence: 3b.

KEYWORDS

Hip; pediatric; manual therapy; mobilization; manipulation; anterior; children; physical therapy

Introduction

Anterior hip pain is a common complaint among young athletes, with a reported incidence rate ranging from 10 to 70% in this population [1–4]. Anterior hip pain accounts for 10% of all sports medicine visits for young athletes [1]. Female high school soccer players commonly sustain hip injuries, with 13% of all injuries attributed to this joint [1]. Among the elite, approximately 70% of soccer players reported hip/groin pain during one season [4]. Of all ages reporting injuries to the hip/groin, 5–9% are found in high school athletes and 3–11% in elite-level athletes [5]. Management of injuries in this region can be complex due to multiple structures that are prone to injury [3]. Pain in the hip causes substantial diagnostic challenges, and there is no consensus for the best treatment [2].

There is little evidence assessing appropriate treatments for anterior hip pain in adolescent athletes. A 2015 systematic review concluded that rehabilitation was superior to surgery for return to play time for athletes with groin pain [6]. For conservative

management of groin injuries, only 6% of studies in one systematic review were considered high quality [7]. For femoroacetabular impingement (FAI), another leading cause of anterior hip pain, a 2013 systematic review was only able to find two high-quality studies for analysis of conservative management [8]. Conservative care in these studies consisted of both passive and active treatments. Treatments included modalities, acupuncture, activity modification, manual therapy, strengthening, and flexibility exercises [6–8].

Manual therapy is a conservative intervention that may be beneficial in the treatment of pediatric anterior hip pain. In adults, manual therapy interventions are supported by strong to moderate level evidence for the treatment of many orthopedic conditions, including hip pain secondary to osteoarthritis (OA) [6–10]. In the treatment of mild hip OA, manual therapy directed at the hip resulted in a success rate of 81%, in comparison to 50% for exercise therapy alone [11]. Another randomized controlled trial (RCT) found manual therapy for chronic groin pain superior to exercise therapy for return to sport time [12]. Despite good evidence for the use of manual

therapy to treat multiple conditions and body regions, support for the treatment of nonarthritic hip pain is still lacking. In the current Clinical Practice Guidelines for the nonarthritic hip, manual therapy is only recommended for treatment based on clinical expertise [13]. Research findings should not be generalized from adult to pediatric populations as there are many differences between the two groups. To date, there is no high-quality evidence to support or refute the usage of manual therapy in the treatment of anterior hip pain in the young, athletic population [14].

Some authors have expressed concerns about the safety of performing manual therapy on younger patients, citing concerns of injuring growth plates and hypermobility [12,13]. A growing child is cited as a precaution for performing certain types of manual therapy [15,16]. Despite frequently being cited as a precaution, there have been no documented cases of a growth plate injury from manual therapy. Additionally, the forces imparted from manual therapy are significantly lower than those that children experience in commonly performed activities [17–19]. Assessing the risk of injury with manual therapy in pediatric patients is important as interventions should be demonstrated safe before they are recommended in care.

Study objectives

There were three primary objectives of this study: (1) to assess whether or not manual therapy improved patient outcomes in the treatment of adolescent anterior hip pain; (2) to ascertain if there was any additional risk in using manual therapy compared to similar patients who did not receive manual therapy; and (3) to report on the types of manual therapy being used clinically in the treatment of this patient population.

Methods

Study design

This was a retrospective study which consisted of a review of medical charts. The authors reviewed the charts of all patients with a diagnosis of anterior hip pain over a five-year period and assessed their eligibility. Each variable was defined and the reviewers were trained prior to data abstraction. The lead author reviewed and verified all data collected from the chart review process. The institutional review board approved this study prior to performing the chart review.

Setting and participants

Patients were considered eligible if they were treated for a diagnosis of anterior hip pain at Nationwide Children's Hospital Sports and Orthopedic Physical Therapy clinics in Columbus, Ohio from January 2010 to July 2015.

