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ORIGINAL RESEARCH

Association between Static Postural Alignment of Lower Limbs and Hip Pain in Dancers

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Abstract

Objective: To investigate whether there is a relationship between the static postural alignment of lower limbs and hip pain in dancers.

Methods: This is an analytical, cross-sectional, and prospective population-based study conducted with 346 dancers of both sexes, each with at least five years of ballet experience. The dancers were assessed during the 2023 Joinville Dance Festival and divided into two groups: Those with hip pain (n = 132) and those without hip pain (n = 214). The following instruments were used: Anamnesis to characterize the sample; DIPA© software (Digital Image-based Postural Assessment) to evaluate static alignment; and HAGOS-Br (The Brazilian Hip and Groin Outcome Score) to assess hip pain. The t-test and Mann-Whitney test were used to compare the groups with and without pain; Pearson's chi-square test was used to identify the association between static alignment and pain.

Results: Regardless of the group, dancers predominantly exhibited varus knees and aligned pelvises (pelvic tilt less than 0.2 cm). Hip pain was associated with pelvic misalignment (χ^2 = 4.628; p = 0.0023) but not with knee posture (right: χ^2 = 0.497; p = 0.780; left: χ^2 = 0.597; p = 0.742). Hip pain was more common among dancers with a higher weekly training frequency (p = 0.016).

Conclusion: Static frontal plane pelvic misalignment is associated with hip pain in dancers and a higher weekly training frequency.

Keywords

Dance, Pain, Hip, Posture

Introduction

Dancers are often recognized for performing movements with large ranges of motion, which require high levels of flexibility. Although this flexibility enhances performance, it can compromise joint stability and, consequently, posture. Ligaments and muscles provide constraints that help maintain proper postural alignment. However, when this support is inadequate, muscles are excessively stretched, and joints such as the hip and knee exceed their normal range of motion, leading to faulty posture [1].

Postural misalignments can reduce athletic performance and increase the likelihood of injuries such as strains, sprains, and cramps, negatively impacting performance and potentially jeopardizing careers [2]. This premise also applies to dancers. A recent study identified pelvic misalignment as a significant risk factor for lower limb injuries in both recreational and elite ballet dancers [3]. Notably, these injuries may be preceded by pain.

Recent research shows that there is no definitive relationship between postural misalignments and pain [4], and pain is considered a multifactorial phenomenon that remains poorly understood [5]. Indeed, the definition of pain, as revised by the International Association for the Study of Pain (IASP) and translated by the Brazilian Society for the Study of Pain (SBED), describes it as "an unpleasant sensory and emotional

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experience associated with, or resembling that associated with, actual or potential tissue damage" [6].

The hip is one of the anatomical regions most vulnerable to injuries in dancers [7]. According to Mayes, et al. (2016, p. 3037), "ballet exposes the hip joint to repetitive loading at extreme ranges of motion and may predispose dancers to pain and osteoarthritis." Ideally, a ballet dancer's hip should feature, in the axial plane, relative acetabular retroversion without excessive anterior coverage, allowing for greater external rotation of the femur (*en dehors*) while maximizing the hip flexion required for movements such as *développé* or *battement en avant*. The aesthetic appeal of wide hip movements often drives dancers, teachers, coaches, directors, family, and peers to encourage stretching beyond natural limits, but such forced range of motion can, by itself, cause painful symptoms [8].

Previous studies on body asymmetries in dancers consider musculoskeletal injuries as consequences of these asymmetries [3]. From this perspective, the aim of the present study is to investigate whether there is a relationship between the static postural alignment of the lower limbs (LL) in dancers and the presence of hip pain.

Materials and Methods

This study is analytical, cross-sectional, and prospective, with a population-based design aimed at establishing associations between variables [9]. It was approved by the Research Ethics Committee of the university where it was conducted (CAAE: 69022023.1.0000.5347).

The research was conducted during the 2023 Joinville Dance Festival. This festival takes place annually in July in the city of Joinville, Santa Catarina, Brazil, and has been recognized by the Guinness Book as the world's largest dance festival in terms of participant numbers. The chosen location and event were selected due to the wide variety of dancers available for evaluation, coming from all regions of Brazil. The goal was to assess 10% of the population registered the previous year (2,500 participants).

