Motor Control and Low Back Pain in Dancers

Authors

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Key words
- dance
- injury
- low back pain
- health
- sacroiliac pain
- joint pain
- hypermobility

Abstract

Professional dancers suffer a high incidence of injuries, especially to the spine and lower extremities. There is a lack of experimental research addressing low back pain (LBP) in dancers. The aim of this study is to compare lumbopelvic motor control, muscle extensibility and sacroiliac joint pain between dancers with and without a history of LBP. 40 pre-professional dancers (mean age of 20.3 years) underwent a clinical test battery, consisting of an evaluation of lumbopelvic motor control, muscle extensibility, generalized joint hypermobility, and sacroiliac joint pain provocation tests. Also self-reported measurements and standardized questionnaires were used. 41% of the dancers suffered from LBP during at least 2 consecutive days in the previous year. Only one dancer suffered from sacroiliac joint pain. Compared to dancers without a history of LBP, dancers with a history of LBP showed poorer lumbopelvic motor control ($p<0.05$). No differences in muscle extensibility or joint hypermobility were observed between dancers ($p>0.05$). Despite their young age, pre-professional dancers suffer from LBP frequently. Sacroiliac joint pain, generalized joint hypermobility or muscle extensibility appears unrelated to LBP in dancers. Motor control is decreased in those with a history of LBP. Further research should examine whether motor control is etiologically involved in LBP in dancers.

Introduction

Dancers are at increased risk for developing low back pain (LBP)[20], as they regularly perform repetitive extensions, high velocity twisting and bending movements. Of all dance injuries, approximately 60–80% occur in the lower limbs and 17–30% in the spine [4,11,21]. Studies examining the one-year incidence of LBP indicate that dancers experience spinal complaints very frequently. For example, in one study performed in 128 professional adult ballet dancers, 95% of the dancers experienced musculoskeletal complaints, and more than 70% of the dancers indicated that they had suffered LBP during the preceding 12 months [26]. In pre-professional dancers, values up to 63% have been reported [32]. In studies including children and adolescents, the incidence and magnitude of LBP experienced during the previous year is significantly greater in dancers and gymnasts compared to control subjects, which are defined as subjects devoting less than 6h per week to physical activity [20].

Despite the high prevalence and incidence of LBP in dancers compared to non-dancers, there is a lack of experimental studies evaluating the back complaints in this population [14]. Only a few case reports exist about LBP in dancers [9,14]. Until further research in this area is undertaken, it remains unclear whether the increasing amount of research dealing with the evaluation and rehabilitation of patients with LBP in the general population is applicable to dancers [14]. Recent developments in LBP research include for example motor control assessment of the lumbopelvic region. The change in feed-forward mechanisms and postural function of spinal muscles observed in the patients with acute and chronic LBP may be very relevant to the dancer's ability to control the spine during limb movement [33].

Several hypotheses regarding the cause of LBP in dancers and athletes have been proposed. The high prevalence of injuries, including LBP, may be due to repetitive movements in the hypermobile range of movement, which is typical for dancing. Another hypothesis states that as a result of

accepted after revision
June 01, 2012

Bibliography
DOI http://dx.doi.org/10.1055/s-0032-1321722
Published online: September 7, 2012
Int J Sports Med 2013; 34: 138–143

ISSN 0172-4622

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injury, degenerative change or repetitive motion, dancers may develop a spinal motor control dysfunction [37]. Impaired motor control of the lumbopelvic region leads to compensatory movements of the spine and lower limbs, which may result in LBP [37].

Surprisingly, there are no data on the incidence of motor control disorders in dancers with LBP. However, it has been suggested more than 20 years ago that dance injuries involving lower extremities are related to dysfunction or derangement of the lower back and pelvis [2]. We previously undertook a study to examine the relationship between motor control, hypermobility and injuries in dancers and found that dancers with altered lumbopelvic motor control at baseline were at risk for developing injuries to the spine and lower extremities [32]. Neither a history of LBP nor generalized joint hypermobility were able to predict the occurrence of new injuries to spine or lower extremities [32]. However, this study evaluated motor control and generalized joint hypermobility in relation to new injuries and not specific in relation to LBP.