The patient data were collected from seven different physical therapy clinics. Patients were included if they were under the age of 18 with a physical therapy diagnosis of anterior hip pain. Anterior hip pain was defined for this study as symptoms located within the borders of the pubic symphysis (medially), greater trochanter (laterally), lower abdomen (superiorly), and proximal 10 cm of the anterior thigh (inferiorly) [20]. Patients were excluded if: their pain did not meet the aforementioned criteria as 'anterior,' they had a medical diagnosis requiring exclusion, such as Legg–Calvé–Perthes disease, slipped capital femoral epiphysis, fracture, or if they had any contraindications to manual therapy. Contraindications included presence of metabolic or infectious disease such as osteoporosis or osteomyelitis, active bone disease, long-term corticosteroid use, fracture, joint, or ligament instability, worsening neurological function, and current use of anticoagulant therapy [15,21]. The chart review spanned the time from the patient's initial evaluation with the physical therapist to their discharge from physical therapy. The number of patients who met the inclusion criteria during the review period determined the sample size.

Variables of interest and data sources

Demographic data including age, gender, diagnosis, number of treating physical therapists, duration of symptoms, pain, pain efficiency, number of physical therapy visits, manual therapy techniques used, and change in self-reported outcome measure scores were collected from patients' medical charts. Duration of symptoms was defined as the total time the patient had reported anterior hip pain at the first visit of physical therapy. Pain was measured using the Numerical Pain Rating Scale (NPRS). The use of the NPRS for assessing pain has been validated for use in adolescent patients and has been found to have a minimal detectable change of 2 points [22]. The NPRS is an 11-point pain-rating scale ranging from 0 (no pain) to 10 (worst imaginable pain) to assess current pain intensity and the best and worst level of pain during the last 24 hours [23]. For the purposes of this study, the highest reported value on the NPRS was used. Change in pain was the difference in the highest reported value at initial evaluation and at the final visit. Pain efficiency was calculated by dividing the change in pain by the total number of visits the patient was seen in physical therapy. A higher pain efficiency score represents greater reductions in pain in fewer visits than a lower score. Pain also assisted in determining adverse reactions. A mild adverse reaction was defined as an increase in pain greater than 2 points on the NPRS; moderate was considered an unplanned visit to the emergency room or physician due to back, hip, or knee pain; severe was considered a long-term injury resulting in decreased function

and/or death. Patients' adherence was calculated as a percentage of attended visits to scheduled visits. Manual therapy techniques used were recorded as joint mobilization, manipulation, instrumented assisted soft tissue massage (IASTM), soft tissue massage (STM), manual stretching, muscle energy technique (MET), or myofascial release. The functional outcome measures used were the Hip Outcome Score (HOS) activities of daily living (ADL) subscale or the Lower Extremity Functional Scale (LEFS). Scores were recorded at initial evaluation and final visit [13,24].

HOS-ADL subscale

The HOS is a self-report measurement tool developed specifically to assess the ability of young individuals. The ADL subscale contains 17 items; examples include walking on level surfaces, hills, stairs, getting in and out of a car, deep squat, heavy work, and recreational activities. Each item is scored from 4 to 0, with 4 being 'no difficulty' and 0 being 'unable to do.' The total number of items with a response is multiplied by 4 to get the highest potential score. An individual's score is divided by the highest potential score, then multiplied by 100 to get a percentage. A higher score is representative of a higher level of physical function for each subscale. This minimal clinically important difference (MCID) of the ADL subsection is 9 points [25].

Lower extremity functional scale

The LEFS is a self-reported 20-item questionnaire related to various levels of current lower extremity function. Each item is scored from 0 to 4 and responses are summed to provide an overall score of 0–80, with a score of 80 representing very high function. The LEFS is found to be valid

and reliable in patients 16 years and above with a lower extremity condition and a test-retest reliability of 0.90–0.98 [26–28]. A change of 9 points represents the MCID [27].

Data analysis

All analyses were conducted using SPSS 21 software. The study's first objective was evaluated using a multi-variate analysis of covariance (MANCOVA). The dependent variables were pain efficiency and patient adherence. Change in function was not included due to low completion rates in the medical charts. The covariates for the MANCOVA were durations of symptoms and initial pain levels. Secondary univariate analyses were performed assessing the individual effect of manual therapy on pain efficiency and adherence. The relative risk of having an adverse reaction from manual therapy was calculated to assess the second aim of this study. A Chi-square analysis was performed to determine if there were any differences between groups for adverse reactions. Descriptive statistics were used to report the types of manual therapy techniques applied in patients with anterior hip pain. Significance level for statistical analyses was set at 0.05.

