

## RESEARCH ARTICLE

# Effectiveness of physiotherapy interventions for injury in ballet dancers: A systematic review

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## Abstract

### Background

The unique repetitive nature of ballet dancing, which often involves transgressing endurance limits of anatomical structures, makes dancers prone to injury. The following systematic review aims to assess the effectiveness of physiotherapy interventions in the treatment of injuries in ballet dancers.

### Methods

The review was performed in line with the PRISMA statement on preferred reporting items for systematic reviews and meta-analyses. Six electronic databases (PubMed, Ovid Embase, Cochrane, Medline, PEDro, Google Scholar) were queried. The study populations comprised active ballet dancers and/or ballet school attendees with acute and chronic injuries and those with persistent pain. There were no restrictions regarding age, sex, ethnicity or nationality. The Modified McMaster Critical Review Form for quantitative studies was used to assess the methodological quality of the studies reviewed in accordance with the relevant guidelines.

### Results

Out of the total of 687 articles subjected to the review, 10 met the inclusion criteria. Diverse physiotherapeutic interventions were described and effectiveness was assessed using different parameters and measurements. Overall, the results indicate that physiotherapy interventions in ballet dancers exert a positive effect on a number of indices, including pain, ROM and functional status.

### Conclusions

Due to the small amount of evidence confirming the effectiveness of physiotherapeutic interventions in ballet dancers after injuries and methodological uncertainties, it is recommended to improve the quality of prospective studies.

## OPEN ACCESS

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## Introduction

Ballet is high-performance dancing that requires a high level of technical skills [1]. Particular demands are placed on flexibility and strength as well as on body aesthetics [2, 3]. The unique repetitive nature of ballet dancing, which often involves transgressing endurance limits of anatomical structures, makes dancers prone to injury [4]. The need to understand the mechanisms of injury in dancers is a considerable challenge on account of methodological limitations regarding injuries and characteristics of the population of dancers [3, 5].

Previous reports have noted the presence of injuries and some risk factors underlying these injuries in ballet dancers. In these studies, acute injuries were observed rarely and were usually associated with loss of balance during practice or a performance. At the same time, overload-related injuries were common, mostly affecting the lower limbs and the lower back (lumbosacral spine) [3, 6–8]. It has been found that ballet dancers may be at risk of low back pain or injury independent of gender, age or level of mastery [9]. Important risk factors for injuries included intensity of training [10, 11], poor control of lumbosacral complex motion, inadequate lower limb strength, poor oxygen endurance [12–14], and lifting in male dancers [15]. Due to the lack of high-quality research, consensus on risk factors for musculoskeletal injuries in dancers remains difficult. There is a need for high-quality prospective studies exploring the multifactorial relationship between risk factors and dance injuries [16].

Some studies have focused mainly on orthopaedic surgery interventions. Foot surgery has often been described [17–20] in relation to such injuries as metatarsal fractures, ankle impingement or tendinopathies. Surgical vs conservative management of fractures in dancers has also been described [21–23]. The hip joints in dancers have increasingly been a topic of interest for researchers, owing to their extreme mobility, with regard to biomechanics and treatment on account of both joint and muscle pathology. In a systematic review, Weber et al. concluded that appropriate surgical indications and good hip surgery techniques can prevent a premature end of career in dancers [24], while Nolton et al. reported on the need to introduce early and comprehensive work-up and management of snapping hip syndrome (SHS) [25].

Treatment of musculoskeletal conditions in ballet dancers has included physiotherapy intervention, including shockwave therapy [27, 28], manual therapy [29–31], stability exercises [32, 33], home exercise programs [31, 33–35] and stretching [36] as well as dry needling and acupuncture [31, 35]. Research has pointed to a level of effectiveness of physiotherapy in reducing pain and improving function [27–36]. However, the evidence base is limited and no systematic reviews to date have analyzed the effectiveness of physiotherapy in the treatment of musculoskeletal dysfunctions in dancers. Accordingly, this review aims to assess the effectiveness of physiotherapeutic interventions in the treatment of injuries in ballet dancers.

## Methods

### Search strategy

The review was performed in line with the PRISMA statement on preferred reporting items for systematic reviews and meta-analyses and is compatible with the PRISMA checklist ([S1 File](#)). The population-intervention-comparator-outcome (PICO) format was used for the search strategy, where the search terms and limits were associated with ballet dancers (population of interest) and physiotherapy (intervention).

To test the search strategy, the databases were searched independently by two reviewers. The search results were then compared to ensure search consistency. In cases where the results were different, the two reviewers discussed these differences together, and any conflicts were resolved by discussion. Only after achieving search consistency did the reviewers begin their

formal queries of the databases. A comprehensive search strategy was developed and six electronic databases (PubMed, Ovid Embase, Cochrane, Medline, PEDro and Google Scholar) were queried between March 26 and March 28, 2020. Only articles in English were taken into account.