Dance injuries in general, and LBP in particular, are seldom caused by one single factor, but are usually the result of repeated overload, superimposed on multiple factors [2]. It is for example known that dancers may compensate a lack of hip external rotation or hip extension by hyperextending the lumbar spine, in order to achieve Arabesque positions (i.e., 90° of hip extension/external rotation with an extended leg during stance) [2]. Anterior pelvic tilt and hyperlordosis of the spine are indeed very common in dancers. Unsurprisingly, spinal pathologies such as spondylosis and spondylolisthesis are much more common in dancers and gymnasts than in the general population [13]. Uncontrolled movement of the pelvis and the lumbar spine may contribute to the complaints. Therefore it is essential to evaluate lumbopelvic motor control in dancers. It is hypothesized that dysfunctional lumbopelvic motor control, muscle extensibility and generalized joint hypermobility are related to (a history of) LBP in dancers.

Finally, also sacroiliac joint pain has been suggested as cause for LBP in dancers [8]. The sacroiliac joint plays an important role in dancing, as dance choreographies lean on correct biomechanics of spine and pelvis [8]. Indeed, dance movements – in which the esthetic aspect is crucial – are only made possible by optimal functioning of muscles, joints and ligaments of spine and extremities. Pelvic motion provides for example a large proportion of the battement movement [5]. Loss of pelvic motion may therefore alter the biomechanics of dance movements, and may be associated with pain and dysfunction. Again, no experimental studies regarding sacroiliac joint pain are available in dancers.

Study aims
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The aim of this study is to compare lumbopelvic motor control, muscle extensibility and sacroiliac joint pain between dancers with and without a history of LBP.

Materials and Methods
▼

Design

A cross-sectional design was used to evaluate differences in test results between dancers with and without a history of LBP. All participants were subjected to a clinical test battery, consisting of the assessment of lumbopelvic motor control, muscle length, generalized joint hypermobility and explosive muscle strength. Pain provocation tests were used to evaluate the sacroiliac joint. In addition, an anthropometric evaluation was performed in all subjects. Finally, participants were asked to fill in several questionnaires. The Human Research Ethics Committee of the local University Hospital approved the study. The study was conducted in accordance with the ethical standards of the International Journal of Sports Medicine and was approved by the University Institutional Review Board [15], all participants completed and signed an informed consent document.

Study participants

Participants were recruited among dancers (n=41) enrolled at the Department of Dance of a Conservatoire, the only professional bachelor education for dance in Belgium. At the start of the academic year, all subjects received verbal information addressing the study. Next, an information leaflet was handed out to the participants. Participants were instructed to read it vigilantly and to ask for additional explanation if necessary. Inclusion criteria were full-time enrolment, availability for study participation, willingness to participate and hence to sign the informed consent form. 40 dancers (2 men, 38 women) agreed to participate in the study and signed the informed consent form. One student performed a stay abroad in a foreign country during the whole academic year and was excluded from the study. The age of the participants varied between 17 and 26 years, with a mean age of 20.3 (2.4) years (see **Table 1**). Dancers suffering from LBP during at least 2 consecutive days were defined as dancers with a history of LBP [20].

Outcome measures

Questionnaires

Participants were asked to fill in several questionnaires such as the Short Form 36-questionnaire (SF-36), the Tampa Scale for Kinesiophobia (TSK) and a self-established medical questionnaire. The psychometric properties of the SF-36 [37] and the TSK [30] have been described elsewhere. The visual analogue scale (VAS – 100 mm) was used for the assessment of pain severity [25]. A standardized questionnaire was used to collect demographic information at baseline, in addition to questionnaire previously used to register LBP in dancers [20]. To gather information about complaints in other regions, the following question was asked in the self-reported questionnaire: Have you at any time during the last 12 months had some trouble (ache pain, discomfort) in: neck, upper back, low back, hips/thighs, knees, ankle/feet [26]. No time frame for the complaints was provided in this questionnaire.

Table 1 Descriptive statistics of 40 dancers.

