STUDIA UBB EDUCATIO ARTIS GYMN., LXI, 2, 2016, pp. 31-47
(RECOMMENDED CITATION)

CORE MUSCLE ASSESSMENT OF DANCERS

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ABSTRACT. Background. To assess habitual postures as well as postures considered correct by dancers of different styles, and the intensity of their (low) back pain. To examine spinal functional status, strength and flexibility of core muscles necessary for correct posture and lumbar motor control skills. Our hypothesis is that lower back pain and deviation in the functional status of the spine are more common among dancers aged 9-18 than in the average population, or other sportsmen. Despite regular trainings, weakness is observed in muscles needed for correct posture. **Methods.** Our survey sample consists of members of three different dance genres. Groups examined include a classic ballet, a hip-hop dance and a ballroom dance group (n=92, mean age:14.15± 2.96). Examination of habitual postures and postures considered correct was performed by a photogrammetric test, while the intensity of low back pain was measured by a visual analogue scale, and the Roland-Morris questionnaire. Lumbar motor control skills were examined by sitting forward lean test and the strength of core muscles by the core test. **Results.** In posture analysis significant difference was found in anterior view of the posture considered correct; ballroom dancers showed significantly better posture (p=0. 038), than the other two groups examined. During the examination of low back pain intensity by a visual analogue scale ballroom dancers reported about the negative effect of pain on performance to a significantly higher degree (p=0.019). Core test demonstrated significantly better core muscle strength among ballroom dancers (p=0.000), than in the other two groups. **Conclusion.** Neither habitual, nor the posture considered correct of the dancers meet the requirements of the biomechanically correct posture. Low back pain manifests at an early age among dancers affecting their performance. Lumbar motor control skills and core muscle strength are inadequate despite regular exercise.

Keywords: dance, low back pain, posture, core muscles

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Introduction

According to Vaganova the owner of the body is the trunk' and the owner of the trunk is the spine. Every movement derives from the trunk, and if its elaboration is adequate, its strength and flexibility allow any physical activity and load ability. Therefore, core techniques require attention, even more; potential trunk injuries may be prevented.

Posture is defined as a position held by the human body's maintenance and motor apparatus. Interaction of posture and gravity differs individually; posture expresses character, physical and emotional life. Posture is a dynamic state of equilibrium, maintained by the constant and diverse activity of hardly visible muscles responsible for posture (Frenkl, 1995).

From a biomechanical perspective, the correct posture is described as the physiologically proper stretch of ligaments and joint capsules, low physical effort of muscles due to harmonic cooperation of muscles responsible for posture, thus joint surfaces have steady loads. This time the pelvis is in the medial state and the sagittal curvatures of the spine above are physiological, the imaginary axis of the body runs through the cervical vertebrae 2-5 and the lumbar vertebrae 2-5, and the spinal kyphosis enables flexible force transmission. In improper postures, the axis is displaced, causing changes in the spinal curvatures.

These may result in muscle and joint load related complaints, and injuries in several spinal regions (Kapandji, 2007; Somhegyi et al., 2014). The low back pain is a serious public problem in Hungary, which utilization and health insurance indicators of outpatient physiotherapy activities are known (Molics et al. 2011; Molics et al. 2012; Molics et al. 2013a; Molics et al. 2013b; Molics et al. 2013c; Molics et al. 2015).

Besides strict shape and physical demands, different dance genres require greater than the physiological ranges of motion of the spine (Bria et al., 2011; Hergenroeder et al., 1993). The physiological range of motion of the cervical spine and the head is 50-60 degrees, although, in the case of classical ballet, contemporary modern dance and ballroom dance, the head has a much greater range of motion, achieving even 75 or 85 degrees. Furthermore, the whole spine is characterized by a more flexible, greater range of motion (Mády, 2013).

Different styles of dance may help develop correct posture and make it automatic. One of them is a modern dance technique, called Limón technique. In basic posture of the technique the feet are parallel exactly under the pelvic joints, wider than the pelvis itself, and the shoulders are above the pelvic joints. The spine is stretched, the head is up, and the body weight is equally distributed

between the two feet, thus, the dancer continuously feels and controls the body's vertical axis. Limón believed that when posture becomes automatic, movements turn to be stable, quick and light (Lewis, 2000).