As there had been no previous systematic reports, no date limitation was applied. The following MESH headings were used: dancer, ballet, ballet dancer, classical dancer, pain, and physical therapy. The complete data base search strategy is described in [S2 File](#).

## Study design

All types of quantitative study design were eligible for inclusion, including randomized controlled trials (RCT), controlled clinical trials (CCT), case studies, pre-post cohort studies and quasi-experimental studies. The inclusion criteria for the PICO format are presented below.

**Population.** Studies of interest were those investigating active ballet dancers and/or ballet school attendees with acute and chronic injuries and persistent pain. There were no restrictions regarding age, sex, ethnicity or nationality. Dancers experiencing a break from activity due to injury were included, but studies of retired dancers, dance instructors as well as those whose dominant style was not ballet dancing were excluded. Studies were also excluded if the study group was not defined precisely enough and was described using such general terms as “dancers” or “professional dancers”.

**Intervention.** As physiotherapy is usually concerned with comprehensive interventions, the review was not limited to a particular type of interventions and intervention parameters were not specified.

Physiotherapy interventions included, but were not limited to, kinesiotherapy, physical therapy, manual therapy, needle therapy and education. Studies where the intervention was limited to orthopaedic procedures or pharmacotherapy were excluded. Comprehensive interventions (physiotherapy combined with other modalities) were allowed.

**Comparator.** Admissible comparator interventions were non-intervention control and usual care.

**Outcome.** In view of the multidimensional nature of pain, differences in injury sites, nature of injury and a diversity of outcomes representing effects of physiotherapy interventions the queries were not limited with regard to any specific outcomes, with outcomes of interest including pain, ROM (range of motion), functional status and quality of life.

## Study selection

The results of the literature searches were transferred to the reference management software EndNote X9 to allow sorting of the identified studies. Duplicate results were removed. The studies were then accepted or excluded by analyzing the title and summary according to the PICO criteria. The full texts of accepted papers were analyzed by two independent reviewers to determine compatibility with the PICO criteria. Any disputes were resolved by discussion.

## Methodological quality

The accepted studies were independently assessed and classified according to “category of intervention” of the National Health and Medical Research Council (NHMRC) hierarchy of evidence by two reviewers. The Modified McMaster Critical Review Form [26] for quantitative studies was used to assess the methodological quality of the studies reviewed in accordance with the relevant guidelines. The tool assessed the following eight domains: study purpose; literature review; study design (all experimental designs); sample (description of subjects, justification of sample size, ethics, consent); outcomes (reliability and validity, outcome areas and

outcome measures employed); intervention (description, contamination, co-intervention); results (statistical significance and clinical importance, analysis methods, drop-outs); conclusions and clinical implications (limitations and bias). Individual elements were rated as “Yes”, “No”, “Not addressed” or “NA—not applicable”. Answers “Yes” were awarded a mark of 1, “No” and “Not addressed”, a mark of 0; if the answer was “NA”, the total score was altered appropriately. Depending on the study design and particular specific items, the maximum total score was 14. Each study was rated independently by each reviewer and any disputes were resolved by discussion.

### Summary of results

A meta-analysis was not performed in view of heterogeneity of the studies. A descriptive summary was carried out instead.

### Results

The literature search yielded 687 results, including 205 duplicates, which were subsequently removed. Analysis of the 482 titles and summaries resulted in the exclusion of 404 items. The remaining 78 articles were analyzed in detail, with 68 subsequently excluded (35 on account of the study population not meeting the inclusion criteria, 24 on account of an inappropriate study design, and 9 on account of an inappropriate intervention). A total of ten articles were compatible with all inclusion criteria and were consequently included in the study. The relevant PRISMA block diagram is presented in [Fig 1](#).

### Risk of bias

[Fig 2](#) summarizes NHMRC levels of evidence and scores assigned to the 10 studies according to the McMaster Quantitative Critical Appraisal Tool [26]. Study designs comprised 1 pre-post study [27], 1 non-randomized case-control study [32], 1 case series [33] and 7 case reports [28–31, 34–36]. The two highest critical appraisal scores of 91.7% and 90% were assigned to the studies by Kovácsné and Filipa et al., respectively, while the lowest score was assigned to the study by Porter et al. (45%), which indicates the lowest quality of that study among the 10 studies. All studies appropriately presented significant basic information and provided a rationale.

The chief methodological shortcoming in the 10 studies was the lack of randomization as 8 of the 10 works were reported case series or case reports. There was no rationale for the sample size in 5 out of the 10 studies [28, 32, 33, 35, 36], while only one study used statistical analysis [32]. Additionally, ethical approval was mentioned in only two studies [27, 32].