Results

During the reviewed time period of five years, 1028 patients with a diagnosis of hip pain were identified, with 201 patients meeting the study inclusion criteria. Full chart reviews were performed on these patients, and all 201 were included in data analysis. Manual therapy was performed on 74 patients (37%). (Figure 1)

Demographic and baseline variables were similar between treatment groups. (Table 1) Patients with

Figure 1. Participant flow diagram.

Table 1. Patient demographics data are means (SD) or numbers (%).

Demographics	All patients (n = 201)	Manual therapy group (n = 74)	No manual therapy group (n = 127)	p value
Age	14.23 ± 2.2	14.45 ± 2.0	14.11 ± 2.3	0.29
Gender (% Female)	149 (74.1%)	58 (78.4%)	91 (71.7%)	0.32
Duration of symptoms (in weeks)	22.28 ± 29.0	22.91 ± 30.59	21.92 ± 28.14	0.82
Initial pain level	6.76 ± 1.7	6.89 ± 1.8	6.69 ± 1.6	0.44

Note: Data are means (SD) or numbers (%).

Table 2. Patient outcomes.

	All patients (n=201)	Manual therapy group (n=74)	No manual therapy group (n=127)
Number of visits seen	8.3 ± 4.8	9.4 ± 3.9	7.6 ± 5.2
Discharge pain level	1.7 ± 2.5	1.9 ± 2.6	1.7 ± 2.5
Change in pain	5.0 ± 2.9	5.0 ± 2.9	5.0 ± 3.0
Functional outcomes (Available)	All patients 22% (44 of 201)	Manual therapy Group 9.5% (17 of 74)	No manual therapy group 21% (27 of 127)
Change in function HOS or LEFS (0–100)	17.1 ± 15.9	18.8 ± 18.8	16.0 ± 14.2

Note: Data are means (SD).

Table 3. Pairwise comparison of pain efficiency and adherence.

	Manual therapy	No manual therapy group	p value	Mean difference (95% CI)
Pain efficiency	0.60 ± 0.50	0.80 ± 0.61	0.01	0.20 (0.05, 0.36)
Adherence	82.5 ± 16.1	78.8 ± 21.3	0.20	3.7 (−1.9, 9.4)

Note: Data are means (SD).

Figure 2. Between group comparison of pain efficiency.

anterior hip pain in both groups were predominately female (74.1%) with an average age of 14 years. Patients reported an average of 5-month duration of hip symptoms at their evaluation. Care for the patients was provided by 30 different physical therapists, with an average of 2 therapists involved in each patient's episode of care. Eighteen of the therapists were board-certified clinical specialists in either sports or orthopedics, and 2 of the therapists had advanced certifications in manual therapy. Sports-certified specialists performed manual therapy in 37% of patients, and orthopedic-certified specialists performed manual therapy in 47% of patients. Therapists with advanced certifications in manual therapy performed it in 50% of their patients with anterior hip pain.

Patients in both groups had similar reductions in reported pain over the course of care (6.89 manual therapy group vs. 6.69 No manual therapy group). (Table 2) The manual therapy group used on average 1.8 more visits than the no manual therapy group. Overall patient adherence rate was 80% with an average of eight visits attended. The MANCOVA assessing pain efficiency and adherence demonstrated a significant difference between treatment groups ($p = 0.022$). Secondary univariate analyses demonstrated a significant mean difference

in pain efficiency ($p = 0.01$) and no difference was noted between groups in adherence ($p = 0.20$). (Table 3) The mean pain efficiency was significantly better if manual therapy was not performed (manual therapy = 0.60 [95% CI 0.47, 0.72]), no manual therapy = 0.80 [95% CI 0.68, 0.90]). (Figure 2) Calculations on the patients' self-reported change in function were not performed due to missing completed functional outcome measures in 149 (74%) of the patients' charts.

