

The Effectiveness of the Mézières Method in Elite Rhythmic Gymnastics Athletes With Low Back Pain: A Randomized Controlled Trial

Orges Lena, Jasemin Todri, Ardita Todri, José Luis Martínez Gil, and Maria Gomez Gallego

Context: One of the main reasons why athletes with a high physical condition suffer from low back pain disease is because they often participate in sports that involve disc compression movements during flexion, lifting loads, or torsion movement. **Objectives:** This study aims to examine the effectiveness of the postural treatment of the Mézières method on elite rhythmic gymnastics athletes with low back pain. **Design:** Double-blind, randomized, controlled trial. **Setting:** The sports hall of “Puente Tocinos,” Murcia, Spain. **Participants:** Ninety gymnastics athletes were randomized into 2 parallel groups (intervention: $n = 39$; control: $n = 51$), of whom 98.9% were women (women = 89; man = 1). **Intervention:** The Mézières method postural therapy was implemented. It lasted about 60 minutes in repeated sessions of 2 to 3 meetings per week by counting in overall 60 sessions during a 24-week period. **Main Outcome Measures:** Visual analog scale of pain, sit and reach flexibility test, Runtastic (pedometer performance android application), Roland–Morris Questionnaire for the physical disability, and the Health Status Questionnaire were used. **Results:** The univariate analysis of variance and independent sample t test revealed a significant improvement in the intervention group concerning the visual analog scale pain assessment scale ($P < .05$, $\eta_p^2 = .625$), and, also, the between-groups effect size was high during the 24 sessions of treatment ($d > 0.8$) compared with the control one. The same situation persists even for Roland–Morris Questionnaire ($P < .05$, $\eta_p^2 = .802$), physical score ($P < .05$, $\eta_p^2 = .613$), mental score ($P < .05$, $\eta_p^2 = .736$), sit and reach flexibility test ($P < .05$, $\eta_p^2 = .666$), and Runtastic performance ($P < .05$, $\eta_p^2 = .790$), where the between-groups effect size was high during the 24 sessions of treatment ($d > 0.8$). **Conclusion:** The Mézières method treatment performed on athletes with low back pain has caused positive effects on all the outcomes analyzed compared with the ones of control group.

Keywords: postural therapy, stretching, muscle chains, balance

There is a real interest in knowing why low back pain (LBP) has become a very common disease in elite gymnastics athletes, given that it is assumed that they are in good physical conditions. One of the main causes cited in the literature about the reason why even athletes with a high physical condition suffer from this disease is because they often develop sports that involve disc compression movements during flexion, lifting loads, or torsion movement.^{1–3}

This means that even the athlete who has a proper muscular development of the trunk while doing sport exercises and related specific techniques, in any case, is exposed to a great stress in this vertebral area.^{3,4} The mechanism that is evidenced in these situations of great physical stress is that the soft tissues, such as the muscles, cartilage of the facets, ligaments, and intervertebral discs, cannot withstand the cutting movements, as well as the compression or twisting movements. This begins to produce imbalances that directly influence the mechanics and biomechanics of the vertebral column.⁵ Therefore, it can be said that athletes, like the general population, can undergo biomechanical adaptations in the lumbar spine tissues.⁶

In this circumstance, it is affirmed that not only is LBP one of the most common conditions in the general population, but it is also present in younger athletes. In this population, LBP has a prevalence between 10% and 15%.^{2,7,8}

The literature mainly indicates 3 main mechanical causes of LBP in this type of population: muscle and ligament disorders, disc degeneration, and spondylolisthesis.^{9,10} From the other side, the less pronounced causes in this population are stress fractures in the joints and faces of the sacrum.^{11–13}

Inspired by this scientific data, with the reason to alleviate lower back pain in the elite gymnasts, this study analyzes the effects that can result from the implementation of the Mézières method (MM) because this postural technique acts directly on the back.