### Study characteristics

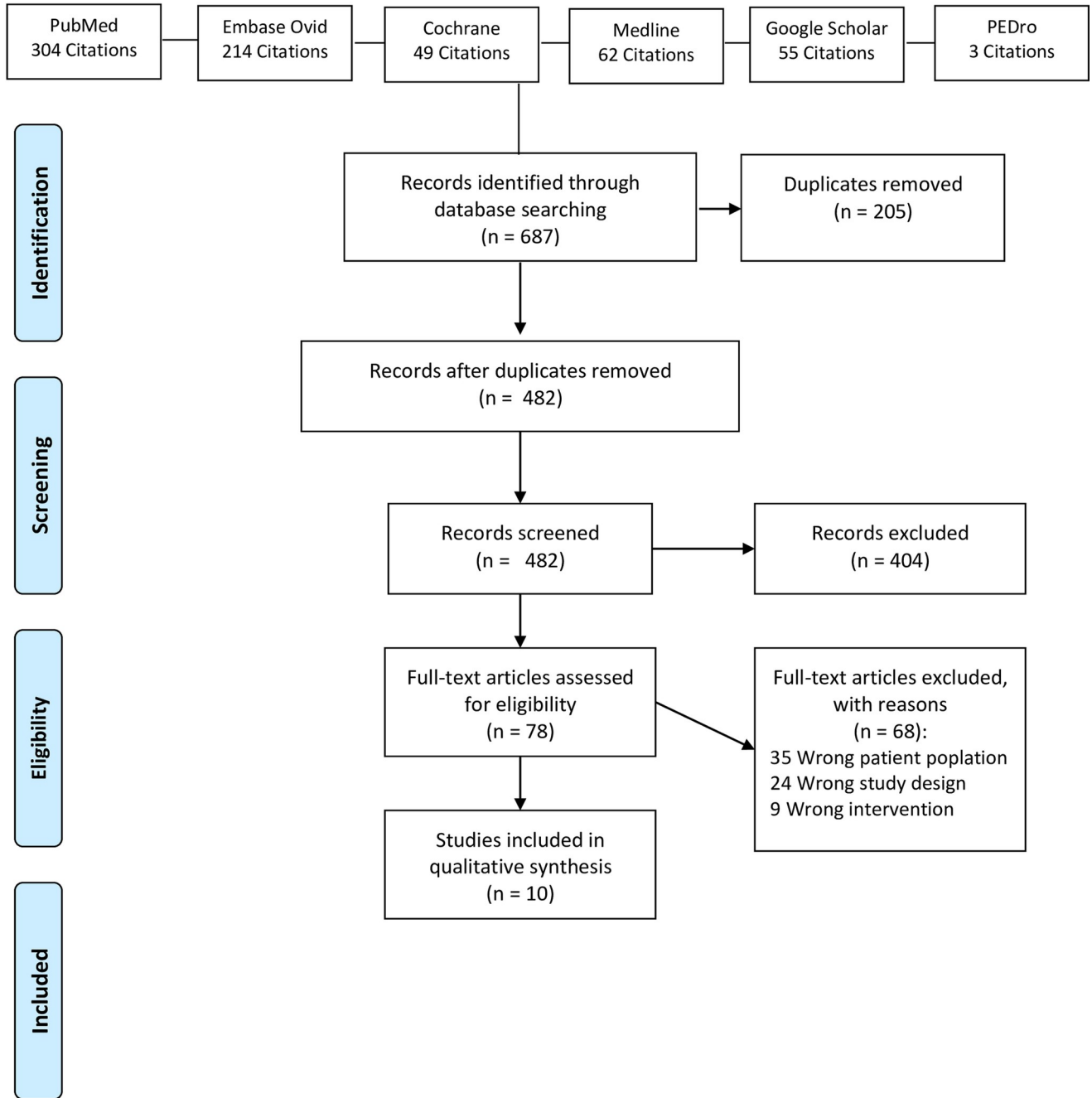
[Table 1](#) summarizes characteristics of the studies. The present systematic review identified various models of research. The studies were carried out in the USA [30, 31, 33–36], Italy [27], New Zealand [29], Hungary [32] and the UK [28]. The papers were published between 1998 and 2018. All studies investigated the effect of physiotherapy interventions on pain reduction and improvement in musculoskeletal function in ballet dancers.

### Participant characteristics

The total number of participants in all the studies was 83. The number of subjects ranged from 1 to 62, aged 11–29. As two studies failed to provide information about the sex of the subjects [32, 33], the proportion of male and female subjects could not be determined. Pain and



**PRISMA 2009 Flow Diagram**



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit [www.prisma-statement.org](http://www.prisma-statement.org).