Inclusion criteria were as follows: Having at least five years of dance experience and not wearing any type of orthotic device during the evaluation. To be included in the group with hip pain, dancers had to report hip pain with a minimum intensity of 3 on the numeric pain scale, have experienced more than one episode of pain, and have had pain for at least three months.

Exclusion criteria included dancers with little or no ballet experience and those using knee or hip prostheses.

Data collection occurred throughout the two-week festival at a booth reserved by the festival's organizers, located in a prominent area. A banner displayed at the evaluation booth invited dancers to participate in the research. This ensured that all dancers attending the festival had an equal opportunity to take part in the data collection.

The evaluation instruments were: (1) Anamnesis, (2) The HAGOS-Br questionnaire, administered only to those reporting hip pain, and (3) The protocol of the DIPA© software (Digital Image-Based Postural Assessment) for static lower limb posture analysis.

For the evaluation, dancers were required to wear appropriate attire, such as a top and shorts or a dance leotard, have their hair tied back, and be barefoot. All evaluations were conducted by two trained evaluators, each with over 15 years of ballet experience and two years of expertise in postural assessment.

Anamnesis

After consenting to participate in the research, each dancer was assigned an alphanumeric identification code, which was used in all stages of the evaluation to preserve their identity and ensure anonymity.

Initially, one evaluator conducted the anamnesis, which provided information for sample characterization and group division (with or without hip pain). During the anamnesis, participants were asked about: (1) The presence or absence of hip pain, pain intensity based on the numeric scale, frequency, and location of the pain (Figure 1).

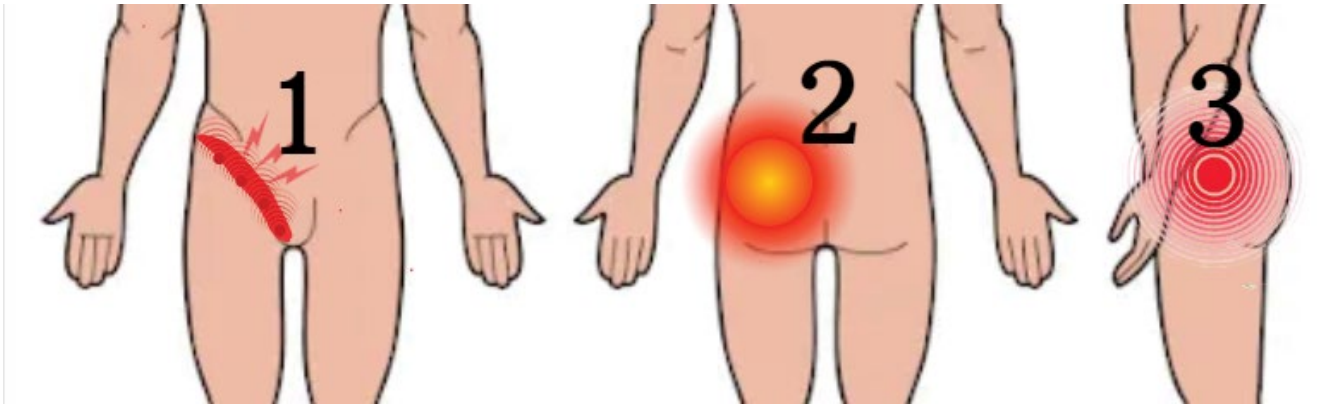


Figure 1: Location of hip pain identified by the dancer during the anamnesis.

Only dancers reporting pain during the anamnesis completed the HAGOS-Br questionnaire.

Characterization of Hip Pain - HAGOS-Br

To characterize hip pain, the "The Brazilian hip and groin outcome score" (HAGOS-Br) questionnaire was used. According to the consensus statement of the International Hip-Related Pain Research Network, HAGOS is one of the most appropriate PROMs (Patient-Reported Outcome Measures) for use in physically active young and middle-aged adults with hip-related pain [10].

Two of the six HAGOS subscales were used in this study: Symptoms and pain. The symptoms subscale consists of seven questions, is the most comprehensive, and addresses potential signs/indicators of hip pain. The pain subscale specifically focuses on the experience of pain, comprising ten questions.