The therapeutic principle of this technique is based on working in a correct position through the lengthening of the muscle chains, progressively balancing the muscular work without making any compensation.^{14,15}

Methodology

Study Design and Sample Size

The ethical committee of Catholic University of Murcia granted approval for this study (no. 6572). It was further registered as a clinical trial (NCT03849053) on Clinicaltrial.gov. A double-blind, randomized, controlled trial was implemented to compare the effectiveness of MM in LBP (pre–post tests at baseline and after 24 wk) between 2 groups (experimental and active

Lena, J. Todri and Gallego are with the Health Science PhD Program, Universidad Católica de Murcia (UCAM), Murcia, Spain. A. Todri is with the Statistics and Engineering Specialist Area, Faculty of Economics, Universiteti “Aleksander Xhuvani,” Elbasan, Albania. Gil is with Hospital University Virgen de Arrixaca (HUA), El Palmar, Murcia, Spain. Lena is also with the “Movimiento Corporal y Desarrollo Humano” Research Group, UCAM, Spain. Lena (orges.lena90@gmail.com) is corresponding author.

comparator). No changes occurred in the methods after trial commencement.

The research protocol was conducted in accordance with the Declaration of Helsinki reference to ethical, legal, and regulatory principles, which provides guidance for health-related research involving human subjects.

The sample size was based on the evaluation of significant back pain of the National Rhythmic Gymnastics of Murcia, Spain. Specifically, it was analyzed through the 1-tail test by comparing the mean scores between 2 independent sample *t* tests. Using a statistical power of 76% in the significance level of .05 and an effect size of 0.5, a sample size of 90 participants was needed (Appendix).

Participants

The participants were recruited from the elite athletes of the National Gymnastics Rhythmic team of Murcia. A total of 139 individuals were invited to participate. The professional athletes, between the ages of 15 and 39 years with LBP, were characterized by a high level of training, with a clinical diagnosis of chronic nonspecific LBP lasting more than 1 month. They practiced sports at a competitive level for a minimum of 2 years and maintained a healthy and sporty lifestyle, with a training time of at least 9 hours per week.

Exclusion criteria were as follows: other type of athletes, pregnancy, back surgery in the last 6 months, vertebral fractures, severe osteoporosis, and infection or inflammation in acute diseases.

All the participants were examined, including minors, who also presented a paternal authorization document and the informed complete consent, after having read and accepted the conditions of participation and the characteristics presented in a previous informative letter.

Randomization and Blinding

In total, 90 gymnastics athletes were randomized into 2 parallel groups. Randomization was done using the uniform distribution (1.1) of the Excel 2016 platform. The participants were assigned prospectively to the intervention of MM in order to evaluate its effect in conjunction with the other types of treatments related to the rehabilitation of LBP, compared with the active control one, which did not receive this type of treatment, following the rehabilitation diary protocol. Outcomes assessor and care provider were blinded.

Setting

The MM was implemented in the sports hall of "Puente Tocinos," Murcia (Spain), the place where the rhythmic gymnastics athletes perform the training sessions.

Intervention

The participants provided individual instruction by the MM professional therapists in the preintervention phase. During each MM treatment session, the tight muscles related to the postural misalignment were progressively stretched into a particular postural position, followed by the active contraction of the antagonist muscles.¹⁴ The therapeutic principle of this technique was based on working in a correct position through the lengthening of the muscle chains, by progressively balancing the muscular work without making any compensation.

The intervention implemented in the athletes with LBP lasted about 60 minutes in repeated sessions of 2 to 3 meetings per week. In total 60 sessions were implemented during a 24-week period. The treatment consisted of 2 different postural treatments: a global neck pumpage with a relaxed lying patient associated with deep diaphragmatic breathing in all cases; and supine frog position for the first 16 weeks. During the last 16-week period, the postural treatment of athletes with LBP was modified; it was addressed by changing the position of the pelvis in 90° flexion, with the knees in 180° maintained by the therapist associated with deep diaphragmatic breathing, and the patient always lying supine in bed therapy. More specifically, the first posture aimed to release the diaphragm muscle and to stretch the anterior muscle chain, which relies on the progressive extension of the lower limbs and adduction of the upper limbs to involve the diaphragm, pectoralis minor, intercostalis, sternocleidomastoid, scalene, iliopsoas, and arm and hand flexors.

The second posture aimed to stretch the posterior muscle chain, which relies on the progressive hip flexion, knee extension, and dorsal flexion of the ankle to involve elevator scapulae, suboccipital, upper trapezius, erector spinae, gluteus maximus, ischiotibial, triceps surae, and foot intrinsic muscles.

