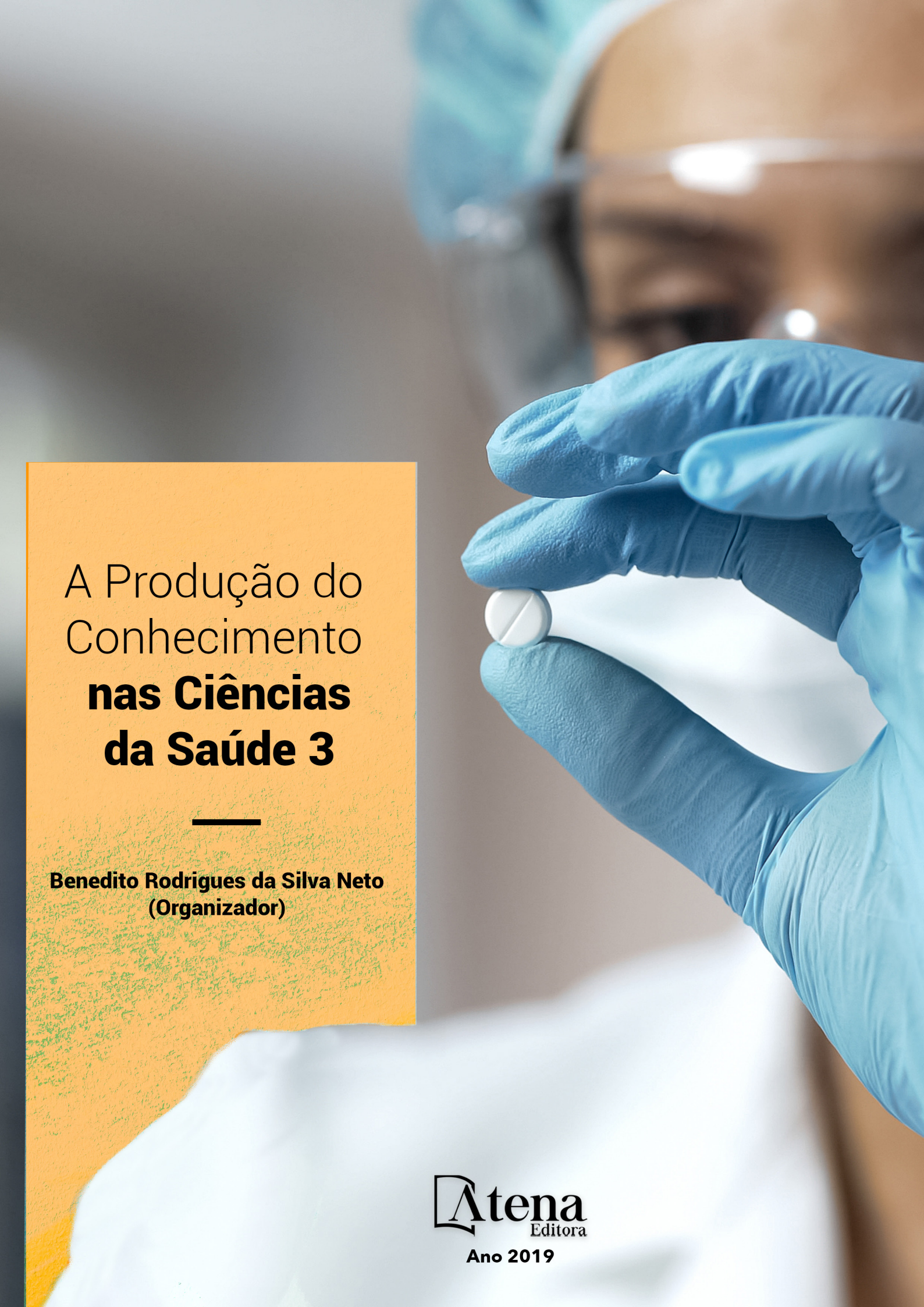

A Produção do Conhecimento **nas Ciências da Saúde 3**

Benedito Rodrigues da Silva Neto
(Organizador)

Atena Editora
Ano 2019

Benedito Rodrigues da Silva Neto
(Organizador)

A Produção do Conhecimento nas Ciências da Saúde
3

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APRESENTAÇÃO

O terceiro volume da coleção “A Produção do Conhecimento nas Ciências da Saúde”, é fruto de atividades de pesquisa desenvolvidas em diversas regiões do Brasil. Composto por trinta e cinco capítulos enriquecedores altamente informativos.

Neste volume o leitor será capaz de obter informações categorizadas e apresentadas sob forma de trabalhos científicos na interface de estudos ligados à educação em saúde.

Os trabalhos aqui apresentados demonstram de forma ampla conceitos atuais relativos aos temas da saúde da família, cuidados paliativos, atenção primária, práticas integrativas, inovações em pesquisa médica, perfil de grupos de risco, promoção e educação em saúde dentre outros diversos temas que poderão contribuir com o público de graduação e pós graduação das áreas da saúde.