However, there are dance and sports genres demanding postures other, than the physiological ones (Cupisti et al., 2004). Ballroom dance includes complex techniques, discipline, high performance, and competitiveness. Deviations from physiologically correct postures are mostly observed in female dancers. While dancing the upper trunk leans backward, the head and the neck as the elongated part of the spine is in lateral rotation.

This irregular position has to be maintained by the dancers causing several symptoms in the cervical region of the spine (Mády, 1998; McCabe et al., 2014). In her PhD thesis Teri Riding reports about examinations of a specific injury affecting the cervical region. The survey investigates 10 dancers with, and 10 dancers with no previous injuries. Concerning anthropometric data average height in the injured group was 167.40 cm, and the average body weight was 59.3 kg, while in the non-injured group they were 166.76cm, and 58.93kg.

Electromyographic (EMG) examinations were conducted to assess the status of the upper m. trapezius (cowl muscle), the m. splenius capitis (splenius), and the m. sternocleidomastoideus (head rotator muscle). The findings revealed that cervical injuries in the injured group resulted from injuries to those muscles; even more, there were also cases in the non-injured group where overstretching and weakness of those muscles were observed (Riding, 2006).

A dancer is an artist exposed to heavy physical exertion, who is able to portray and dance characters on the stage with delicate emotion. The extent of the load accompanying dance is almost the same as the one experienced in a team sport, known as American football. Astrand et al. measured excessively high lactic acid level after a solo dance in an American prima ballerina (10mmol/l), which is surprising, as similar values are measured in sportsmen after hockey or football matches (Beck et al., 2015; Dahlstrom et al., 1997; Schantz & Astrand, 1984). So high lactic acid level shows that ballet movements demand a significant anaerobic capacity. With regard to elements of physical exertion, it is impossible to set exact requirements for dancers, hence, besides physical demands – in most cases – special achievements complete the performance unifying the dance and the dancer, thus, raising the genre from the sphere of simple physical load (Bretus & Zórándi, 1998).

Research Objective

- to assess the dancers' habitual postures, and the ones considered correct by them, and the intensity of low back pain, as well as their spinal functional status;
- to assess the lumbar motor control skills;
- to assess core muscle strength and flexibility necessary for correct posture.

Hypotheses

- Habitual posture of dancers do not correlate with the biomechanically correct ones;
- Postures considered correct by the dancers do not correlate with the biomechanically correct ones;
- Low back pain in dancers occurs during training;
- Low back pain occurring during training manifests already in dancers aged 9-18;
- Certain functional loss in the spinal status develops already in dancers aged 9-18;
- Lumbar motor control skills and core muscle strength are inadequate in the age group 9-18.

Research Materials

Inclusion criteria: A minimum of 3 years dance experience in companies or schools.

Exclusion criteria: spinal disease requiring treatment, spinal surgery, sports injury in the last 3 months, participation in core prevention programmes in the last 6 months.

Sample: Our sample consists of dancers (n=92, mean age: 14.15± 2.95(9-24) years). The analysed groups are composed of a classical ballet group (n=30, mean age: 12.7±2.18 (9-19) years), a hip-hop group (n=30, mean age: 13.17±2.88 (9-24) years), and a ballroom dance group (n=32, mean age: 15.8±2.87 (10-22) years).

Ballet dancers have been dancing for 4.5 ± 2.51 (end values: 1-10) years on average, with 3±1.06 (end values: 2- 6) trainings a week, where the training period is 96±12.2 minutes (end values: 90-120), and also with an

average number of a monthly theatre performance from 1.3±1.68 (end values: 0-10) with the length of 35.1±26.11 minutes (end values: 0-120). The members of the ballroom dance group have been dancing for 6.07±3.09 years (end values: 2-15) on average, with the number of 3.05±0.98 (end values: 2-5) and the length of 90±0.00 (end values: 90-90) minute trainings. They have monthly theatre performances as well with the number of 1.47±1.24 (end values: 0-4) and the length of time 24.03±21.54 (end values: 0-120) in minutes.