The hips were flexed, abducted, and laterally rotated with the feet soles touching each other. The posture progressed in the direction of the extension of the lower limbs and adduction of the upper limbs.¹⁴

In the postural treatment, all the body segments had to be positioned correctly. The mobilization served only to overcome tensions and muscle stiffness; therefore, the posture kept the necessary time to reach elasticity. Meanwhile, the patient had to endure muscular tensions that were often painful. All the corrections should be emphasized, including the references and positioning of the toes, heels, ankles, knees, back, and occipital while using the deep breathing technique that harmonizes the posture.

The participants of the control group continued to follow the normal daily training, in respect to the athletes' rehabilitation diary protocol, which did not include any form of stretching technique related to MM implemented during the 24-week period.

Outcomes

The outcomes were assessed at baseline and before 24 weeks of treatment. The following 5 measurements were taken under consideration: (1) the severity of pain measured with the visual analog scale,¹⁶ scored in the range of 0 (painless) and 10 (severe pain); (2) the sit and reach flexibility test,¹⁷ designed to test the flexibility of the lower back and hamstring muscles. The score is recorded to the nearest inch/centimeter as the distance reached by the hand. For women, the lowest value is less than -15 cm, and the highest is greater than +30 cm. For men, instead, the lowest value is less than -20 cm, and the highest is greater than +27 cm; (3) Runtastic (pedometer performance android application),¹⁸ which is aimed at recording fitness in many activities and sports. It captured all the basic data: distance, average speed, speed between mile markers, altitude, pace, step between mile markers, duration, calories burned, and route plotted on a map using the global positioning system. The final result shows how many steps are made in the arc of 60 seconds; (4) the Roland-Morris Questionnaire¹⁹ measured the physical disability. High levels of disability are reflected by great numbers on a 24-point scale; and (5) the Health Status Questionnaire measured the general health

conditions. Concretely, the physical component (physical score) and the mental component (mental score) were evaluated.²⁰ The questionnaire consists of 12 questions, and the completion time is around 2 minutes. Scores ranged from 0 to 100; higher scores reflected better quality of life.

Statistical Analysis

The sample calculation was done by the G*Power 3.1.9.2 program (Kiel, Schleswig-Holstein, Germany). It determines the effect size before the initial collection as well as in the post hoc analysis (Appendix).

The statistical analysis was performed using the SPSS for Windows (version 21; IBM, Chicago, IL). The data were reported as mean (SD), and the confidence level of 95% was implemented, while the significance of the differences between the 2 groups were assessed using independent *t* tests.

For the comparison between the groups' effect size (experimental group—Mézières method group [MMG] and control comparator group [CCG]), the univariate analysis of variance was used. Effect sizes were calculated for changes in scores between the baseline and posttest. The Bonferroni test was used to identify the differences, maintaining an overall significance level of 5%.

Results

Participants

A flowchart of participants in the study is shown in Figure 1. From the 139 athletes initially enrolled in the study, 90 rhythmic gymnasts met the inclusion–exclusion criteria. During the study period, 39 participants were assigned in the experimental group (MMG), 6 were transferred to the control group, and, in total, 51 were assigned in the CCG.

Specifically, the sample consists in 2 groups composed of 90 participants (MMG: *n* = 39; CCG: *n* = 51), of whom 98.9% are women (women = 89; man = 1).

Regarding the age of the study, the sample is characterized by athletes aged 15–38 years (mean age = 20.89; SD = 4.63), with a height of 153 to 173 cm (mean height = 164.1; SD = 5.4) (Figure 2).

At baseline, there was not any between-groups difference for the study outcome measures, such as the visual analog scale, *t*(88) = .510, *P* = .611; Roland–Morris Questionnaire, *t*(88) = −.096, *P* = .923; physical score, *t*(88) = −1.777, *P* = .079; and sit and reach flexibility test, *t*(88) = −.755, *P* = .452, with the exception of the subscales mental score of health scale (Health Status Questionnaire), *t*(88) = −2.475, *P* = .015, and Runtastic performance, *t*(88) = −4.759, *P* = −4.759.