O conhecimento sobre saúde hoje, na contemporaneidade, é multifatorial, deste modo, entender o indivíduo na sua integralidade é importante, assim conhecimento embasado e contextualizado aos temas transversais são fundamentais.

O profissional da saúde atual precisa cada vez mais estar conectado com as evoluções e avanços tecnológicos. Descobertas e publicações de alto impacto são diárias e fazem com que o profissional se atualize e aprimore cada vez mais suas atividades ligadas à linha de atuação na saúde. Portanto a leitura integra e crítica de material bibliográfico substancial torna-se necessária.

A integração de cada capítulo permitirá ao leitor ampliar seus conhecimentos e observar diferentes metodologias de pesquisa e revisões relevantes para atualização dos seus conhecimentos.

Deste modo, o conteúdo de todos os volumes é significante não apenas pela teoria bem fundamentada aliada à resultados promissores, mas também pela capacidade de professores, acadêmicos, pesquisadores, cientistas e da Atena Editora em produzir conhecimento em saúde nas condições ainda inconstantes do contexto brasileiro. Desejamos que este contexto possa ser transformado a cada dia, e o trabalho aqui presente pode ser um agente transformador por gerar conhecimento em uma área fundamental do desenvolvimento como a saúde.

Dr. Benedito Rodrigues da Silva Neto

SUMÁRIO

CAPÍTULO 34

SPINAL POSTURE OF CLASSICAL BALLET DANCERS: A SYSTEMATIC REVIEW

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ABSTRACT: Objective: To conduct a systematic review to evaluate acute and chronic effects of ballet practice on the vertebral posture. **Methods:** Searches for scientific papers in PubMed, Science Direct and the LILACS data base were conducted by two independent researchers. A secondary search was conducted by reading the references in manuscripts on posture. We included studies of postural outcome in dancers of any age and length of experience. A modified Downs and Black checklist and GRADE were used to evaluate the methodological quality and evidence-strength of the included studies, respectively. **Results:** Out of 436 articles initially screened, five were included. Only one was chronic. Three studies evaluated the thoracic and cervical spine, four evaluated the lumbar spine, and one evaluated the spine posture in dynamic situation. The studies found that the lumbar lordosis and thoracic kyphosis angle changes in classical ballet dancers, presenting rectification of the thoracic region as a chronic effect. However, changes in lumbar lordosis angle were controversial. **Conclusion:** This systematic review evidenced the need for future studies to clarify which postural changes occur in classical ballet dancers, especially in the lumbar region, given the divergence of results among studies.

KEYWORDS: Ballet; Kyphosis; Lordosis; Dance.

RESUMO: Objetivo: Realizar uma revisão sistemática para avaliar os efeitos agudos e crônicos da prática do balé clássico na postura vertebral. **Métodos:** Pesquisas científicas

no PubMed, Science Direct e na base de dados LILACS foram realizadas por dois pesquisadores independentes. Uma busca secundária foi realizada por meio da leitura das referências em trabalhos sobre postura. Foram incluídos estudos com o desfecho postura em bailarinas clássicas de qualquer faixa etária e tempo de experiência. Foram incluídos estudos de resultados posturais em bailarinos de qualquer idade e tempo de experiência. Um checklist modificado de Downs e Black e o GRADE foram usados para avaliar a qualidade metodológica e a força-evidência dos estudos incluídos, respectivamente. **Resultados:** Dos 436 artigos inicialmente selecionados, cinco foram incluídos. Apenas um era crônico. Três estudos avaliaram a coluna torácica e cervical, quatro avaliaram a coluna lombar e um avaliou a postura da coluna em situação dinâmica. Os estudos constataram que a lordose lombar e o ângulo da cifose torácica se modificam em bailarinas clássicas, apresentando como efeito crônico a retificação da região torácica. Entretanto, mudanças no ângulo da lordose lombar foram controversas. **Conclusão:** Esta revisão sistemática evidenciou a necessidade de estudos futuros para esclarecer quais alterações posturais ocorrem em bailarinas clássicas, especialmente na região lombar, dada a divergência de resultados entre os estudos.
PALAVRAS-CHAVE: Ballet; Cifose; Lordose; Dança.

1 I INTRODUCTION

Classical ballet is an artistic activity that requires physical demands such as strength, stability and flexibility (HAMILTON et al., 1992). One of the main characteristics of traditional ballet practice is the development of a specific body posture. This posture, typical in ballet, reflects good health and is visually aesthetically pleasing (KOUTEDAKIS; JAMURTAS, 2004), which are the main drivers for the initialization of its practice.

However, exhaustive repetition of movements in order to achieve perfection can promote postural adaptations that become a risk factor for musculoskeletal system injuries (MILAN, 1994). There is evidence that from 10-17% of the lesions in dancers occur in the spine and are the result of lumbar spine hyperextension and psoas muscle insufficiency (MILAN, 1994).

The patterns of movements performed, the physiological and biomechanical demands, and the routine of training of classical ballet dancers are little explored and known by health professionals (D'HEMECOURT; LUKE, 2012; GREER; PANUSH, 1994).