**Fig 1. PRISMA block diagram.**

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Study	Study design	NHMRC Level	Items on Modified McMaster critical review form																Raw score	
			1	2	3	4a	4b	4c	5a	5b	6a	6b	6c	7a	7b	7c	7d	8	Pointes	%
Albisetti [27]	Pre-post study	Level III-3	Y	Y		19	Y	Y	Y	Y	Y	N	N/A	N	Y	Y	N/A	Y	10 out of 12	83,00%
Baigent [29]	Case report	Level IV	Y	Y		1	Y	N/A	Y	N	Y	N/A	NAD	N	Y	N	N/A	Y	8 out of 10	70%
Kovácsné [32]	Non-randomized controlled trial	Level III-2	Y	Y		62	N	Y	Y	Y	Y	N/A	NAD	Y	Y	Y	N/A	Y	11 out of 12	91,70%
Filipa [30]	Case report	Level IV	Y	Y		1	Y	N/A	Y	Y	Y	N/A	NAD	N	Y	Y	N/A	Y	9 out of 10	90%
Kho-Summers [34]	Case report	Level IV	Y	Y		1	Y	N/A	Y	Y	Y	N/A	NAD	N	Y	N	N/A	Y	8 out of 10	80%
Kline[33]	Case Series (report)	Level IV	Y	Y		5	N	N/A	Y	Y	Y	N/A	NAD	N	N	Y	N/A	Y	7 out of 11	64%
Mason [35]	Case report	Level IV	Y	Y		1	N	N/A	Y	Y	Y	N/A	NAD	N	Y	N	N/A	Y	7 out of 10	70%
Porter [36]	Case report	Level IV	N	Y		1	N	N/A	Y	Y	Y	N/A	N	N	Y	N	N/A	N	5 out of 11	45%
Quarrier [31]	Case report	Level IV	Y	Y		1	Y	N/A	Y	Y	Y	N/A	N	N	Y	N	N/A	Y	8 out of 11	73%
Silk [28]	Case report	Level IV	N	Y		1	N	N/A	Y	Y	Y	N/A	NAD	N	Y	N	N/A	N	5 out of 10	50%

**Fig 2. Items on Modified McMaster Critical Review form.**

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dysfunctions concerned the feet [27, 28, 30, 36], hips [29, 31, 34], lumbosacral spine [32, 33] and knees [35].

### Type of intervention

Even though all studies were concerned with the use of physiotherapy in the treatment of injuries in ballet dancers, variability with respect to both the type of intervention and the mode of application thereof was very much noticeable. Silk et al. investigated one intervention, while the others assessed several interventions each, which makes it difficult to determine causality. The interventions comprised shockwave therapy (ESWT) [27, 28], manual therapy [29–31], stability training for the lumbosacral spine [32, 33], a home exercise program following prior instruction as an adjunct to therapy [31, 33–35] as well as heat therapy [29, 30] and dry needling and acupuncture [31, 35].

### Outcome measures (OMs)

The types of outcome measures for assessing the effectiveness of physiotherapy interventions varied between the studies with regard to the nature of dysfunction and site of the problem. Both subjective and objective measures were used, including measures of pain intensity (VAS, NRS), muscle length tests (SLR, Thomas test, Ober test), diagnostic special test (Patrick), hypermobility (Beighton), physical assessment and posture and gait analysis. Imaging studies (MRI, x-ray, CT, ultrasound) were also used and mood was assessed with the Pediatric Quality of Life Inventory (PedsQL). Moreover, DFOS (Dance functional outcome survey) and PSFS (the Patient Specific Functional Scale) questionnaires were used.

Assessment time points also varied: medium term outcomes were assessed in all studies and short-term outcomes were assessed only by Mason et al. In the studies of Silk et al. and Quarrier et al., the desired outcomes were obtained at the 1-year and 6-year marks. Adverse effects of the physiotherapy intervention were not reported in any of the studies. The range of outcome domains and measures in specific studies is presented in Table 2.

Table 1. Characteristics of the studies.

Follow up	2,2 years follow up, 3-5 weeks return to dance	7 months	3 months	6 months	5 months	1,5 months	3 months	9 months	6 years	1 year
<b>Outcome addressed</b>	MRI, X-ray, CT	NRS, ROM, posture and gait analyse, X-ray	VAS, LL-test, Core-test, posture analyse	NRS, ROM, RTD, DFOS, SL balance with eyes closed test, manual muscle tests, Airplane Test, Topple Test, PedsQL, MRI, Beighton scale X-ray	NRS, SLR, Sahrman	NRS, ROM, SLR, Core-test, PSFS	NRS, ROM, SLR, Thomas, Ober, FLS squat, deep squat, posture and gait analyse, MRI, X-ray	ROM, posture and gait analyse, MRI, X-ray, USG	ROM, Thomas, Ober, Patrick, X-ray, MRI, Kendall and McCreary's manual muscle test grading and guidelines, specific manual muscle tests of the left hip, palpation of the groin, supine to sit test	X-ray, CT
<b>Comparator/control</b>			Tree-months spine prevention programme			The dynamic sling exercises were performed on a Redcord System, with a float mat placed under the device for safety. These participants did approximately 20 minutes of home exercises one time per week and exercised using the dynamic sling system for 25 to 30 minutes two times a week for 6 weeks.				
<b>Co-intervention</b>		Chiropractic		Malleo Train (active stabilizer)				Walking boot, surgical intervention	Medications, psychological consulting, chiropractic, arthroscopy, surgical intervention	