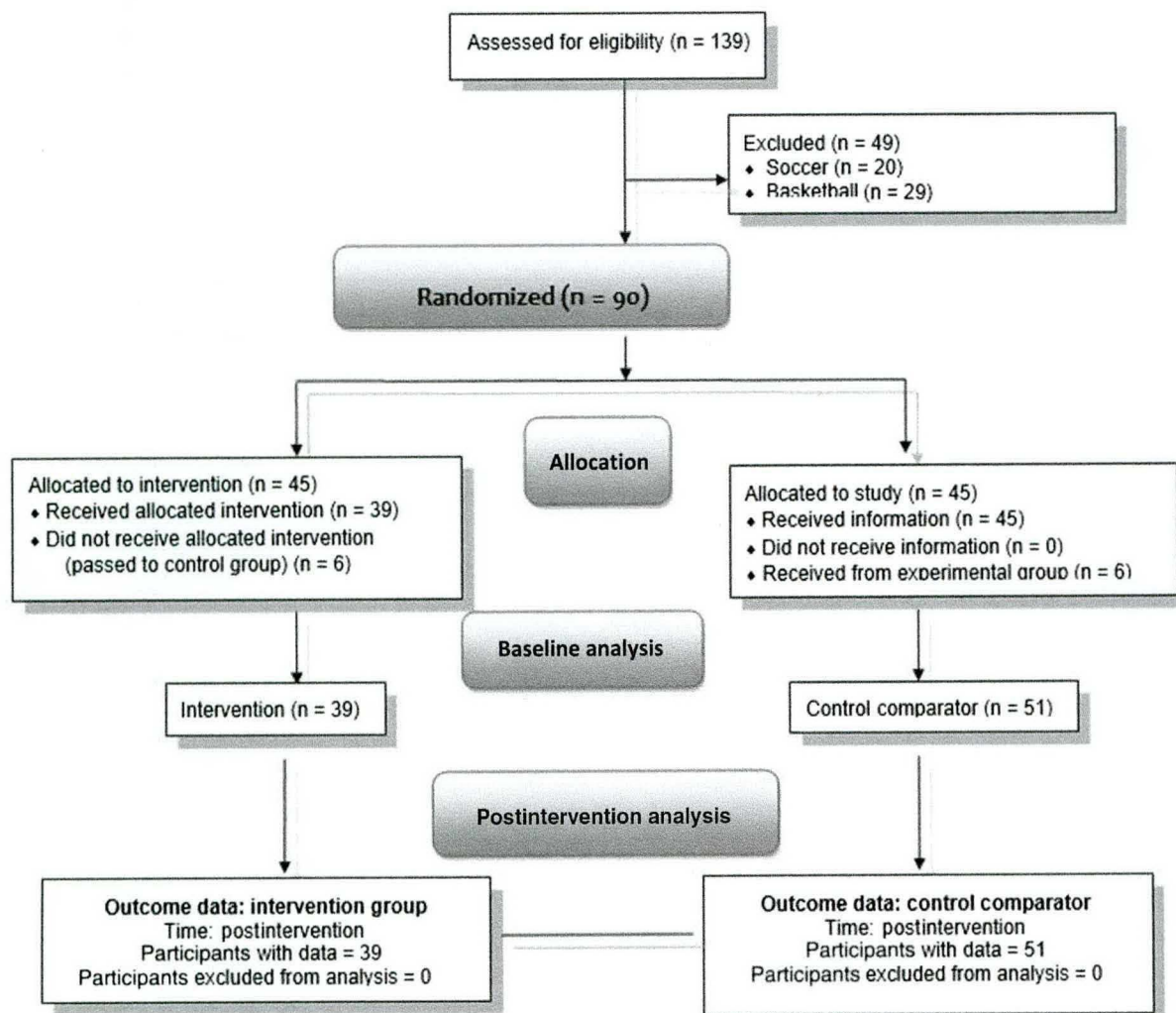


Figure 1 — Flowchart of participants.

Figure 2 gives a clear picture of descriptive data distribution in the 2 study groups, and Table 1 gives a specific analysis of all the data.

Outcomes

By observing the CCG and the MMG, it is evidenced that the visual analog scale pain assessment scale in pre–post tests (T0–T1) had a significant value ($P < .05$, $\eta_p^2 = .625$) in the between-groups analysis, and the between-groups effect size was high during the 24 sessions of treatment ($d > 0.8$).

Also, for the Roland–Morris Questionnaire ($P < .05$, $\eta_p^2 = .802$), physical score ($P < .05$, $\eta_p^2 = .613$), mental score ($P < .05$, $\eta_p^2 = .736$), sit and reach flexibility test ($P < .05$, $\eta_p^2 = .666$), and

Runtastic performance ($P < .05$, $\eta_p^2 = .790$), between-groups effect size was high during the 24 sessions of treatment ($d > 0.8$ as described in Table 1).