For all questions, responses are standardized using a 5-point Likert scale, where each question is scored from 0 to 4, with 0 indicating no problem.

Equation 1 was used to calculate the total score for each subscale. A score below 100 corresponds to hip pain, with an inverse relationship: the lower the score, the greater the symptoms and pain.

$$Score\ on\ the\ subscale = 100 - \frac{Total\ score\ of\ the\ subscale \times 100}{Maximum\ score\ of\ the\ subscale} \quad (1)$$

Static Posture Assessment – DIPA© Software

The DIPA© software protocol uses photogrammetry to assess static posture, providing quantitative data on postural variables and a postural diagnosis [11]. For this research, a reduced version of the DIPA© protocol, specifically designed for the evaluation of lower limbs, was used.

With the location prepared according to the specifications of DIPA© software version 3.3 [12], eight anatomical reference points were palpated, and reference markers were attached with double-sided tape: Right and left anterior superior iliac spines (ASIS), apex of the right and left patellae, right and left anterior tibial tuberosities, and right and left lateral malleoli (Figure 2).

After placing the reference markers, the dancer was positioned facing the camera (Sony Cyber-shot-hx-100-30x). At the moment of the photo, the dancer was required to maintain an upright posture, with feet positioned according to the anatomical alignment of the knees and the gaze fixed horizontally (Figure 2).

Two postural variables were evaluated:

- **Static frontal pelvic alignment:** Corresponds to the symmetry between the right and left sides of the pelvis, allowing classification of the pelvis as aligned (up to 1 cm difference between sides) or misaligned (more than 1 cm difference between sides).
- **Frontal knee alignment:** Allows classification of the knee as normal (when the knee angle is between 170° and 175°), valgus (when less than 170°), or varus (when greater than 175°).

Data analysis

The static posture assessment photos were imported and digitized using the DIPA© software on a computer (Notebook VAIO FE15, Brazil), which provided the values for the variables *Static frontal pelvic alignment* and *Static frontal knee alignment*.

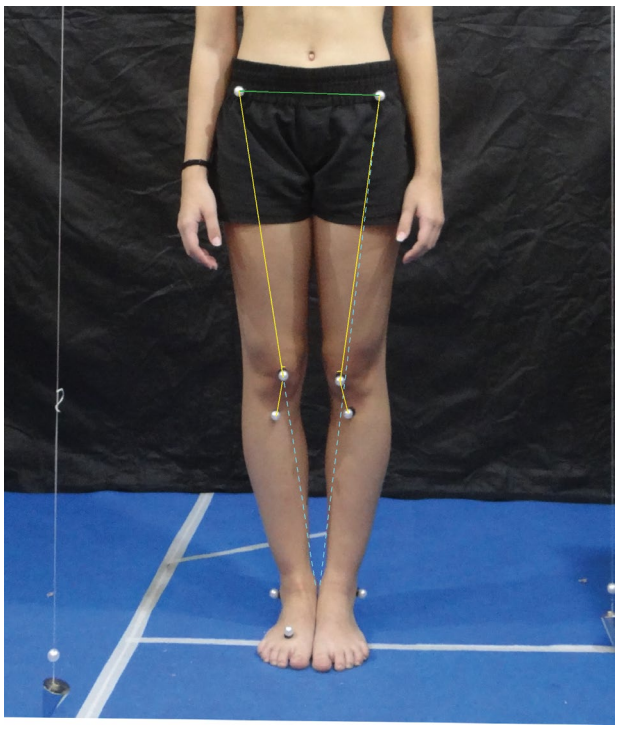
Statistical analysis

The data were tabulated in Excel (2016 version) and analyzed using the Statistical Package for the Social Sciences (SPSS), version 20.0. The Kolmogorov-Smirnov test was applied to assess data normality. The t-test and Mann-Whitney test were used to compare groups with and without pain. Pearson's chi-square test was used to identify associations between static alignment and pain (FIELD, 2009). The significance level was set at 0.05.

Results

Sample characterization

A total of 364 dancers were assessed during the Festival, with 346 included in the study. The sample



Author, 2023.

Figure 2: Photographic record obtained using the DIPA© software for the assessment of lower limb static posture in the frontal plane.