	Mean	SD	Range [min;max]
age (y)	20.30	2.40	[17;26]
height (m)	1.66	0.06	[1.6;1.8]
weight (kg)	56.43	5.71	[48.8;74.8]
BMI (kg/m2)	20.45	1.65	[16.7;28.9]
waist hip-ratio	0.73	0.04	[0.7;0.8]
sum skinfolds (mm)	41.70	8.05	[25.1;93.0]
physical activity during classes (h/week)	21.5	2.1	[6.9;29.7]
physical activity outside classes (h/week)	4.6	1.3	[0;23.3]

SD = standard deviation; [min;max] = minimal and maximal value; BMI = Body Mass Index

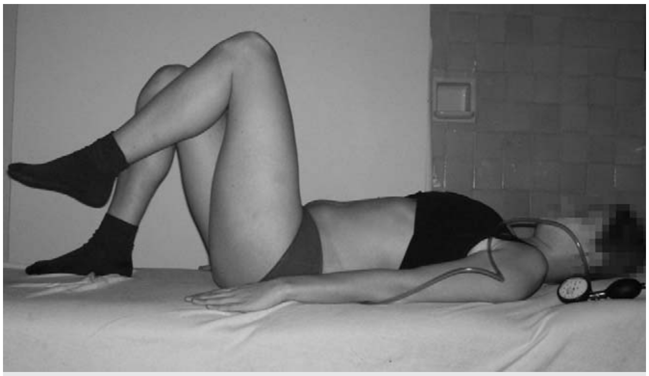

Fig. 1 Knee lift abdominal test. The subject is instructed to lift one foot off the table to 90° of hip flexion with knee flexion, keeping the lumbar spine stable.

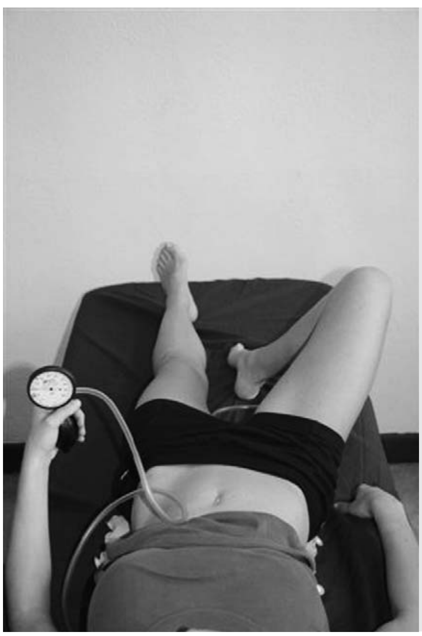

Fig. 2 Bent knee fall out. The subject is instructed to lower out the bent leg to approximately 45° of abduction/lateral rotation, while keeping the foot supported beside the straight leg, and then to return to the starting position.

Lumbopelvic motor control

Lumbopelvic motor control was assessed by evaluating the subjects' ability to control movement of lumbopelvic region while performing simple movements in the hips. The Knee Lift Abdominal Test (KLAT, see ▸ **Fig. 1**) and Bent Knee Fall Out (BKFO, see ▸ **Fig. 2**) were used for the evaluation of lumbopelvic motor control. The tests were performed in supine position and monitored with a pressure biofeedback unit (PBU), as previously described [32]. In brief, the pressure of the PBU was inflated to 40 mmHg (baseline pressure) [28]. Participants were instructed to maintain neutral spine position (i.e., preventing spinal movement) during lower extremity movement. The other leg was extended (BKFO) or flexed (KLAT) and rested on the table, except for the bilateral KLAT. A pre-testing trial was organized to familiarize the subjects with the PBU and the clinical tests. Maximal pressure deviation from baseline was recorded during each test and these scores were used for further analyses. The aim of the test was to have as little deviation from the baseline pressure as possible. Although it is unnatural to keep the spine still during movements, previous research demonstrated that healthy subjects with good trunk stabilization are able to maintain neutral spine position while moving the legs [17] and that significant differences are observed between patients with LBP and healthy subjects [32]. The reliability of these tests is acceptable [32].

In addition, contraction of the M. transversus abdominis was assessed in the dancers by the abdominal 'drawing in' action in crook lying [7]. For a correct test performance (negative test), participants should be able to tension the M. transversus abdominis (hollowing of the lower abdominal wall) without excessive overflow to the upper abdominal wall, expansion of the Mm. internal obliques, spinal or rib cage movement, as previously described [7,27]. Observation and manual palpation were used to evaluate the correct contraction of M. transversus abdominis. In case of compensations as mentioned above, the test was considered positive. In addition, the breathing pattern during the test was observed, as breath holding occur in patients with LBP, which is also considered as compensatory strategy [31]. Movements of the thorax and the abdomen during respiration were inspected and palpated during motor control tests. A normal breathing pattern (costo-diaphragmatic breathing) was defined as a displacement of the ribcage in cranial, lateral outward and ventral direction and an outward movement of the abdomen during inspiration and the reverse pattern during expiration. All other breathing patterns were defined as asynchronous breathing patterns [31].