Discussion

The results of this pilot randomized controlled trial provide preliminary support for the feasibility and effects of MM intervention in elite rhythmic gymnastics with LBP associated with muscular disequilibrium that does not allow normal movement and forces the motor system to compensate.

The intervention had a significant impact on these athletes. Perhaps the high effect size of the between-groups difference is

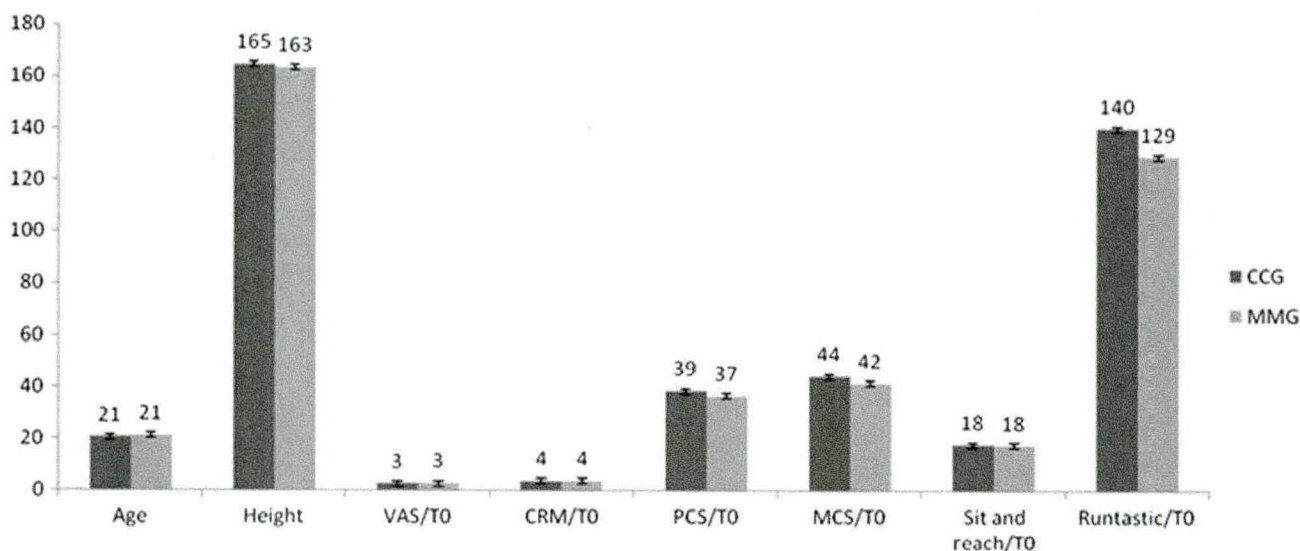


Figure 2 — Descriptive data of participants at baseline (mean [SD]). CCG indicates comparator control group; CRM, Roland–Morris Questionnaire; MCS, mental score; MMG, Mézières method group; PCS, physical score; T0, baseline pretest; VAS, visual analog scale.

Table 1 Comparison of Outcomes Between Groups

Outcomes	Sample	n	Baseline (T0)			24 wk (T1)			T1–T0 effect size	T1–T0/between- groups difference		
			Mean (SD)	P	t	Mean (SD)	P	t	Cohen d	Mean difference (95% CI)	P	Partial η^2
VAS	MMG	39	2.8 (1.07)	.61	.51	1.1 (1.12)	<.001	–10.22	2.39	–2.5 (–2.9 to –2.07)	<.001	.625
	CCG	51	2.7 (1.04)			3.5 (1.1)						
CRM	MMG	39	3.7 (1.39)	.92	–.09	1.5 (1.25)	<.001	–14.98	3.12	–3.5 (–4.03 to –3.06)	<.001	.802
	CCG	51	3.8 (1.39)			5.1 (1.01)						
PCS	MMG	39	36.6 (4.85)	.08	–1.77	43.4 (5.48)	<.001	8.47	2.48	11.5 (9.6 to 13.5)	<.001	.613
	CCG	51	38.5 (5.16)			33.8 (5.26)						
MCS	MMG	39	41.6 (4.72)	.02	–2.47	50.5 (5.52)	<.001	11.7	3.33	15.7 (13.7 to 17.7)	<.001	.736
	CCG	51	44.2 (5.28)			37.4 (5.03)						
Sit and reach	MMG	39	17.5 (2.25)	.45	–.75	21.7 (3.6)	<.001	8.65	2.75	5.7 (4.8 to 6.5)	<.001	.666
	CCG	51	17.8 (2.11)			16.4 (2.23)						
Runtastic	MMG	39	129.2 (11.52)	<.001	–4.75	140.4 (9.55)	<.001	4.06	4.47	19.7 (17.9 to 21.6)	<.001	.790
	CCG	51	140.2 (10.27)			131.6 (10.71)						