Considering that classical ballet dancers do not seek medical care due to a fear of being misunderstood or instructed to stop dancing (SHAH, 2008) -- a behavior usually initiated during childhood when the occurrence of lesions can affect development (HINCAPIÉ; MORTON; CASSIDY, 2008) -- studying and knowing the physical demands and adaptations caused by this kind of physical activity is crucial.

There are several systematic reviews that investigated injuries in dancers

(HINCAPIÉ; MORTON; CASSIDY, 2008; MOITA et al., 2017; SMITH et al., 2015), however, there is a lack of systematic reviews of body posture of ballet dancers. Therefore, the present systematic review aimed to analyze the studies that evaluated acute and/or chronic effects of ballet practice on the vertebral posture of classical ballet dancers in order to provide a critical analysis of the main outcomes and point out the need for future studies. The hypothesis is that classical ballet dancers present postural changes.

2 I METHODS

This systematic review was conducted to conform to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (MOHER et al., 2009), and was registered (protocol number: CRD42018084113) in the International Prospective Register of Systematic Reviews (PROSPERO) (BOOTH et al., 2012).

2.1 Literature Search strategy

A computerized systematic search was conducted in PubMed, Science Direct and LILACS. All articles published before December 1, 2018 were considered. Two independent researchers (R1 and R2) evaluated the articles and extracted the data. Controversies on data extraction were solved by discussion between them and, in case of disagreement, by the judgement of a third researcher (R3). Keywords included “biomechanics,” “posture,” “postural,” “spine,” “vertebrae,” “spinal column,” “vertebral column,” and “kinematics,” each one combined with “ballet” or “dancers.” All keywords were limited to a search of titles/abstracts in PubMed, titles in LILACS and abstracts/titles/keywords in the Science Direct data base. The complete search strategy is available in Supplemental Table 1 (S1). Reference lists of all retrieved papers were manually searched for potentially eligible papers. Figure 1 presents the flow of papers through the study selection process.

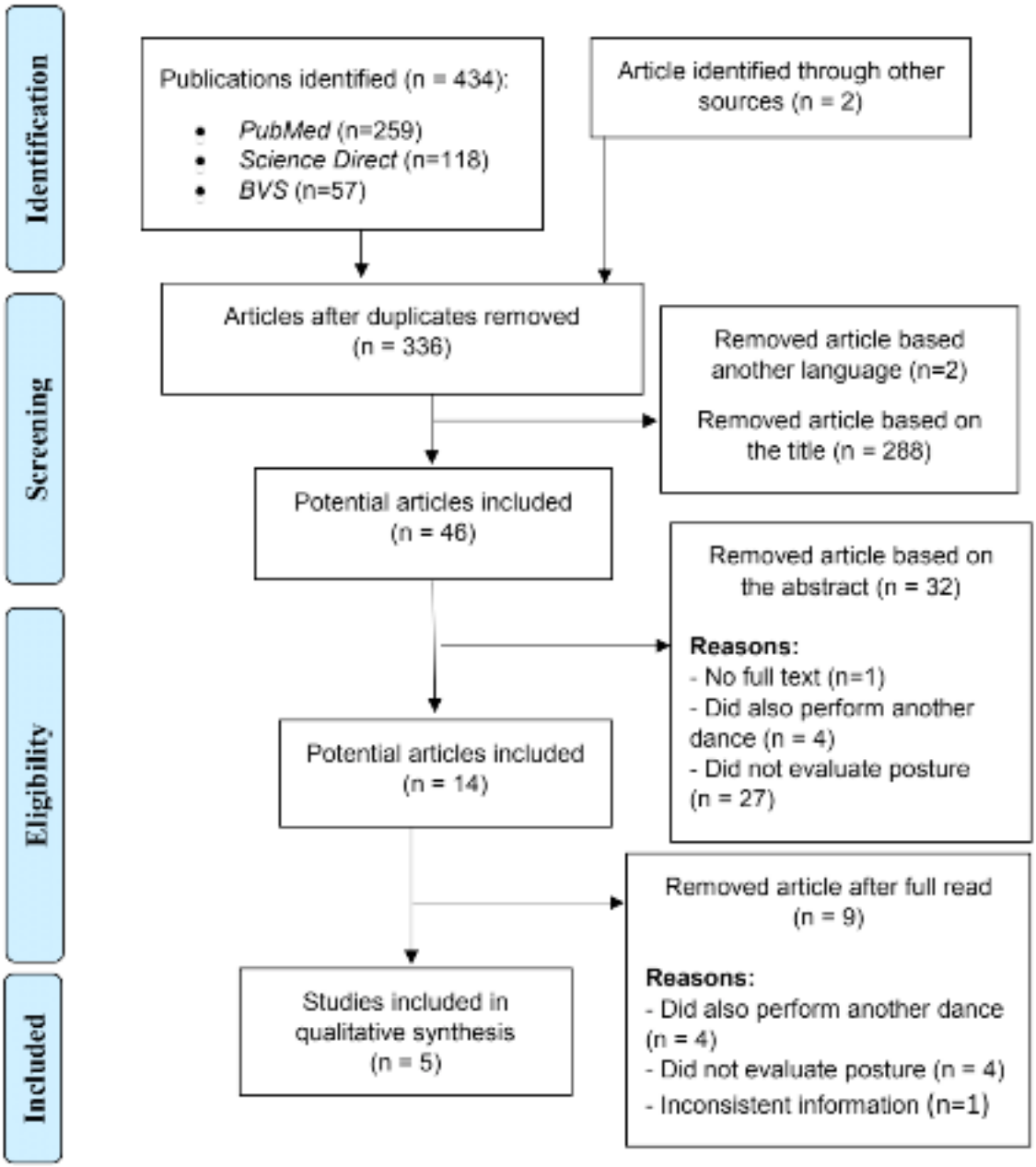

Figure 1. PRISMA schematic summarizing the process of data collection.