The hip-hop dancers have been dancing for 5.03±3.13 (end values: 2-14) years, with an average weekly number of 2.43±0.69 (end values: 2-5) and length of trainings of 115.71±45.25 (end values: 60-180) minutes, completed by monthly theatre performances with a number of 1.68±0.67 (end values: 0-3) and the length of time with 44.82±27.77 (end values: 0-120) minutes.

The whole sample can be described as - despite their young age - dancers with an average of 5.22±2.97 years (end values: 1-15) dance experience, training 3.02±1.02 (end values. 2-6) times, for 100±28.08 (end values: 60-180) minutes a week. Besides weekly trainings they have regular monthly performances with a number of 1.49±1.27 (end values: 0-10) and the length of time 34.21±26.28 (end values: 0-120) minutes.

Examination/Test location: Institute of Physiotherapy and Sport Science, Faculty of Health Sciences, University of Pécs (Rét u.4, Pécs, H-7623, Hungary)

- Classical Ballet group: High School of Arts, Department of Dance (Radnics u.9. , Pécs, H-7624);
- Ballroom Dance Group: Kapronczai Elementary Institute for the Arts (Széchenyi u. 73/1, Szigetvár, H-7900);
- Hip-hop dance group: T-Dance Hip-Hop Dance Company (Légszeszgyár u. 22, Pécs, H-7622).

Research methods

Postural Assessment by Photogrammetry

Process of examination: Subjects to be assessed were taken photos of from three angles, one anterior and two lateral views. With regard to clothing, dancers were asked to be bare feet, wear tight-fitting clothes, and girls were not allowed to let their long hair down on the shoulder, in order to make the

neck and shoulder visible. Photos were taken by a NIXON COOLPIX L21 camera from a 2m distance in front of a symmetry matrix surface adhered to the wall (focus distance= 6.72m, flash: Flash fired, sensitivity: ISO200, normal exposition program, number F: 3.1). The height of the symmetry matrix surface is 2m, the width is 1m and the matrix size is 6,5x6.5 cm.

- For habitual posture assessment dancers were asked to take a posture they usually do.
- For the examination of the 'posture considered correct' dancers were asked to stand in a way they think is correct.

Assessment: Parameters defining posture were designated by numbers. In frontal plane, when lines of the shoulders and the pelvis were parallel, dancers were given 2 points, while if the lines were asymmetric 1 point was given to the subjects. The frontal plane axis bisects the line of the nose and the navel, and passes to the ground between the two feet, in the middle, it is the physiological frontal axis meaning 2 points, but in the case of aphysiological axis, with no bisection of the above mentioned body parts, only 1 point was given.

In the sagittal plane, physiological spinal curvatures were evaluated by 3 points, while the aphysiological ones by 2 points. I the sagittal plane the axis should bisect the ear, the L1 and L5 vertebrae, and eventually should pass to the ground in the lateral malleolus line, receiving 2 points. In case the axis did not bisect any of the above parameters, it meant 1 point (Smith, 2009).

***Visual Analogue Scale** (VAS)*

Visual analogue scales assessed intensity and severity of low back pain. Subjects were asked to mark the degree of low back pain intensity on a scale (0-100%) with regard to the effect of low back pain on performance during training (VAS1), the degree of pain during training (VAS2), and the degree of pain after training (VAS3). 0% meant no influential role in the question, but the 100% meant a significant influential role (Ogon et al., 1996).

The Roland-Morris questionnaire is composed of 24 statements concerning the relationship between pain and routine activities. Respondents were asked to mark the statement they felt adequate for the day. Thus, the result of the questionnaire is a point on a scale from 0-24, which is proportional to the degree of functional decrease (Davidson & Keating, 2002; Stratford et al., 1996).

Lumbar Motor Control Skills Test

- **Sitting Forward Lean Test**

The focus is on the person examined who sits on the examination couch with the popliteal space of the knee touching the couch. The hip and the knee are in a 90-degree flexion position; the inguinal region and the spine are in a neutral position. Setting the correct posture is assisted. From the S1 vertebra, 10 cm is measured upward in the medial axis of the spine, and a ballpoint marks the two endpoints of the distance. After marking, the subjects were asked to pull their right, then left knees to the chest 6 times, then stretch the lifted up arms backward also 6 times. It was followed by a leaning forward exercise 3 times with flat back.