Table 1: Characterization of the sample in terms of anthropometric (weight and height) and demographic (age, practice duration, and weekly class frequency) data.

	Weight (kg)	Height (cm)	Age (years)	Practice duration (years)	Weekly class frequency (hours)
Total Sample	56.9 ± 10.7	162.8 ± 6.9	19 (15-58)	12 (5-43)	8 (1-60)
With pain (n = 132)	57.5 ± 11.8	163.2 ± 7.5	19 (15-58)	12 (5-43)	9 (1-47)
Without pain (n = 214)	56.5 ± 9.9	162.6 ± 6.5	18 (15-49)	12 (5-41)	7 (1-60)
p-value	0.087[a]	0.188[a]	0.152[b]	0.921[b]	0.016[b*]

[a]T-test; [b]Mann-Whitney U

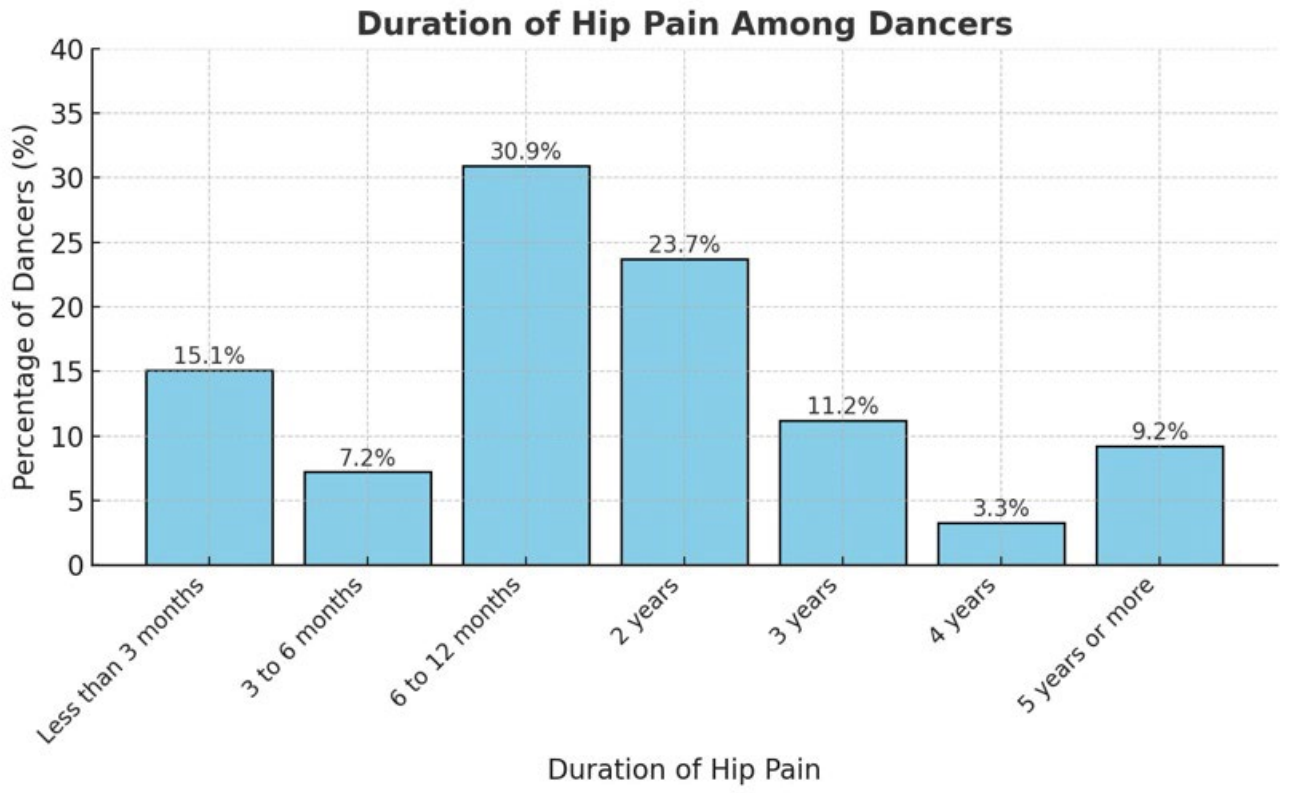


Figure 3: Frequency distribution regarding the duration of hip pain.

loss of 18 dancers was due to various reasons, such as the loss of one or more reference markers or missing evaluation data.