2.2 Inclusion and exclusion criteria: Participants, Interventions, Comparators, Outcomes (PICO)

Manuscripts published in English, Spanish, and Portuguese that described or evaluated the vertebral postural characteristics in classical ballet dancers of any age group and of any technical level were included. Participants were not restricted by age or sex. Documents were excluded if they were: (i) missing the full text; (ii) a letter to editor, book sections, theses, film/broadcasts, observational studies, opinion articles and abstracts without adequate data or reviews; (iii) studies involving dancers who also participate in other types of dance (e.g., jazz, contemporary dance, ballroom dancing, etc.); (iv) studies with only qualitative analysis; and (v) studies that did not consistently present information about the methods adopted. A first screening process of the full text of the articles was performed independently by R1 and R2. After initial screening of

titles, irrelevant studies were removed, which included overlapping studies, abstracts and irrelevant articles, such as editorials and discussion papers that did not match the inclusion criteria. Duplicate papers were then identified and removed. We further excluded studies due to insufficient data for analyses, and non-ballet interventions (Figure 1).

2.3 Data extraction

The following data of the included studies were: authors' names, year of publication, study design, characterization of the groups studied (ballet experience, age, body mass, height and body mass index (BMI)), analyzed variables, main outcomes, *p* values adopted, and protocol of data collection (task performed and collection instrument). When articles missed important information, attempts were made to contact authors to obtain missing details.

2.4 Study quality and evidence strength

Study quality was assessed by R1 and R2 using an adaptation to observational studies (MUTHURI et al., 2014) of the Downs and Black checklist (DOWNS; BLACK, 1998)internal validity (bias and confounding. This modified scale included ten items. Each item received a score of 1 for positive response and 0 for negative. If an item could not be determined, it was scored as zero. The highest possible score for quality was 10. Strength of evidence was evaluated by the Grading of Recommendations Assessment, Development and Evaluation process (GRADE) (GUYATT et al., 2011)Development, and Evaluation (GRADE. Using GRADE, the evidence strength is classified into four levels: "high," "moderate," "low" and "very low." The initial classification was defined from the study design (observational: "low"; and randomized clinical trial: "high"). From the initial classification, criteria were analyzed in order to reduce or raise the level of evidence.

3 I RESULTS

The initial search netted 434 studies, with more two studies (FEIPEL et al., 2004; PRATI; PRATI, 2006) found via hand-search rather than data base search. After deduplication, 100 duplicate studies were excluded from the review process, then, 290 of the 336 remaining studies were excluded. The remaining 46 full-text copies were obtained and subjected to further evaluation. The 46 studies were evaluated for eligibility criteria, and 32 of these studies were excluded, with annotated reasons. Nine of the 14 remaining studies also were excluded and the reasons for exclusion were annotated. At the end of the process, five publications meeting the eligibility criteria were selected for review (Figure 1).

3.1 Participant characteristics

Participant characteristics are summarized in Table 1. When combined, 125 ballet dancers (106 women and 19 men) and a control group of 108 non-dancers (97 women and 11 men) participated in the included trials. Mean age ranged from 7.2-21.0 years. Most studies (n = 3) recruited only women (IUNES et al., 2016; MOLLER; MASHARAWI, 2011; PRATI; PRATI, 2006)divided into three subgroups according to age and years of ballet experience. Results: Dancers with 1-3 years experience compared to controls of the same age shows alterations in External Rotation Angle ($P < 0.05$ and two studies recruited both sexes (FEIPEL et al., 2004; NILSSON; WYKMAN; LEANDERSON, 1993). Three studies recruited children and/or adolescents (IUNES et al., 2016; MOLLER; MASHARAWI, 2011; NILSSON; WYKMAN; LEANDERSON, 1993)divided into three subgroups according to age and years of ballet experience. Results: Dancers with 1-3 years experience compared to controls of the same age shows alterations in External Rotation Angle ($P < 0.05$, one study recruited adolescents and adults (FEIPEL et al., 2004) and one study (PRATI; PRATI, 2006) did not inform of the age of participants recruited. Mean ballet experience of participants ranged from one year (NILSSON; WYKMAN; LEANDERSON, 1993) to more than 15 years (FEIPEL et al., 2004). Only one study (MOLLER; MASHARAWI, 2011)lumbar lordosis (LL did not report the ballet experience of participants (Table 1).