Abbreviations: CCG, control comparator group; CI, confidence interval; CRM, Roland–Morris Questionnaire; MCS, mental score; MMG, Mézières method group; PCS, physical score; *t*, independent sample *t* test; VAS, visual analog scale. Note: Effect size: $d = 0.2$ (small), 0.5 (medium), and 0.8 (large); partial $\eta^2 = .01$ (small), $.09$ (medium), and $.25$ (large).

derived from the fact that MM applied in the intervention group used global stretching techniques to reestablish the balance of muscular tension that causes postural alterations, especially in the lumbopelvic area, which extends toward the caudal and the cranial one.²¹ Concretely, the aim of the study was to analyze the effects of MM on the outcomes associated with LBP (ie, pain, flexibility, function, state of health, and performance yield). The most common alterations were the misalignments of the pelvis in the sagittal plane and the functional limitation that causes pain with loss of flexibility.²²

Referring to the epidemiological data on the LBP in athletes, the frequency is 1% to 30%,⁸ and the data that vary depending on the sport are more frequent in gymnastics among others. Other factors also impact LBP, such as sex, intensity and frequency of training, as well as sports technique. Other authors show that back pain is a common symptom in adolescent athletes.²³

Meanwhile, rhythmic gymnastics is characterized by the use of the gymnast's body in articulated ranges outside the physiological limits, by adopting hygienically inadequate postures that can cause a large external load during the exercises of great torsion, performed even at high speed.^{24–26} Through the movements most frequently encountered in a rhythmic gymnastics exercise are hyperextensions of the lumbar spine, causing collisions between the facet joints of the spinous and transverse processes, as well as the bone contacts of the spinous processes of the vertebrae, which, in some cases, may facilitate the appearance of arthritis, faceted syndromes and arthritis in the joints of the posterior aspect of the spine.²⁷

It is therefore considered that this fact may be the main reason why LBP has become one of the most common injuries in rhythmic gymnastics, causing even a loss of training days.¹²

Moreover, referring to the significant results of the outcomes, it can be noted that the MM positively influenced the quality of life of the athletes treated. Therefore, a significant difference was noted again between the 2 groups (MMG and CCG). In this context, it was also shown that after the proposed treatment, MMG patients increased flexibility and reduced the percentage of functional disability. Similarly, the results coincide with other studies acting through similar interventions, showing significant changes in the intragroup LBP.^{28,29} These treatments are based on training programs with the integration of health education techniques and manual therapy.³⁰

Other previous studies that combined different rehabilitation modalities have shown better results when manual therapy and therapeutic exercise have been combined with the ones of control groups derived from a general medical practice, considering that statistical differences are more significant for pain in favor of combined physiotherapy,³⁰ as in the case of the present study.

The results of all functional and psychological examinations in this study (pain, flexibility, performance, physical disability, and health status) showed significant improvements compared with the initial time, and the differences are very significant for both groups in terms of improvement. In the differences within groups, a significant improvement was observed ($P < .001$ in all cases) in comparison with the CCG due to an extra treatment like MM. In fact, these results are expected after a controlled, supervised, and completed exercise program³¹; however, the value of the intervention is focused on the mean differences of individuals between the values in the initial evaluation and after the exercise program because, in this way, the course of each individual is analyzed.³²

Limitations

It was very difficult to find documented scientific studies elaborated by Françoise Mézières. The technique is known all over the world, but the method has been modified over time, and not only by respective disciples, such as Busquet, Campignon, Denys-Struyf, Souchart, and so forth. All the variations of the technique are exploited for a good scientific basis with the same principles but with different elements that lose the originality of the MM itself, and, therefore, they limit the scientific reproduction of the method nowadays.

Other limitations of the present study include the small sample size and few sessions in the intervention period, which may have influenced the results.

In future studies, it will be necessary to examine larger samples of athletes whether the implementation of the technique should be managed from more than 3 professional therapists.