In the *no pain* group (n = 214), 114 were young individuals and 100 were adults, with 197 females. The most prevalent practice duration was 10 to 20 years (n = 111), followed by 5 to 10 years (n = 81), 0 to 5 years (n = 13), and over 20 years (n = 9). Regarding dance styles, ballet was predominant in the *no pain* group (n = 194). The geographical region with the highest representation in this group was the Southeast (n = 127), followed by the South (n = 61), Midwest (n = 15), Northeast (n = 8), and North (n = 3).

In the *pain* group (n = 132), most dancers were adults (n = 74), followed by young individuals (n = 58). The ranking for practice duration, dance style, and region mirrored the *no pain* group. The majority (n = 61) had 10 to 20 years of practice, followed by 5 to 10 years (n = 50), 0 to 5 years (n = 10), and over 20 years (n = 11). Ballet was the most practiced style (n = 121), and the Southeast had the highest representation (n = 76), followed by the South (n = 44), Midwest (n = 8), Northeast (n = 3), and North (n = 1). Females also prevailed in this group (n = 118).

Regarding anthropometric and demographic characteristics, there were no differences between the *pain* and *no pain* groups, except for the weekly practice frequency, which was higher in the *pain* group (Table 1).

For the group with hip pain, the intensity of the pain was also assessed, with a mean and standard deviation of 4.8 ± 1.8, respectively. Most dancers in the pain group (39.5%) reported anterior hip pain. Lateral hip pain was cited by 27%, while 13% reported posterior hip pain. The remaining 20% reported pain in more than one hip region. Regarding pain duration, most dancers experienced pain between 6 and 12 months (Figure 3). Those who reported hip pain for less than 3 months were classified as pain-free, as this study focuses on

Table 2: Comparison between groups with and without hip pain for the postural variables: Frontal knee alignment and Frontal pelvic alignment.

Postural Variable	Group With Pain	Group Withou Pain	p-value*
Frontal Pelvic Alignment (cm)[a]	0.18 ± 0.9	0.02 ± 0.8	0.163
Frontal Knee Alignment R (degrees)[b]	177.7 (167-180)	177.8 (167.4-180)	0.429
Frontal Knee Alignment L (degrees)[b]	177.1 (168.3-180)	177.2 (166.3-180)	0.907

*Mann-Whitney U test; [a]mean and standard deviation; [b]median and range (min/max)

Table 3: Frequencies of Frontal alignment of the right and left knees (varus, valgus, and normal) and the presence/absence of hip pain.

		Right Knee			
		Valgus	Varus	Normal	Total
Hip Pain	Yes	2	110	17	129
	No	2	176	32	210
Total		4	286	49	339
		Left Knee			
		Valgus	Varus	Normal	Total
Hip Pain	Yes	2	100	27	129
	No	6	160	44	210
Total		8	260	71	339

Table 4: Frequencies of Frontal pelvic alignment (aligned and misaligned) and the presence/absence of hip pain.

		Pelvis		
		Misaligned	Aligned	Total
Hip Pain	Yes	34	95	129
	No	35	175	210
Total		69	270	339

chronic pain. As for the HAGOS-Br results, the symptoms subscale had an average score of 68 points, while the pain subscale had an average score of 80 points.

Static Posture Assessment – DIPA© Software

In the analysis of the static posture of the lower limbs, no significant differences were observed between the groups with and without hip pain for the postural variables (Table 2). Differences were noted between the right and left knees; therefore, the results for both are presented.

Additionally, the knee posture analysis revealed that, for the variable Frontal knee alignment, most dancers exhibited varus knee, in both the right and left limbs (Table 3). The chi-square association test indicated no association between hip pain and the static posture of the right knee ($\chi^2 = 0.497$; $p = 0.780$) or the left knee ($\chi^2 = 0.597$; $p = 0.742$).

In the frequency analysis of pelvic posture (aligned and misaligned) concerning groups with and without pain (Table 4), it was observed that the presence of a misaligned pelvis is associated with hip pain in dancers ($\chi^2 = 4.628$; $p = 0.0023$).