3.2 Studies' design

Among the articles included in this systematic review, only one was chronic (MOLLER; MASHARAWI, 2011)lumbar lordosis (LL. Three studies evaluated the thoracic and cervical spine (MOLLER; MASHARAWI, 2011; NILSSON; WYKMAN; LEANDERSON, 1993; PRATI; PRATI, 2006)lumbar lordosis (LL, four evaluated the lumbar spine (IUNES et al., 2016; MOLLER; MASHARAWI, 2011; NILSSON; WYKMAN; LEANDERSON, 1993; PRATI; PRATI, 2006)divided into three subgroups according to age and years of ballet experience. Results: Dancers with 1-3 years experience compared to controls of the same age shows alterations in External Rotation Angle ($P < 0.05$, and one evaluated the spine posture in dynamic situation (FEIPEL et al., 2004) (Table 2). Two studies (IUNES et al., 2016; PRATI; PRATI, 2006) used the photography method to evaluate the modifications of the spine, one used an inclinometer (MOLLER; MASHARAWI, 2011)lumbar lordosis (LL, one used a cyphometer (NILSSON; WYKMAN; LEANDERSON, 1993) and one used an electrogoniometer (FEIPEL et al., 2004). The procedures and tasks performed in each study are presented in Table 3.

References	Subjects (n)	Male/ Female	Age (year)	Body mass (kg)	Height (m)	BMI (kg/m^2)	Ballet experience (years)
Moller and Masharawi (2011)	D: 14 C: 13	0/100 0/100	7.2 ± 0.9 7.8 ± 1.1	26.0 ± 6.7 30.0 ± 7.0	1.26 ± 0.7 1.27 ± 0.5	17 ± 3 18 ± 3	NI NA

Nilsson, Wykman and Leanderson (1993)	D: 23 C: 36	48/52 31/69	10 10	NI NI	NI NI	NI NI	1 NA
Prati and Prati (2006)	D: 11	0/100	NI	NI	NI	19.9 ± 1.6	>7
Iunes et al. (2016)	D1: 9 D2: 21 D3: 22 C1: 9 C2: 22 C3: 28	0/100 0/100 0/100 0/100 0/100 0/100	11.2 11.5 17.7 11.0 11.2 17.1	NI NI NI NI NI NI	NI NI NI NI NI NI	19.4 17.5 20.7 18.0 17.3 20.0	1-3 4-9 >9 NA NA NA
Feipel et al. (2004)	D: 25	32/68	21.0 ± 4.0	NI	NI	NI	15.0 ± 4.0

Table 1. Participant characteristics.

D: ballet dancers; C: control group; BMI: body mass index; NI: not informed; NA: not applicable.

Reference	Study design	Objective	Variables analyzes	Main outcomes	p-value
Moller and Masharawi (2011)	Cohort	To examine the effect of the first ballet lessons on TK, LL and external hip rotation.	LL and TK	*Between groups:* LL: no significant difference at t0 e t2 LL: D > C at t1 TK: no significant difference at t0, t1 e t2 *Intragroup:* LL: t2 < t0, in the group D LL: t2 < t0, in the group C TK: t1 < t0, in the group D TK: t1 < t0, in the group C	 NA p<0.05 NA p<0.05 p<0.05 p<0.05 p<0.05 p<0.05
Nilsson, Wykman and Leanderson (1993)	Cross-sectional	To analyze spinal sagittal mobility.	LL and TK	TK: C > D LL: C > D	p<0.01 p<0.01
Prati and Prati (2006)	Cross-sectional	To analyze the postural trend of classical dancers.	Index of postural correction of body segments: head/neck; and dorsal/lumbar	Head/neck: Trend to kyphosis Dorsal/lumbar: Trend to hyperlordosis	NI NI
Iunes et al. (2016)	Cross-sectional	To evaluate the posture of classical dancers in relation to individuals of the same age.	*Sagittal plane:* LL	*Between groups:* LL: D1 and D3 No significant difference related to respective control groups. LL: C2 > D2 *Intra dancers group:* No significant difference.	 NA p=0.007 NA
Feipel et al. (2004)	Cross-sectional	To analyze the three-dimensional kinematics of the lumbar spine during ballet movements in expert dancers.	Lumbar movement in frontal, sagittal and transversal planes during the movements: PM, DS, DSB and *arabesque*.	The four movements were accompanied by ipsilateral lumbar flexion and contralateral axial rotation of the lumbar spine. *Arabesque* was accompanied by lumbar extension. *Front plane:* Lateral flexion in PM < DS and DSB *Sagittal plane:* Lumbar flexion in PM > DS and DSB *Transversal plane:* Axial rotation in PM > DS and DSB	NA NA p<0.0017 p<0.0001 p<0.003

Table 2. Details of exercise intervention protocols and main outcomes of included studies for spinal posture.

LL: lordosis lumbar angle; TK: thoracic kyphosis angle; D: ballet dancers; C: control group; PM: *pied en mains*; DS: développé à la seconde without bar; DSB: développé à la seconde with bar; NI: not informed; NA: Not applicable.