Ten total adverse reactions were noted in the patients' charts. Five mild adverse reactions were noted in each group with no moderate or severe adverse reactions noted in either group. All adverse reactions noted in this chart review had a significant increase in hip pain of $\geq 2/10$ reported at the end of the session. The relative risk of an adverse reaction from performing manual therapy is 1.27 (95% CI 0.68, 2.4). No significant differences in the number of patients experiencing an adverse reaction were noted between groups ($p = 0.503$).

Manual therapy techniques directed at the hip, pelvis, and lumbar spine were performed on 74 patients with anterior hip pain. Manual therapy was used in a mean of 4.19 (SD 2.99) visits throughout the course of care. The manual techniques performed were up to the discretion of the therapist and were based upon the individual presentation of the patient. The most common manual techniques applied were grade III-IV joint mobilizations directed to the hip joint (59%); IASTM (31%), STM (24%), MET (30%) directed at the pelvis, and manipulations (22%) were also commonly used. (Table 4) Myofascial release (12%) and manual stretching (8%) were the least commonly used manual techniques observed in this retrospective review.

Discussion

The therapists observed in this chart review treated in line with the recommendations in the current clinical practice guidelines [13]. This includes joint mobilization/manipulation and soft tissue mobilization directed at the hip and/or pelvis for the purpose of pain reduction and restoration of motion [13]. With 37% of the patients in this study receiving manual therapy, it is clear that this is a common treatment choice by clinicians for this population. There is an abundance of high-level evidence supporting manual therapy interventions directed at the hip and/or lumbopelvic regions for the treatment of hip pain in the adult population [7,11,29]. However, based on

Table 4. Pain efficiency of manual techniques.

	Mobilization (n=44)	Manipulation (n=16)	IASTM/STM (n=35)	MET (n=22)	Myofascial release (n=9)
Pain efficiency	0.57 ± 0.50	0.52 ± 0.41	0.67 ± 0.47	0.76 ± 0.55	0.71 ± 0.55

Note: Data are means (SD).

the results of this retrospective study, the use of manual therapy to treat anterior hip pain in pediatric patients needs further investigation.

The results of this study provide valuable information regarding the frequency and effectiveness of manual interventions in this population. The most clinically relevant finding was the statistically significant improvement in pain efficiency in the group that did not receive manual therapy. This indicates that the individuals who received manual therapy interventions had a combination of more visits in their episode of care and/or a lower total reduction in pain from their first to last visit. Similarly, a recent controlled study of an adult population with FAI receiving manual therapy interventions in conjunction with exercise found no significant differences in outcomes compared to a home program [30]. Yet, there is a large body of evidence, including both the adult and the pediatric populations, supporting manual therapy directed at the lumbopelvic regions for the treatment of various orthopedic conditions [8,31,32].

It is important to note that manual therapy interventions did not result in an increased risk of adverse reactions in this pediatric population with anterior hip pain. An equal number of mild adverse reactions were found in both groups, indicating that clinicians can utilize manual therapy techniques in this patient population without fear of causing an adverse event. In this study, 22% of patients received manipulation directed at the lumbopelvic region with no significant increased risk of adverse reactions. This information is in line with previous trials that found no increased risk of adverse reactions in adolescent patients receiving lumbar manipulation [31,33,34]. To date, there are no other studies which assess the risk of adverse reactions from manual therapy in the pediatric patients with anterior hip pain [35].

As this study was retrospective by design, there are several limitations inherent to it. First, due to a lack of reporting on subjective outcome measures in the majority of the charts reviewed (74%), this study was unable to assess effectiveness of manual therapy in regard to function. Due to lack of functional outcome data, we were unable to control for initial level of disability. There may have been a selection bias when therapists chose to perform manual therapy, but without initial levels of function we cannot determine if manual therapy was more frequently performed on patients with lower functional levels. In addition, there was no control over the skill of the manual therapist providing the interventions, and no way to assess inter-therapist reliability. A range from first-year practicing therapists to certified manual therapists

were performing the techniques. Additionally, there was no control over the types of manual techniques applied to the individual patients. Although these limitations reduce the ability to determine the effectiveness of manual therapy in children with anterior hip pain, it is a representation of current clinical practice.