(Continued)

Table 1. (Continued)

Follow up	2,2 years follow up, 3-5 weeks return to dance	7 months	3 months	6 months	5 months	1,5 months	3 months	9 months	6 years	1 year
<b>Intervention</b>	18: ESWT; 1: US + EMF	Soft tissue therapy: isometric contraction of bilateral psoas major muscle; concentric muscle stretches prescribed for piriformis, psoas major and vastus medialis, thermotherapy (alternate heat and ice)	Tree-months spine prevention program. The program consists of three units: 1st–2nd months: raising awareness to and automatizing the correct posture, core muscle strengthening and stretching exercises to facilitate sufficient muscle balance, exercises to improve lumbar motor control ability. The 3rd month: the muscle balance and lumbar motor control exercises include dance-specific exercise material	Therapeutic exercises, therapeutic activity, modalities, neuromuscular reeducation, manual therapy, cryotherapy, e-stim, pre-mod. The intervention was divided into 4 levels: - acute (1-4 weeks), - early RTD (5-10 weeks), - RTD (11-15 weeks) - end-stage RTD (16-20 weeks). The intervention concerned: pain reduction, increase ROM, increase foot/ankle strength, increase hip/knee strength, increase lumbopelvic control, increase lower extremity flexibility, improving balance, increase cardiovascular endurance, improving closed kinetic chain functional mobility	Education about faulty postures and movement impairments, supervised practice of walking and dance, home exercise program. Education for functional activities included corrections for impairments in standing and sitting. Corrections for gait included instructions to lift the heel sooner after midstance. The home exercise program consisted of a variety of exercises to improve muscle performance and precision of hip flexion and extension.	Lumbar stabilization, home exercise program. The HEP consisted of approximately 20 minutes of the same exercises (bridge, plank, side plank) used for strength and endurance testing, three times a week for 6 weeks.	Dry needling, home exercise program. Treatment with dry needling at two separate visits, with 48 hours between treatment sessions. In both sessions DN was performed to target the palpable areas consistent with MTPs in the right gastrocnemius, soleus, and distal popliteus at the attachment to the medial tibia. Home exercise program after first visit: standing gastrocnemius and standing soleus stretches - each stretch 2 to 3 times, statically holding for a minimum of 30 seconds, repeated 3 to 4 times daily. Progress in home exercise program: single leg squat with contralateral isometric hip abduction with instructions to progress to single leg squat focusing on pelvic stability and proper knee alignment and hip abduction with resisted side stepping using a resistance band.	Stretching, eccentric strengthening (before surgical intervention); continuation of physiotherapy after surgery	Physical therapy: soft tissue stretching and strengthening (hip flexor stretching, soft tissue mobilization and joint mobilization); a muscle energy technique by Magee, acupuncture, (with no changes in symptoms); home exercise program (after surgery): basic postsurgical lower extremity ROM exercises followed by a progressive quadriceps, hamstring, adductor/abductor strengthening program	ESWT

(Continued)



Table 1. (Continued)

Follow up	2,2 years follow up, 3-5 weeks return to dance	7 months	3 months	6 months	5 months	1,5 months	3 months	9 months	6 years	1 year
<b>Symptoms</b>	Foot pain	Bilateral hip pain, mobility restriction, secondary bilateral knee pain	Low back pain	Foot pain, mobility restriction, lower limb weakness	Hip pain and groin, hip snapping	Low back pain	Posterior knee pain	Medial ankle pain	Chronic hip and groin pain	Midfoot pain
<b>Injury</b>	Stress fractures of the base of the metatarsal bones (II and III)	Bilateral hip pain and restriction	Low back pain	Condition after os trigonum excision	Acetabular labral tear	Low back pain	Posterior knee pain	Flexor hallucis longus (FHL) tendinopathy	Hip dysfunction (unknown etiology)	Metatarsal fracture
<b>Gender</b>	F: 10; M: 9	F: 1	Not given	F: 1	F: 1	Not given	F: 1	F: 1	F: 1	F: 1
<b>Mean age</b>	16,4 (+/- 1,5)	14 years	12,7 (+/- 2,2); 13,7 (+/- 2,9)	15 years	29 years	11-18 years	16 years	17 years	18 years	29 years
<b>Sample size</b>	19	1	Intervention 30; Comparator 32	1	1	5	1	1	1	1
<b>Country</b>	Italy	New Zealand	Hungary	USA	USA	USA	USA	USA	USA	UK
<b>Study</b>	Albiseti [27]	Baigent [29]	Kovácsné [32]	Filipa [30]	Kho-Summers [34]	Kline [33]	Mason [35]	Porter [36]	Quarrier [31]	Silk [28]

Abbreviations: CT—computed tomography, DFOS—Dance functional outcome survey, EMF—electromagnetic fields, ESWT—external shock wave therapy, F—female, FSL squat—full single leg squat, LL-test—leg lowering test, M—male, MRI—magnetic resonance imaging, NRS—Numerical Rating Scale, PedsQL—The Pediatric Quality of Life Inventory, PSFS—the Patient Specific Functional Scale, ROM—range of motion, RTD—Return-To-Dance, SLR—straight leg rising, US—ultrasound therapy, USG—ultrasound scan, VAS—Visual Analogue Scale, X-ray—radiography

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Table 2. The range of outcome domains and measures in specific studies.