Study	Task performed	Evaluation method
Moller and Masharawi (2011)	Standing with the upper limbs at the side of the body for measurements of TK and LL. Sitting for external rotation measurements in the hip. The measurements were performed at three times: before the start of classes, six months later and one year after the start of classes.	Inclinometer
Nilsson, Wykman and Leanderson (1993)	Standing, looking forward. Measurements obtained by means of a cyphometer. TK was measured between spinal segment of C7-T1 and T11-T12. LL was measured between spinal segment of T11-T12 and S1-S2.	Cyphometer
Prati and Prati (2006)	Standing posture. Photographs in the frontal plane (posterior view) and in the sagittal plane (lateral view).	Photography
Iunes et al. (2016)	Standing with the upper limbs at the side of the body with feet parallel and in the first position. The measurements were performed in the frontal plane (anterior view) and in the sagittal plane (right lateral view).	Photography
Feipel et al. (2004)	First position of feet and movements of the classic ballet: *pied en main*, *développé à la seconde* with and without use of the bar and *arabesque*. The measurements were analyzed in the frontal, sagittal and transverse planes.	Electrogoniometer

Table 3. Intervention protocols of included studies.

TK: thoracic kyphosis angle; LL: lordosis lumbar angle.

3.3 Main outcomes

Moller and Masharawi (2011)lumbar lordosis (LL submitted, on three separate occasions (prior to ballet classes, 6- and 12-months later), the two groups of participants (classical ballet dancers and non-dancers) to thoracic kyphosis (TK) and lumbar lordosis (LL) assessment during a standing posture with the upper limbs at the side of the body, and found lower values ($p<0.05$) of TK after 6 months (18.5±5.6º [ballet dancers] and 15.9±4.4º [non-dancers], respectively) than at baseline (34.6±12.1º [ballet dancers] and 47.1±8.1º [non-dancers], respectively). No significant difference was noted in the TK between the two groups for all three measurements over time. Nilsson, Wykman and Leanderson (1993) found significant lower mean values of TK in the ballet dancers (11.8 [range: 4º-23º]) than in non-dancers (29.4º [range: 16º-44º]). Prati and Prati (2006) found a tendency to kyphosis in the cervical region of classical ballet dancers (index of postural correction [ICP]: 92.0±7.54%); however, no difference was found between the classical ballet dancers and non-dancers (Table 2).

Regarding lumbar spine, Iunes et al. (2016) performed a cross-sectional study in which classical ballet dancers that performed in two to three 60- to 90-minute ballet

classes per week were subdivided into three subgroups according to years of ballet experience (1-3, 4-9 and >9 years). Additionally, a non-dancer control group was subdivided into three subgroups and paired to the subgroups of classical ballet dancers by age, body mass and height. The authors found a significant greater mean LL value (159.86 [range: 156.66º-163.06º]) in the group with 4-9 years of ballet experience compared to the respective control group (151.22 [range: 146.83º±155.60º]). Nilsson, Wykman and Leanderson (1993) also reported significant lower mean LL values in ballet dancers (22.1º [range: 6º-35º]) than in non-dancers (30.7º [range: 15º-53º]). On other hand, Moller and Masharawi (2011)lumbar lordosis (LL observed that six months after beginning ballet classes (two classes of 90 minutes per week), the ballet dancers showed significant greater LL values in relation to the non-dancer group (23.7±6.0 *vs* 19.5±3.9º; p<0.05); however, one year after the beginning of the classes, LL values in the two groups were significantly lower (p<0.05) than those of the first evaluation (23.5±6.0º *vs* 30.9±5.3 [ballet dancers] and 20.9±6.2º *vs* 36.0±9.2 [non-dancers], respectively). Prati and Prati (2006) found a trend toward hyperlordosis (ICP: 86.6±10.9%). Feipel et al. (2004) found that all movements evaluated (*pied en mains*, *développé à la seconde* with or without bar and *arabesque*) were accompanied by ipsilateral lumbar flexion (30±10º, 16±14º, 12±9º, and -21±10º, respectively) and contralateral axial rotation of the lumbar spine (-20±5º, -17±7º, -15±7º, and -11±6º, respectively). The *arabesque* was also accompanied by lumbar extension in the sagittal plane. The analysis of the several movements indicated that the *pied en mains* movement presents a significantly greater lumbar flexion in the sagittal plane (30±10º) and greater axial rotation in the transversal plane (-20±5º), compared to the *développé à la seconde* with bar (16±14º and 12±9º, respectively; p<0.0001) and without bar (-17±7º and -15±7º; p=0.003). Due to heterogeneity of the spinal posture, the evaluated method used in the included studies did not allow for further meta-analytical approach, which precludes us from estimating the results obtained from the variations.