Through the implementation of manual therapy, and specifically aiming at muscle stretching, deep breathing, and self-control (MM characteristics), this study creates a pioneering scientific tool to develop the knowledge in the prevention and treatment line, while possibly opening the door to future scientific studies in the field of rehabilitation.

Conclusion

The aim of this work is to demonstrate how a postural therapeutic approach like MM allows for a better and more global management of chronic lumbar pain. It shows that rehabilitation cannot use a “dosage” approach but that the patient must be treated as an active subject in the rehabilitation path. Through an integrated approach, it should be acted on the patient, as well as on the context in which he/she lives (domestic environment, sports field, university, etc), by eliminating the risk factors.

Therefore, in respect to the hypothesis raised in this study, it can be concluded that the treatment performed on athletes with LBP has caused positive effects on all the variables analyzed compared with those of the control group. In this way, the main research hypothesis is confirmed.

Acknowledgments

The authors appreciate the collaboration of all the National Gymnastic Rhythmic of Murcia athletes as well as the professional trainers involved. The authors have no conflicts of interest to disclose. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Trial registration: clinicaltrials.gov Identifier: NCT03849053.

References

1. Rodríguez-García PL, López-Miñarro PA, Santonja FM. The effect of school physical education programmes on low-back pain in school-children. *J Phys Educ Health*. 2013;2(4):43–48.
2. Trompeter K, Fett D, Platen P. Prevalence of back pain in sports: a systematic review of the literature. *Sports Med*. 2017;47(6):1183–1207. PubMed ID: 28035587 doi:10.1007/s40279-016-0645-3
3. Ghofrani M, Olyaei G, Talebian S, Bagheri H, Malmir K, Mousavi S. Immediate effects of lumbosacral belt on postural control during challenging tasks in patients with chronic low back pain. *J Modern Rehab*. 2017;11(2):119–126.