Muscle extensibility

Muscle extensibility was evaluated by assessing the range of motion of several joints. The length of the hip adductors was examined in supine position, with the contralateral leg hanging over the table to stabilize the pelvis. The leg to be measured was then abducted passively with the leg maintained in neutral position (foot pointing towards the ceiling). Range of motion of hip abduction was evaluated with the stationary arm of the goniometer on a line between the umbilicus and the symphysis pubis and the moving arm along the long axis of the abducted thigh, between the umbilicus and the patella [34]. Both the mono-articular adductors (knee flexion of the testing leg) as the bi-articular adductors (extended leg) were assessed.

The length of the hamstrings muscles was evaluated in supine position with the contralateral leg resting on the table. The leg to be measured was flexed passively in the hip, with an extended knee, while fixating the pelvis to avoid pelvic movement (straight leg raise maneuver). The moving arm of the goniometer was positioned parallel with the lateral knee epicondyle and the greater trochanter, while the stationary arm was positioned horizontally (parallel with the table) [24].

The length of the M. tensor fascia latae was evaluated in side lying (Ober's test) [38].

Generalized joint hypermobility was assessed according to the description provided by Beigthon et al. [3]. The clinimetric properties of the Beigthon score have been summarized elsewhere [22]. 3 subgroups were defined based on the individual Beigthon scores: tight (0–3); hypermobile (4–6); extremely hypermobile (7–9) [35].

5 pain provocation tests for the assessment of sacroiliac joint pain were used in the present study: Posterior Pelvic Pain provocation test (P4), Patrick or Faber Test, Gaenslen Test, Compression Test and distraction or gapping test [29]. The reliability and validity of these tests is moderate to good, especially when used in clusters [18,29]. Dancers were therefore classified as having a sacroiliac joint pain disorder when three or more tests were positive [18,29].

An anthropometric evaluation was performed in all subjects. The subjects wore light clothes (T-shirts and tights) and no shoes. Height was measured to the nearest centimeter (cm) using a stadiometer[a]. Weight was measured using a CE approved medical digital column scale[b]. Hip and waist circumference as well as subcutaneous thickness (middle of the triceps and of the biceps, 5 cm above the superior and anterior iliac spine and 2 cm below and lateral below the inferior angle of the scapula) were measured with a calliper [10]. Body Mass Index (BMI) and waist to hip ratio were calculated.

Statistical analysis

Statistical analysis was performed with Statistical Package for Social Sciences (SPSS)[f] version 18.0. We used a one-sample Kolmogorov-Smirnov (K-S) goodness-of-fit test to examine whether the variables were normally distributed. In cases of normally distributed variables, we used the independent samples Student's *t*-test to compare the dancers with a history of LBP with the dancers without LBP. If the K-S revealed that a variable was not normally distributed, then the nonparametric Mann-Whitney test was used. The Fisher's exact test was used to compare categorical data between the participants with and without LBP. A Spearman correlation coefficient was used to analyze correlations between several parameters. The significance level was set at 0.05, except for the correlation analysis which was set at 0.01 to help protect against potential type I errors.
Sample size calculations indicated that we need to study 17 subjects for each group. These calculations were based on a power analysis (power of 0.80 and α of 0.05), based on a previous study assessing lumbopelvic motor control in healthy subjects and patients with LBP [31] and on a study evaluating LBP in dancers [32]. We anticipated that approximately half of the dancers would have experienced LBP in the year before the study and that differences in pressure between healthy subjects and patients would be 2.5 mm Hg (2.3). In order to account for possible drop out, 44 dancers were recruited.

Results

40 dancers completed the study. Descriptive statistics of the study participants are presented in ▶ **Table 1**. 24 dancers (60 %) demonstrated generalized joint hypermobility. 9 of these dancers (22 %) obtained a Beigthon score ≥7, which can be considered as extreme hypermobility. 23 dancers (58 %) experienced at least once LBP during the previous year. Fifteen dancers (38 %) experienced at least once upper back pain during the previous year. The percentage of dancers experiencing complaints at hips, thighs, knees or ankle and feet during the previous year was 54 %, 48 % and 45 %, respectively.