3.4 Methodological quality and strength evidence

Assessment of the study quality is reported in Table 4 Quality was assessed as a score out of 10, with a mean score of 8.0 ± 0.7 (minimum 7, maximum 9). All included studies specified their main outcomes, main findings and interventions. The less focal question investigates the fact of whether or not the participants invited to the studies are representative of the entire population from which they were recruited. The GRADE system indicated that one study had a “very low” quality of evidence (PRATI; PRATI, 2006), three studies were considered to be of “low quality” (FEIPEL et al., 2004; IUNES et al., 2016; NILSSON; WYKMAN; LEANDERSON, 1993) and only one study obtained “moderate” quality of evidence (MOLLER; MASHARAWI, 2011)lumbar lordosis (LL. Only two studies (33.3%) reported no conflict of interest (IUNES et al., 2016; MOLLER; MASHARAWI, 2011)divided into three subgroups according to age and years of ballet

experience. Results: Dancers with 1-3 years experience compared to controls of the same age shows alterations in External Rotation Angle (P < 0.05. Three studies (60%) (IUNES et al., 2016; MOLLER; MASHARAWI, 2011; PRATI; PRATI, 2006)divided into three subgroups according to age and years of ballet experience. Results: Dancers with 1-3 years experience compared to controls of the same age shows alterations in External Rotation Angle (P < 0.05 reported the approval of the Ethics Committee (Table 4).

Study	Moller and Masharawi (2011)	Nilsson, Wykman and Le-anderson (1993)	Prati and Prati (2006)	Iunes et al. (2016)	Feipel et al. (2004)
Conflict of interest	N	NI	NI	N	NI
Ethics committee	Y	NI	Y	Y	NI
1. Is the hypothesis/aim/objective of the study clearly described?	Y	Y	Y	Y	Y
2. Are the main outcomes to be measured clearly described in the Introduction or Methods section?	Y	Y	Y	Y	Y
3. Are the characteristics of the patients included in the study clearly described?	Y	Y	N	Y	Y
6. Are the main findings of the study clearly described?	N	Y	Y	N	Y
7. Does the study provide estimates of the random variability in the data for the main outcomes?	Y	Y	Y	Y	Y
10. Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?	N	Y	N	Y	Y
11. Were the subjects asked to participate in the study representative of the entire population from which they were recruited?	Y	N	Y	N	N
12. Were those subjects who were prepared to participate representative of the entire population from which they were recruited?	Y	N	Y	Y	Y
18. Were the statistical tests used to assess the main outcomes appropriate?	Y	Y	N	Y	Y
20. Were the main outcome measures used accurate (valid and reliable)?	Y	Y	Y	Y	Y
SCORE	**8**	**8**	**7**	**8**	**9**
***GRADE**	⊗⊗⊗○	⊗⊗○○	⊗○○○	⊗⊗○○	⊗⊗○○

Table 4. Study Quality and Strength Evidence of the Included Studies.

Item numbers refer to items on the Downs and Black scale. NI: not informed. GRADE: Grading of Recommendations Assessment, Development and Evaluation. *A circle filled: very low quality; two circles filled: low quality; three circles filled: moderate quality; four circles filled: high quality

4 I DISCUSSION

The aim of this systematic review was to analyze the studies that evaluated acute and/or chronic effects of ballet practice on the spine posture of classical ballet dancers. The findings indicate data for lumbar lordosis, thoracic kyphosis, and cervical lordosis.

The postural profile of classical ballet dancers is popularly recognized as healthy and aesthetically pleasing; however, the postural adaptations found in the studies included in this review point to changes in the natural cervical curvature, TK and LL. Changing the natural curvatures may be maleficent for ballet practitioners, since moderate curvatures minimize overload during movements in which the spine is subjected to compression (SRBINOSKA et al., 2013). Nilsson, Wykman and Leanderson (1993) observed lower TK in the group of dancers compared to the non-dancers. In addition, Moller and Masharawi (2011)lumbar lordosis (LL also observed this behavior in their second collection in relation to the first one. Besides, Prati and Prati (2006) found a tendency towards kyphosis in the cervical region, evidencing the rectification of natural cervical lordosis, which has already been demonstrated as associated with neck complaints (GORE, 2001; MCAVINEY et al., 2005).

The rectification behavior presented in the cervical and thoracic regions may be a consequence of the postural behavior required during the lessons, in which alignment and rectification of the spine is recommended in all movements, including those of great range of motion. Daprati, Iosa and Haggard (2009) analyzed video files recorded during the course of 60 years of a professional classical ballet company, which showed the increased use of movements over time, with greater elevation of the lower limbs without changing the slope of the trunk.

Regarding LL, Prati and Prati (2006) found hyperlordosis in the group of dancers. This result is not in line with those found by Iunes et al. (2016) and Nilsson, Wykman and Leanderson (1993), where a rectification of a LL was reported. Moller and Masharawi (2011)lumbar lordosis (LL reported lower LL in the non-dancer group compared to the group of ballet dancers, but also observed that after one year of ballet classes, LL was reduced in the dancers in relation to the first collection.