Preliminary evidence suggests that manual therapy is safe in the treatment of this patient population, but its effectiveness is questionable. Future research should move toward randomized controlled trials using skilled manual therapists to identify whether or not manual therapy can be an effective treatment in pediatric patients with anterior hip pain.

Conclusion

In this grouping of pediatric patients with a diagnosis of anterior hip pain, manual therapy was a safe intervention, but resulted in lower pain efficiency. Due to limited functional outcome data, conclusions about the effect of manual therapy on function could not be made. Future research should be performed to assess the effectiveness of manual therapy, when performed by skilled therapists, in pediatric patients with hip pain in a controlled manner.

Contributors

MG conceived and designed the study, collected the data, interpreted the results, wrote the article in part, and revised the article. BC conceived and designed the study, collected the data, interpreted the results, wrote the article in part, and revised the article. MS contributed in design of the study, obtained ethics approval, analyzed the data, wrote the article in part, and revised the article.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Briana Crowe <http://orcid.org/0000-0002-6082-1084>

References

- [1] Prather H, Colorado B, Hunt D. Managing hip pain in the athlete. *Phys Med Rehabil Clin N Am*. 2014;25(4):789–812.
- [2] Rankin A, Bleakley C, Cullen M. Hip joint pathology as a leading cause of groin pain in the sporting population: a 6-year review of 894 cases. *Am J Sports Med*. 2015;43(7):1698–1703.