Comparison of data between dancers with and without a history of LBP

16 dancers (41 %) reported at least one experience of LBP lasting more than 2 consecutive days in the last year. This group is further classified as dancers with a history of LBP.

Evaluation of range of motion and generalized joint hypermobility

There was no difference in Beigthon score for the assessment of generalized joint hypermobility or in range of motion between dancers with or without a history of LBP (see ▶ **Table 2**).

Lumbopelvic motor control assessment

Significant differences were observed between dancers with and without a history of LBP for 2 lumbopelvic motor control tests (see ▶ **Table 3**).
A significant difference was also found for the proportion of dancers with a correct contraction of the transversus abdominis muscle. 30 % (7/23) of the dancers without a history of LBP were not able to perform a correct contraction of the transverse abdominis muscle, compared to 63 % (10/16) of the dancers with a history of LBP (p = 0.048).

Sacroiliac joint pain provocation tests

Only one dancer had more than 3 positive sacro-iliac joint pain provocation tests. This dancer did not experience LBP during the previous year.
No correlations were observed between muscle extensibility, generalized joint hypermobility, and sacroiliac joint pain on the one hand, and LBP on the other hand.

Table 2 Assessment of joint hypermobility and joint ROM in dancers with and without a history of low back pain.

	No LBP (n = 23)		LBP (n = 16)						
	Mean	SD	Mean	SD	t	df	p	95 % CI	
Beigthon score (0–9)	4.30	2.265	4.69	2.798	−0.472	37	0.640	−2.029	1.263
hip flexion left (°ROM)	119.48	12.724	116.50	13.337	0.705	37	0.485	−5.581	11.537
hip flexion right (°ROM)	121.65	13.435	119.69	10.209	0.493	37	0.625	−6.103	10.032
hip adduction left (°ROM)	61.70	7.468	60.06	8.330	0.641	37	0.526	−4.162	5.700
hip adduction right (°ROM)	61.26	8.433	60.00	8.907	0.449	37	0.656	−0.301	0.187

SD = standard deviation, CI = confidence interval. Values are expressed as total score (Beigthon Score) or degrees in range of motion (ROM)

Table 3 Motor control assessment in dancers with and without a history of low back pain.

	No LBP (n = 23)		LBP (n = 16)					
	Mean	SD	Mean	SD	t	df	p	95 %CI
knee lift abdominal test bilateral (mm Hg)	53	8.2	59	8.9	−2.041	37	0.048*	−11.3 −0.041
bent knee fall out left (mm Hg)	36.1	5.7	32.9	3.1	2.037	37	0.049*	0.017 6.39
bent knee fall out right (mm Hg)	35.1	5.8	33.5	2.8	1.042	37	0.304	−1.55 4.82

SD = standard deviation, CI = confidence interval. Values are expressed in mm Hg

Questionnaires

No differences were observed for the results of the SF-36 between dancers with and without a history of LBP. Also the results of the Tampa Scale for Kinesiophobia did not differ between the 2 groups (for the dancers without and with a history of LBP mean value of 34.2 and 36.2, respectively, $p = 0.293$).

Discussion

The results of the present study demonstrate that LBP is very common in dancers and that dancers with a history of LBP do not demonstrate increased muscle extensibility or joint hypermobility, but show altered motor control of the lumbopelvic region (2 out of 3 tests), when compared to dancers without a history of LBP. Sacroiliac joint pain, generalized joint hypermobility or muscle extensibility appears unrelated to LBP in dancers.

The incidence of musculoskeletal complaints to the spine and the lower extremities during the last year was in line with other studies on professional and pre-professional dancers [4, 11, 21]. The spine is the second most injured area of the body in dancers [4, 11, 13]. Literature reports indicate that 10–29% of the dance injuries involve the lower back [4, 21]. 58% of the dancers in the present study reported that they had at least one episode of LBP in the previous year, and 41% of the dancers suffered from LBP lasting at least 2 consecutive days. This is comparable to the values observed in young dancers and gymnasts, ranging from 32–50% [20]. In children and adolescents, it has been suggested that more than 30 h of physical activity per week increases the likelihood of developing LBP [20]. Our population has a schedule with nearly 30 h of weekly physical activity, which may explain the high proportion of dancers with LBP observed in the present study.