Hyperlordosis behavior can be justified by the excessive repetition of hyperextension movements characteristic of artistic sports, and by the compensation of external rotation required in classical ballet (*turnout*) (D'HEMECOURT; LUKE, 2012; GOTTSCHLICH; YOUNG, 2011; SHAH, 2008). Another important aspect is the fact that abdominal muscle and gluteal muscle contraction are a requirement during the execution of classic ballet movements with the goal of stabilizing the trunk and promotion of *turnout* (D'HEMECOURT; LUKE, 2012). Thus, the lack of strength needed to stabilize the spine may also be a cause of hyperlordosis (D'HEMECOURT; LUKE, 2012; GOTTSCHLICH; YOUNG, 2011). On the other hand, classical ballet commonly requires the mechanics of pelvic retroversion, also known as "hip fitting." This movement causes flexion of the lumbar region resulting in lordosis decrease, as demonstrated by

Nilsson, Wykman and Leanderson (1993) and Iunes et al. (2016).

Among the studies included in this systematic review, only Feipel et al. (2004) investigated spine behavior in dynamic situation. The authors found that the movement that most causes rectification of the lumbar region is the *pied en mains*. Since this study evaluated semiprofessional and professional ballet dancers, it is possible to consider that they had technical excellence. Therefore, this result may reinforce the previously mentioned idea that strength is required for trunk stabilization. Besides, because the dancers had high technical proficiency, their skill level was effective in performing the pelvic retroversion.

To the best of our knowledge, this review is the first of its kind to analyze changes in spine posture, and our results may help coaches, ballet dancers and health professionals to understand cervical, thoracic and lumbar alterations by providing information that can help choose classical ballet movements to perform and define adequate spine expectations from the outcomes.

The findings of this systematic review should be interpreted with consideration of some limitations. The first is that the methodological quality indicated that the greatest risk of bias is related to a sample that is not representative of the population. Second, the heterogeneity in the evaluation methods of cervical curvature, TK and LL, in the included studies may have influenced the comparisons made, and did not permit further meta-analytical approach, which precludes us from estimating the results obtained from the variations. Third, the studies have a convenience sample; however, because they are biomechanical studies, it is common for the samples to be for convenience. Lastly, despite the fact that the strength of the evidence of the great majority of the included studies was considered “low” or “very low,” such can be justified because they are observational studies that already start with low classification. Therefore, further research with high study quality and with standardized methodologies for spinal evaluation is needed. Nevertheless, we believe that these limitations do not prevent the conclusions of this systematic review to be drawn.

5 I CONCLUSIONS

The findings from this systematic review indicated that classical ballet dancers present rectification of the thoracic region as a chronic effect. Based on our results, few studies characterized the postural changes resulting from classical ballet. Moreover, this systematic review evidenced the need for future studies to clarify which postural changes occur in classical ballet dancers, especially in the lumbar region, given the divergence of results in this region. Thus, classical ballet dancers and coaches will have a better knowledge of spine behavior at each technical level, which can prevent injuries and improve technique.

PubMed	(((((((((biomechanics[Title/Abstract]) OR posture[Title/Abstract]) OR postural[Title/Abstract]) OR spine[Title/Abstract]) OR vertebrae[Title/Abstract]) OR spinal column[Title/Abstract]) OR vertebral column[Title/Abstract]) OR kinematics[Title/Abstract])) AND ((ballet[Title/Abstract]) OR dancers[Title/Abstract])
Science Direct	TITLE-ABSTR-KEY(biomechanics) and TITLE-ABSTR-KEY(ballet) TITLE-ABSTR-KEY(posture) and TITLE-ABSTR-KEY(ballet) TITLE-ABSTR-KEY(postural) and TITLE-ABSTR-KEY(ballet) TITLE-ABSTR-KEY(spine) and TITLE-ABSTR-KEY(ballet) TITLE-ABSTR-KEY(vertebrae) and TITLE-ABSTR-KEY(ballet) TITLE-ABSTR-KEY(spinal column) and TITLE-ABSTR-KEY(ballet) TITLE-ABSTR-KEY(vertebral column) and TITLE-ABSTR-KEY(ballet) TITLE-ABSTR-KEY(kinematics) and TITLE-ABSTR-KEY(ballet) TITLE-ABSTR-KEY(biomechanics) and TITLE-ABSTR-KEY(dancers) TITLE-ABSTR-KEY(posture) and TITLE-ABSTR-KEY(dancers) TITLE-ABSTR-KEY(postural) and TITLE-ABSTR-KEY(dancers) TITLE-ABSTR-KEY(spine) and TITLE-ABSTR-KEY(dancers) TITLE-ABSTR-KEY(vertebrae) and TITLE-ABSTR-KEY(dancers) TITLE-ABSTR-KEY(spinal column) and TITLE-ABSTR-KEY(dancers) TITLE-ABSTR-KEY(vertebral column) and TITLE-ABSTR-KEY(dancers) TITLE-ABSTR-KEY(kinematics) and TITLE-ABSTR-KEY(dancers)
Lilacs	(ti:(biomechanics)) OR (ti:(posture)) OR (ti:(postural)) OR (ti:(spine)) OR (ti:(vertebrae)) OR (ti:(spinal column)) OR (ti:(vertebral column)) OR (ti:(kinematics)) AND (ti:(ballet)) OR (ti:(dancers))

Supplemental Table 1. Search Term Combination used in PubMed, Science Direct and LILACS data base.

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