Outcome Domain and Outcome Measures	Structural condition	USG							✓			
		CT	✓								✓	
		X-ray	✓	✓		✓		✓	✓	✓	✓	
		MRI	✓			✓		✓	✓			
	Posture and gait analysis			✓	✓			✓	✓			
	Questionnaires	PedsQL				✓						
		PSFS						✓				
		DFOS					✓					
	Physical assessment	Manual muscle tests				✓					✓	
		Deep squat							✓			
		Balance and proprioception tests					✓					
		FSL squat							✓			
		Sahrmann						✓				
		Core-tests			✓			✓				
		RTD					✓					
		LL-test			✓							
		ROM		✓			✓		✓	✓	✓	
		Diagnostic special test	Patrick								✓	
	Muscle length tests	Ober						✓		✓		
		Thomas						✓		✓		
		SLR					✓	✓	✓			
	Hypermobility	Beighton				✓						
	Pain	N/G	✓						✓	✓	✓	
		NRS		✓			✓	✓	✓			
		VAS			✓							
	Study		Albisetti [27]	Baigent [29]	Kovácsné [32]	Filipa [30]	Kho-Summers [34]	Kline [33]	Mason [35]	Porter [36]	Quarrier [31]	Silk [28]

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**Pain.** Although pain was the dominant reason for a physiotherapy intervention in all dancers examined, 6 out of the 10 studies employed a subjective pain intensity scale (VAS [32] and NRS [29, 30, 33–35]), with the remaining studies failing to specify the measurement tool. All 10 studies stated that the physiotherapy intervention had produced a positive effect as the dancers were able to resume the practice of ballet pain-free following various time intervals from the beginning of the intervention.

**Range of motion.** In order to test the patients’ functional status, the ROM of selected joints was measured in six studies depending on the site of the dysfunction [29, 30, 31, 33, 35, 36]. Kline et al. employed a goniometer for that purpose, and the remaining studies did not specify the measurement tool. ROM was assessed in lower limb joints (hip, knee, foot), with only one study noting an unrestricted pain-free ROM [35] before the intervention. The physiotherapy produced the positive effect of regaining unrestricted pain-free ROM in the joints tested.

**Physical assessment.** Physical function was assessed with various tests before and after physiotherapy. Tests which produced a positive result before the intervention were repeated after the intervention. Improvement was noted in the SLR (straight leg raise) test in patients with hip and lower back pain [33, 34] and in core tests in patients with chronic low back pain [32, 33]. Two studies included the Thomas and Ober tests, which were negative [31, 35]. The Patrick test, leg lowering test, single leg squat and deep squat tests were also performed, as were tests such as return-to-dance and a movement system examination by Sahrman. All tests demonstrated desired effects post-intervention.

**Posture and gait analysis.** Four studies investigated the dancers' posture [29, 32, 35, 36] and gait [29, 35, 36]. To this end, a Camera Nikon Cool PIX L21 was used in the study of patients with low back pain [32], and the results were subjected to a statistical analysis. In three studies, this assessment revealed abnormalities that improved after the intervention [29, 32, 35].

**Quality of life.** Filipa et al. [30] employed a standardized questionnaire used for assessing quality of life with health in the paediatric population (PedsQL, the Pediatric Quality of Life Inventory). A baseline assessment of a 15-year-old female dancer with pain in the area of the left ankle joint (status post removal of os trigonum) was 68 (75%), improving to 100% post-intervention, indicating a reduction in pain-related depressive symptoms. This was the only study out of the 10 which assessed dancers' quality of life.

**Structural status (imaging studies).** Imaging studies were performed in 8 out of the 10 studies [27–32, 35, 36]. They were often administered as part of diagnostic work-up, but were repeated in four studies in order to assess the effectiveness of the physiotherapy intervention. MRI was the only tool, apart from a subjective pain rating scale, to assess the effectiveness of ESWT in dancers with metatarsal fractures [27]. Improvement was noted in 17 of the 18 dancers after 3–5 weeks of therapy. One patient was treated with ultrasound therapy and EMF (electromagnetic fields), as the MRI showed a fracture line going through the metatarsal cartilage plate, and changes were additionally assessed with CT. Similar findings were reported by Silk et al. [28] in a female patient following a metatarsal fracture, with positive effects obtained with ESWT. Changes were assessed with conventional radiographs and CT before and on completion of a cycle of physiotherapy.