The exact cause of the spinal complaints remains unknown. Using magnetic resonance imaging, Capel observed a similar rate of degenerative disc diseases between dancers and non-dancers [6]. Medical imaging is, however, not recommended in the general population to examine patients with non-specific LBP [1]. An exception may be the use of medical imaging in dancers in which spondylolisthesis is suspected. Recent developments regarding LBP in the general population focus on the bio-psychosocial aspect. In addition to psychosocial factors, spinal motor control appears to be an important issue in patients with recurrent LBP [36]. It has been demonstrated that the observed alterations of motor control are associated with a reorganization of trunk muscle representation at the motor cortex [36].

Motor control of the lumbopelvic region seems essential in dancers as well, to control the spine during limb movement. Most dance movements involve lower extremities or the trunk while keeping the esthetic aspect in mind, and are made possible by dynamic stabilization of the lumbopelvic region. The rapid and extreme movements of the legs in all directions, the jumps, twisting and bending movements impose tremendous forces on the spine and the pelvis [8]. It is known from the general population and athletes that patients with LBP demonstrate altered motor control of the lumbopelvic region [16, 31]. Poor technique, muscle imbalance and altered motor control have been suggested as contributing factors to LBP in dancers [12, 13, 14, 33]. Nevertheless, this is the first study reporting altered motor control in dancers with LBP. A large proportion of dancers with a history of LBP are not able to contract their M. transversus abdominis, and these dancers demonstrate higher pressure deviations on the pressure biofeedback unit during 2 out of 3 motor control tests.

Altered motor control was the only factor which was significantly different between dancers with and without a history of LBP, implying that neither generalized joint hypermobility, nor sacroiliac joint pain are more prevalent in dancers with a history of LBP. The role of altered motor control in the etiology of LBP should be further explored. In the present study, the observed differences between the groups are consistent, but relatively small. In addition, the present study has a cross sectional design and causative interpretations should not be made.

In a prospective study, performed in a similar population, altered motor control was the only test associated with an increased injury risk to the lower extremities and the spine [32]. Again, generalized joint hypermobility appeared to be unrelated to dance injuries [32]. Taking the multifactorial etiology of LBP into consideration, it is important to analyze other factors that may be related to LBP. In the general population, psychosocial factors appear to play an important role in the recurrence of LBP as well. In the present study, fear avoidance was similar in dancers with and without a history of LBP. Also the results of the SF-36 did not differ between the 2 groups. Only limited attention has been paid to psychological factors in dancers until now. Anxiety, stress and self-critique are common in dancers [8]. Noh et al. identified major sources of stress in Korean dancers (i.e., physical, psychological, interpersonal and situational) [23]. Mainwaring et al. observed a strong correlation between stress and injuries [19]. These studies evaluated stress and psychosocial factors in relation to injuries in general and not in relation to LBP. Further research should evaluate to what extent stress, emotional and psychological factors may play a role in LBP in dancers.

Limitations of the Present Study

The results of this study should nevertheless be seen in the light of some methodological concerns. Firstly, these results apply to pre-professional dancers following a Bachelor in Dance. University dance programs may not reflect general dance populations and the evaluation of lumbo-pelvic motor control in relation to LBP should certainly be performed in professional dance companies as well, thereby differentiating the different dance styles (ballet vs. contemporary dancing). Secondly, we performed field tests using a goniometer for the evaluation of joint range of motion, as we had no possibility to evaluate dancers in a controlled laboratory setting.

Conclusion

Dance is a physically demanding activity. Strength, extensibility, endurance and motor control are required to perform dance choreographies. The repetition of movements to extreme positions can contribute to pain. Dancers with a history of LBP do not demonstrate increased muscle extensibility or joint hypermobility, but show altered motor control of the lumbopelvic region, when compared to dancers without a history of LBP. Sacroiliac joint pain appears to be unrelated to the LBP in dancers. Further research should evaluate the psychosocial aspect in dancers with LBP and should develop strategies to prevent and manage LBP in dancers.

Acknowledgements

Funding sources Nathalie Roussel, Liesbeth Daenen en Anne Schütt were financially supported by a research grant supplied by the Royal Conservatoire, Artesis University College Antwerp, Antwerp, Belgium. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript. The authors thank all dancers and dance teachers for their participation.

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