Discussion

Hip pain

The human body has alert systems that automatically identify injuries or diseases, releasing substances that send pain signals to the brain. Chronic pain, lasting more than three months, as investigated in this study, causes physical, emotional, and social issues [13].

Although adolescent dancers are predisposed to an increased risk of pain related to musculoskeletal trauma [14], in the present study, the adult group had a higher number of individuals with hip pain (n = 74) compared to the younger group (n = 58).

In the HAGOS-Br, lower scores indicate greater symptoms and pain. Therefore, it can be inferred that the requirements of the symptom subscale, such as discomfort, clicks, and stiffness, affect the dancer population more significantly, as the mean score was lower (68 points) compared to the pain subscale (80 points).

Pain, understood as a multifactorial process, is difficult to associate with a single factor, such as posture. When postural misalignments and pain are analyzed together, it is possible to observe individuals with and without pain symptoms who exhibit misalignments [1].

Joint alignment, the focus of this study, has been identified in previous studies as a risk factor for lower limb injuries in both recreational and elite dancers [3]. Changes in the biomechanical conditions of exercise have been considered the main factor leading to overuse injuries in ballet [15]. The present study did not focus on injuries but on pain. However, as stated by Sobrino and Guillén, overuse injuries in dancers are often presented as pain and are most prevalent among younger professional dancers [16].

Dancers suffering from overuse injuries often underestimate pain and frequently do not allow their bodies to recover from fatigue. Furthermore, they poorly distinguish between pain considered habitual and related to dance performance and pain that might indicate a potential injury [17]. Thus, understanding the association between alignment and pain can help diagnose problems early and reduce the risk of injuries that could negatively impact dancers' careers and performance.

Knee

When the knee segment is evaluated, alterations in

valgus in the static posture do not appear to be a common characteristic among dancers. In the present study, the percentage of dancers with knee valgus was very low (n = 4), and in other studies, it was not even observed [18]. However, knee hyperextension is common in this population, ranging from 53.3% to 71.42% [18-20]. Knee valgus associated with knee hyperextension can lead to functional bowing, where the knees are apart when the feet are together, obscuring the valgus knee, but it becomes apparent when the lower limbs are placed in a neutral knee extension position [1]. In other words, the high rate of knee hyperextension in this population may be influencing the low tendency for knee valgus. Moreover, being a dancer or not was a factor that had a statistically significant effect on the presence of varus knee [18]. In the study by Simas and Melo, one of the most common alterations in the anterior view was varus knee, in 46% of the dancers [21]. Jazz dancers also showed a high prevalence of varus knee (71.43%), with only 14.28% exhibiting knee valgus [22].

In the present study, the highest prevalence was also of varus knee (Table 2), with a significant difference between the right and left knee. A possible explanation for these asymmetries found in the frontal plane may be the fact that, in training specific movements, the dancer repeats the motor gesture on the side where the technique is better performed, which develops the muscles in a disharmonic way, leading to muscle soreness and even postural changes [23].

Pelvis

Lateral pelvic tilt to one side (right or left) is commonly found in dancers [24]. In fact, some studies highlight the presence of this asymmetry in dancers: 58% presented pelvic tilt to one side [21]; 60% showed asymmetry of the anterior-superior iliac spine - ASIS [18]; 70% of dancers have a higher left ASIS [23]. The findings of the present study regarding the static posture of the pelvis contradict the results of these previous studies, as, despite the presence of pelvic tilt in the frontal plane among the evaluated dancers, this difference was, on average, less than 1 cm (Table 4), which is considered common and typically does not indicate significant clinical problems [25].

However, in the present study, an association was found between pelvic tilt in the frontal plane and hip pain (Table 4). Given the complexity of the human movement system, which has interrelated components [26], it is speculated that pelvic misalignment may alter hip mechanics. Altered mechanics, with improper load distribution in the joint, could, in turn, generate pain.

Conclusion

In general, dancers have varus knees and aligned pelvis when evaluated in the static frontal plane. Dancers with hip pain have a higher weekly class frequency, in hours, than those without pain. Hip pain is associated with static pelvic misalignment in the frontal plane but not with knee posture.

Authors Contribution

We declare that all authors contributed equally to the conception, development, and revision of this work.

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