## Summary of results

The results of all 10 studies are summarized in 6 domains in [Table 3](#). The results suggest that physiotherapy exerted a positive influence in all 6 domains. The evidence indicates that physiotherapy interventions reduced the signs and symptoms and improved function. Considering the small number of studies, these findings are encouraging, especially with regard to pain reduction and improvement in ROM and in physical functions. Despite those promising effects, caution is required when interpreting these results in view of methodological shortcomings, including the lack of statistical significance in most studies (9/10).

## NHMRC FORM framework

A summary of the results with the NHMRC FORM framework is presented in [Table 4](#). Despite the positive results, methodological concerns regarding the evidence base lowered the overall level of recommendations. While these results may be helpful in physiotherapy of dancers, the recommendations should be implemented with caution.

## Discussion

The present systematic review aimed to investigate scientific evidence regarding physiotherapy interventions in ballet dancers. It is the first systematic review to present physiotherapeutic

Table 3. The results of all 10 studies in 6 domains.

Effect of physiotherapy interventions for the management of	Structural condition	USG							(?)		
		CT	(?)								
	X-ray	(=) = 10; (?) = 9	(=)		(?)		(?)	(=)	(=)	(=)	(+) ↑
	MRI	(+) ↑			(?)		(?)	(?)			
	Posture and gait analysis		(+) ↑	(+) ↑				(+) ↑	(=)9=0		
Questionnaires	PedsQL				(+) ↑						
	DFOS				(+) ↑						
	PSFS						(+) ↓				
Physical assessment	Manual muscle tests				(+) ↑					(+) ↑	
	Deep squat							(+) ↑			
	Balance and proprioception tests				(+) ↑						
	FSL squat							(+) ↑			
	Sahrmann					(+) ↑					
	Core-tests			(+) ↑*			(+) ↑				
	RTD				(+) ↑						
	LL-test			(+) ↓*							
	ROM		(+) ↑		(+) ↑		(+) ↑	(+) ↑	(+) ↑	(+) ↑	(+) ↑
	Patrick										(?)
Muscle length tests	Ober							(=)		(=)	
	Thomas							(=)		(=)	
	SLR					(+) ↑	(+) ↑	(=)			
Hypermobility	Beighton				(?)						
Pain	N/G	(+) ↓							(+) ↓	(+) ↓	(+) ↓
	NRS		(+) ↓		(+) ↓	(+) ↓	(+) ↓	(+) ↓			
	VAS			(+) ↓*							
Study		Albisetti [27]	Baigent [29]	Kovácsné [32]	Filipa [30]	Kho-Summers [34]	Kline [33]	Mason [35]	Porter [36]	Quarrier [31]	Silk [28]

Abbreviations: CT—computed tomography, DFOS—Dance functional outcome survey, EMF—electromagnetic fields, ESWT—external shock wave therapy, F—female, FSL squat—full single leg squat, LL-test—leg lowering test, M—male, MRI—magnetic resonance imaging, NRS—Numerical Rating Scale, PedsQL—The Pediatric Quality of Life Inventory, PSFS—the Patient Specific Functional Scale, ROM—range of motion, RTD—Return-To-Dance, SLR—straight leg rising, US—ultrasound therapy, USG—ultrasound scan, VAS—Visual Analogue Scale, X-ray—radiography

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management in dancers. The evidence base was rather modest, with 10 studies representing different research projects. The summary of the results indicates that physiotherapy interventions may exert a positive influence in several domains, such as pain, ROM, functional status, posture, gait or quality of life. Consistent evidence in favor of effectiveness of physiotherapy was particularly demonstrated with regard to pain reduction, which indicates that physiotherapy interventions may be instrumental in the return of dancers to practice and performances. Despite these positive findings, the results need to be interpreted with caution in view of methodological limitations and non-homogeneity of the evidence base.

Physiotherapy interventions in ballet dancers were associated with positive effects in several areas as demonstrated by both positive and negative measurements. This revealed a potential for using physiotherapy in this group of patients.

Table 4. NHMRS FORM framework.

Component	Grade	Comments
1. Evidence base	<i>D–Poor</i>	Quantiti: 10 studies
		Participants: 83 ballet dancers with musculoskeletal pain
	<i>Level IV studies, or level I to III studies with high risk of bias</i>	Level II: 0 studies
		Level III-2: 1 study
		Level III-3: 1 study
2. Consistency	<i>C–Satisfactory</i>	Level IV: 8 studies
		Findings consistent
	<i>Some inconsistency reflecting genuine uncertainty around clinical question</i>	Multiple study designs
		Heterogeneous interventions
		Varied population–injury type, age
3. Clinical impact	<i>D–Poor</i>	Varied outcome measures and time point measurements
		Consistent findings for outcomes: in particular pain
	<i>Slight</i>	Only one study has statistical significance
		The clinical significance should be approached with caution
4. Generalisability	<i>B–Good</i>	No adverse effects reported
		Population of studies is similar to the target
	<i>Population/s studied in the body of evidence are similar to the target population for the guideline</i>	Age range: 11–29 years
		Despite various types of injuries and interventions, symptoms in the entire population were associated with ballet dance training
5. Grade of recommendations	<i>D—poor</i>	Studies conducted in five different countries that have different health care contexts
		These studies had low evidence and were of moderate methodological quality.
	<i>The evidence is weak, so the recommendations should be used with caution</i>	Although overall there were positive results, the current evidence base is not homogeneous in terms of diagnosis, interventions delivered, and parameters and results measured for ballet dancers