4. Pajek MB, Pajek J. Low back pain and the possible role of Pilates in artistic gymnastics. *Sci Gymn J*. 2009;1(1):55–61.
5. Stergioulas A. Why are elite athletes suffering from low back pain. *J Biolog Exer*. 2013;9:2.
6. Jagadish A, Nandyala SV, Marquez-Lara A, Singh K, Lee YP. Spinal interventions—the role in the athlete. *Oper Tech Sports Med*. 2013; 21:185–190. doi:10.1053/j.otsm.2013.10.007
7. d'Hemecount PA, Gerbino PG, Micheli LJ. Back injuries in the young athlete. *Clin Sports Med*. 2000;19(4):663–679. doi:10.1016/S0278-5919(05)70231-3
8. Farahbakhsh F, Rostami M, Noormohammadpour P, et al. Prevalence of low back pain among athletes: a systematic review. *J Back Musculoskelet*. 2018;31(5):901–916. doi:10.3233/BMR-170941
9. Mehdizadeh R, Rajabi M, Abbasi S. Prevalence of low back pain among elite athletes. *Int Res J Basic Appl Sci*. 2013;4(2):329–331.
10. Gera A, Pereira PC, Eapen C. Low back pain in adolescent athletes; evaluation and rehabilitation. *J Exer Sci Physiother*. 2015;11(2):76. doi:10.18376/2015/v11i2/67706
11. Sward L, Hellstrom M, Jacobsson B, Nyman R, Peterson L. Disc degeneration and associated abnormalities of the spine in elite gymnasts. A magnetic resonance imaging study. *Spine*. 1991;16(4): 437–443. PubMed ID: 1828629 doi:10.1097/00007632-199104000-00009
12. Hsu WK, Jenkins TJ. Management of lumbar conditions in the elite athlete. *J Am Acad Orthop Surg*. 2017;25(7):489–498. PubMed ID: 28574940 doi:10.5435/JAAOS-D-16-00135
13. Zetaruk MN, Fors MV, Zurakowski D, Mitchell J, Mitchell WA Jr, Micheli LJ. Injuries and training recommendations in elite rhythmic gymnastics. *Apunts Med Esport*. 2006;41(151):100–106. doi:10.1016/S1886-6581(06)70018-4
14. Mezieres F. Retour à l'harmonie morphologique par une reéducation spécialisée. *Kinesithérapie Scientifique*. 1978;157:95–106.
15. Elgström E. La técnica fisioterapéutica de Françoise Mézières: una solución efectiva para la corrección de las problemáticas posturales y respiratorias de los instrumentistas de viento. *Artseduca*. 2017;17: 224–231.
16. Downie WW, Leatham PA, Rhind VM, et al. Studies with pain rating scales. *Ann Rheum Dis*. 1978;37(4):378–381. PubMed ID: 686873 doi:10.1136/ard.37.4.378
17. Wells KF, Dillon EK. The sit and reach—a test of back and leg flexibility. *Res Q Am Ass Health Phys Educ Recreate*. 1952;23(1): 115–118. doi:10.1080/10671188.1952.10761965
18. Antón AM, Rodríguez BR. Runtastic PRO app: an excellent all-rounder for logging fitness. *Br J Sports Med*. 2016;50(11):705–706. doi:10.1136/bjsports-2015-094940
19. Kovacs FM, Llobera J, del Real MTG, et al. Validation of the Spanish version of the Roland-Morris questionnaire. *Spine*. 2002; 27(5):538–542. PubMed ID: 11880841 doi:10.1097/00007632-200203010-00016
20. Luo X, George ML, Kakouras I, et al. Reliability, validity, and responsiveness of the short form 12-item survey (SF-12) in patients with back pain. *Spine*. 2003;28(15):1739–1745. PubMed ID: 12897502 doi:10.1097/01.BRS.0000083169.58671.96
21. Nisand M, Geismar S. *La Méthode Mézières: Un Concept Révolutionnaire: Mal De Dos et Déformations ne Sont Plus une Fatalité*. Paris, France: Éditions Josette Lyon; 2013.
22. Williams K, Steinberg L, Petronis J. Therapeutic application of Iyengar yoga for healing chronic low back pain. *Int J Yoga Therap*. 2003;13(1):55–67.
23. Schmidt CP, Zwingenberger S, Walther A, et al. Prevalence of low back pain in adolescent athletes—an epidemiological investigation. *Int J Sports Med*. 2014;35(8):684–689. doi:10.1055/s-0033-1358731
24. Paillard T. Plasticity of the postural function to sport and/or motor experience. *Neurosci Biobehav Rev*. 2017;72:129–152. PubMed ID: 27894829 doi:10.1016/j.neubiorev.2016.11.015
25. Zerf M. Body composition versus body fat percentage as predictors of posture/balance control mobility and stability among football players under 21 years. *Physic Educ Stud*. 2017;21(2):96–102. doi:10.1556/1/20755279.2017.0208
26. Potop V, Boloban V, Triboi V, Gorascenco A. Correlative analysis of the biomechanical characteristics and performances achieved by junior gymnasts in balance beam events. *Discobolul-Phys Edu, Sport Kinetoterap J*. 2017;2(48).
27. Kruse D, Lemmen B. Spine injuries in the sport of gymnastics. *Curr Sport Med Rep*. 2009;8(1):20–28. doi:10.1249/JSR.0b013e3181967ca6
28. Lawand P, Júnior IL, Jones A, et al. Effect of a muscle stretching program using the global postural reeducation method for patients with chronic low back pain: a randomized controlled trial. *Joint Bone Spine*. 2015;82(4):272–277. PubMed ID: 25881758 doi:10.1016/j.jbspin.2015.01.015
29. Bade M, Cobo-Estevez M, Neeley D, et al. Effects of manual therapy and exercise targeting the hips in patients with low-back pain: a randomized controlled trial. *J Eval Clin Pract*. 2017;23(4):734–740. PubMed ID: 28127827 doi:10.1111/jep.12705
30. Gomes-Neto M, Lopes JM, Conceição CS, et al. Stabilization exercise compared to general exercises or manual therapy for the management of low back pain: a systematic review and meta-analysis. *Phys Ther Sport*. 2017;23:136–142. PubMed ID: 27707631 doi:10.1016/j.ptsp.2016.08.004
31. Liddle SD, Baxter GD, Gracey JH. Exercise and chronic low back pain: what works? *Pain*. 2004;107(1–2):176–190. doi:10.1016/j.pain.2003.10.017
32. La Touche R, Fernández-de-Las-Peñas C, Fernández-Carnero J, et al. The effects of manual therapy and exercise directed at the cervical spine on pain and pressure pain sensitivity in patients with myofascial temporomandibular disorders. *J Oral Rehab*. 2009;36(9):644–652. doi:10.1111/j.1365-2842.2009.01980.x

Appendix: The Power Analysis of Sample Measured With G*Power 3.1.9.2 Program