- [3] Quinn A. Hip and groin pain: physiotherapy and rehabilitation issues. *Open Sports Med J*. 2010;4:93–107.
- [4] Thorborg K, Serner A, Petersen J, et al. Hip adduction and abduction strength profiles in elite soccer players: implications for clinical evaluation of hip adductor muscle recovery after injury. *Am J Sports Med*. 2011;39(1):121–126.
- [5] Dd SA, Holmich P, Phillips M, et al. Athletic groin pain: a systematic review of surgical diagnoses, investigations and treatment. *Br J Sports Med*. 2016;50(19):1181–1186.
- [6] Childs J, Cleland J, Elliott J, et al. Neck pain: clinical practice guidelines. *J Orthop Sports Phys Ther*. 2008;38(9):A1–A34.
- [7] Cibulka M, White D, Woehrle J, et al. Hip pain and mobility deficits - hip osteoarthritis: clinical practice guidelines. *J Orthop Sports Phys Ther*. 2009;39(4):A1–A25.
- [8] Delitto A, George S, Dillen L, et al. Low back pain: clinical practice guidelines. *J Orthop Sports Phys Ther*. 2012;42(4):A1–A57.
- [9] Martin R, Davenport T, Paulseth S, et al. Ankle stability and movement coordination impairments: ankle ligament sprains: clinical practice guidelines. *J Orthop Sports Phys Ther*. 2013;43(9):A1–A40.
- [10] Martin R, Davenport T, Reischl S, et al. Heel pain - plantar fasciitis: revision 2014: clinical practice guidelines. *J Orthop Sports Phys Ther*. 2014;44(11):A1–A33.
- [11] Hoeksma H, Dekker J, Ronday H, et al. Comparison of manual therapy and exercise therapy in osteoarthritis of the hip: a randomized clinical trial. *Arth & Rheum*. 2004;51:722–729.
- [12] Weir A, Jansen J, van de Port I, et al. Manual or exercise therapy for long-standing adductor-related groin pain: a randomized controlled clinical trial. *Man Ther*. 2011;16(2):148–154.
- [13] Enseki K, Harris-Hayes M, White D, et al. Nonarthritic hip joint pain. *J Orthop Sports Phys Ther*. 2014;44(6):A1–A32.
- [14] Almeida MO, Silva BNG, Andriolo RB, et al. Conservative interventions for treating exercise-related musculotendinous, ligamentous and osseous groin pain. *The Cochrane Library*. 2013, Issue 6. Art. No.: CD009565.
- [15] Puentedura E, O'Grady W. Safety of thrust joint manipulation in the thoracic spine: a systematic review. *J Man Manip Ther*. 2015;23(3):154–161.
- [16] Gatterbauer A. Contraindications in osteopathy. Vienna: Danube University Krem; 2009.
- [17] Gal J, Herzog W, Kawchuk G, et al. Biomechanical studies of spinal manipulative therapy (SMT) quantifying the movements of vertebral bodies during SMT. *J CCA*. 1994;38(1):11–24.
- [18] Bruggeman G. Biomechanics in gymnastics. *Med Sport Science*. 1987;25:142–176.
- [19] Gatt CJ Jr, Hosea TM, Palumbo RC, et al. Impact loading of the lumbar spine during football blocking. *Am J Sports Med*. 1997;25(3):317–321.
- [20] O'Kane J. Anterior hip pain. *Am Fam Physician*. 2015;90(6):1687–1696.
- [21] McGalliard M SP, Ezell D. The Hip: physical therapy patient management using current evidence. *Current Concepts of Orthopaedic Physical Therapy*. 4th ed. La Crosse, WI Orthopaedic Section, APTA, Inc. 2016; p. 1–63.
- [22] Childs JD, Piva SR, Fritz JM. Responsiveness of the numeric pain rating scale in patients with low back pain. *Spine (Phila Pa 1976)*. 2005;30(11):1331–1334.
- [23] Jensen MP, Turner JA, Romano JM. What is the maximum number of levels needed in pain intensity measurement? *Pain*. 1994;58(3):387–392.
- [24] Wang Y, Hart D, Stratford P, et al. Clinical interpretation of a lower-extremity functional scale-derived computerized adaptive test. *Phys Ther*. 2009;89(9):957–968.
- [25] Martin RL, Philippon MJ. Evidence of reliability and responsiveness for the hip outcome score. *Arthroscopy*. 2008;24(6):676–682.
- [26] Lin CW, Moseley AM, Refshauge KM, et al. The lower extremity functional scale has good clinimetric properties in people with ankle fracture. *Phys Ther*. 2009;89(6):580–588.
- [27] Binkley JM, Stratford PW, Lott SA, et al. The Lower Extremity Functional Scale (LEFS): scale development, measurement properties, and clinical application. North American orthopaedic rehabilitation research network. *Phys Ther*. 1999;79(4):371–383.
- [28] Watson CJ, Propps M, Ratner J, et al. Reliability and responsiveness of the lower extremity functional scale and the anterior knee pain scale in patients with anterior knee pain. *J Orthop Sports Phys Ther*. 2005;35(3):136–146.
- [29] French H, Cusack T, Brennan A, et al. Exercise and manual physiotherapy arthritis research trial for osteoarthritis: a multicenter randomized controlled trial. *Arch Phys Med Rehabil*. 2013;94:302–314.
- [30] Wright A, Hegedus E, Taylor J, et al. Non-operative management of femoroacetabular impingement: a prospective, randomized controlled clinical trial pilot study. *J Sci Med Sport*. 2016;19:716–721.
- [31] Alqwist A, Hagman M, Kjellby-Wendt G, et al. Physical therapy treatment of back complaints on children and adolescents. *Spine*. 2008;33(20):E721–E727.
- [32] Ruddock J, Sallis H, Ness A, et al. Spinal manipulation vs sham manipulation for nonspecific low back pain: a systematic review and meta-analysis. *J Chiropractic Med*. 2016;15(3):165–183.
- [33] Selhorst M, Selhorst B. Lumbar manipulation and exercise for treatment of acute low back pain in adolescents: a randomized controlled trial. *J Man Manip Ther*. 2014;23(4):226–233.
- [34] Hayden J, Mior S, Verhoef M. Evaluation of chiropractic management of pediatric patients with low back pain: a prospective cohort study. *J Manip Physiol Ther*. 2003;26(1):1–8.
- [35] Vaughn D, Kenyon L, Sobeck C, et al. Spinal manual therapy interventions for pediatric patients: a systematic review. *J Man Manip Ther*. 2012;20(3):153–159.