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There is evidence confirming analgesic effectiveness of similar interventions in physically active populations, for example with ESWT [37, 38]. Hides et al. confirmed the effectiveness of stability training for the lumbosacral spine in athletes [39]. However, other authors of systematic reviews have objected to formulating strong conclusions about this type of training as an isolated intervention for improving sports results, including pain reduction and reducing recovery time following an injury [40, 41]. It has also been reported that dry needling produced the desired effects in the treatment of knee pain both as a sole intervention in athletes with patellofemoral knee syndrome [42, 43] and in conjunction with manual therapy and exercise in patients with osteoarthritis [44].

The effectiveness of physiotherapy in dancers was assessed with various functional tests and, often, ROM measurements. The following tests are often used for assessing the functional status of the lower limbs and lumbosacral spine owing to ease of administration, simplicity and reproducibility: SLR, Patrick test, Thomas test, single leg squat test and others [45–48]. In view of the aesthetic and technical demands of dance, associated with extreme ROM, Filipa et al. used the Beighton scale to identify joint hypermobility syndrome (JHS) [30]. Other

studies have considered JHS a risk factor for experiencing pain in children and adults [49, 50]. However, the evidence that this tendency is also present in dancers is not equivocal [51, 52]. There are functional assessment scales designed with dancers in mind, such as the Dance Functional Outcome Survey (DFOS), which was used in one study [30]. Other authors have also used this tool to assess the effectiveness of comprehensive rehabilitation of a modern female dancer with metatarsal instability, achieving an improvement from 11% to 90% [53].

Filipa et al. reported improved mood on completion of the physiotherapy intervention [30], using the standardized PedsQL questionnaire as a tool. This was probably due to the positive influence of pain reduction and resumption of dance practice. Earlier studies had reported higher levels of burnout in dancers [54] and athletes [55, 56], who suffered physical and emotional exhaustion, compared to injury-free individuals. Reduced quality of life was also reported in injured athletes [57]. This confirms a significant negative effect of pain on depressive mood and increased risk of burnout in physically active individuals. Depressed mood in dancers may be associated with excessive physical training, which, combined with other external factors, may lead to injuries and overload syndromes, which may produce a general deterioration of health and well-being in the dancers [58]. Furthermore, the break from practice in injured athletes may reduce their quality of life. Adequate injury perception by physically active individuals would facilitate evidence-based treatment and physiotherapy strategies targeting the physical and psychosocial aspects of health [59]. Consequently, this systematic review can prove very useful in planning effective physiotherapy interventions in dancers.

## Limitations

Even though the present paper is based on the best practices for systematic reviews (PRISMA), it is not free of limitations. The review was based on electronic data bases, implementing secondary search strategies. As a result, certain studies may have remained unidentified and excluded from the review. The exclusion of non-English publications was another limitation.

Ultimately, a total of 10 publications meeting the inclusion criteria were qualified, which is a modest evidence base, although the findings were actually consistently positive. At the same time, there were certain concerns and limitations as regards the methodological quality of the studies reviewed. 80% of the studies were case reports or case series, and, therefore, the provision of a rationale for the sample size and statistical analysis might turn out to be unnecessary or impossible. Accordingly, there are no grounds for extrapolating these results to the entire population of ballet dancers. Furthermore, in some of the studies, physiotherapy procedures were supplemented by other interventions, such as surgery.

## Conclusions

The positive effects of physiotherapeutic interventions have highlighted the potential role of physiotherapy for ballet dancers after injuries, which are an important health problem in this specific group of patients. Due to the small amount of evidence confirming the effectiveness of physiotherapeutic interventions in ballet dancers after injuries and methodological uncertainties, it is recommended to improve the quality of prospective studies. The use of more standard results with long observation periods would help to identify potential therapeutic effects in ballet dancers.

## Practical implications

There is evidence to support the use of physiotherapy interventions in injured ballet dancers. Physiotherapy exerted a positive influence in several domains, including pain, ROM and

functional status. However, while physiotherapy may be considered as an option for managing injuries in ballet dancers, caution should be exercised while these recommendations are implemented on account of methodological concerns regarding the existing evidence base.

## Supporting information

**S1 Fig. PRISMA 2009 flow diagram.**

(DOC)

**S2 Fig. Items on Modified McMaster Critical Review form.**

(TIF)

**S1 File. PRISMA 2009 checklist.**

(DOC)

**S2 File. Search protocols.**

(DOCX)

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