During the exercises, the subjects were asked to adjust the original correct sitting posture before each movement, then the distance between the marked points were measured by a tape measure and recorded in mm. After the assessment, the difference of the two values was considered and given in mm. The values demonstrated a positive outcome when they were 10 cm after the exercises too, but a 3 mm deviation into both directions (10.4 cm and 9.6cm) already shows impaired lumbar motor control skills (Enoch et al., 2011).

Core test

Subjects were asked to get into a push up position with elbows on the ground (forearm support), making sure the whole body, from top to heel, is in a straight line (plank position). It was important to ensure that the shoulders are above the elbows, the head is straight as the elongation of the spines, and the hip is neither tilted, nor lifted too high, so that the lumbar lordosis is not increased. After fixing, the exact position time – how long the subjects could hold the position–was measured by a stopwatch (max120 s). The test was over when the subject gave it up, or the lumbar region control was lost. In every case, the actual second was recorded, then evaluated based on a core test table (Oliver et al., 2010). (Table 1)

Table 1. Evaluation of the Core test

Time	Level
>120 sec	excellent
76-120 sec	good

Time	Level
45-75 sec	average
< 45 sec	poor

Results

Posture assessment

- **Assessment of habitual posture**

The frontal view photogrammetric examination of the habitual posture did not detect significant differences (p=0.275) between the groups; 50% of hip-hop dancers, 68.8% of ballroom dancers, and 66.7% of ballet dancers showed symmetric values. Neither did the lateral habitual posture assessment (p=0.476). Considering lumbar lordosis, only 35.7% of hip-hop dancers, 43.3% of ballet dancers, and 56% of ballroom dancers demonstrated physiological curvatures. Increased lumbar lordosis was identified in 32% of hip-hop dancers, 33.3% of ballet, and 28.1% of ballroom dancers. (Table 2)

Table 2. Assessment of habitual posture

Parameters	Ballet (%)	Ballroomdance (%)	Hip-hop (%)	p-value
Habitual posture in the frontal plane				
1 point: asymmetric	33,3	31,3	50,0	0,275
2 point: symmetric	66,7	68,8	50,0	
Habitual posture in sagittal plane				
1 point: excessive	33,3	28,1	32,1	0,48
2 point: flat	23,3	15,6	32,1	
3 point: physiological	43,3	56,3	35,7	

- **Assessment of posture 'considered correct'**

The frontal view posture considered correct (Fixing a posture as a response to the instruction: Stand in a way you think is appropriate) was correct or symmetric in 46.4% of hip-hop dancers, 73.3% of the ballet and 75% of the ballroom dance group. The frontal view posture considered correct by the hip-hop dancers was significantly worse (p=0.038) than the ones in the

other two groups. It is important to note, that this value in the hip-hop group is 4.6%lower than the one measured in the habitual posture examination, which means that the posture considered correct is worse (less physiological) than the habitual.

However, this value has improved with 6.2% in ballroom dancers and 6.6% in ballet dancers. The lateral view of the posture considered correct has impaired both in the examined ballet and ballroom dancers, although, it remained stable in the hip-hop group. (Table 3)

Table 3. Assessment of posture considered correct posture

Parameters	**Ballet (%)**	**Ballroom dance (%)**	**Hip-hop (%)**	**p-value**
Considered correct posture in the frontal plane				
1 point: asymmetric	26,7	25,0	53,6	0,038
2 point: symmetric	73,3	75,0	46, 4	
Considered correct posture in sagittal plane				
1 point: excessive	53,3	34,4	53,6	0,22
2 point: flat	10,0	12,5	10,7	
3 point: physiological	36,7	53,1	35,7	

Assessment of low back pain

Visual Analogue Scale

- **Frequency of low back pain occurring during training (VAS1)**

Based on the answers acquired, no significant difference was detected (p=0.206), but the highest percent of dancers (12.8%) complaining of low back pain that occurs during training was among ballroom dancers. At the same time, pain only affected 9% of ballet and 8.04% of hip-hop dancers.

- **Effect of low back pain on performance during training (VAS2)**

The results demonstrated that low back pain most significantly occurs among ballroom dancers (p=0.019), that may affect their performance. 7.67% of ballet dancers and 5.89% of hip-hop dancers reported about existing low back pain, while among ballroom dancers 19.06% complained of that.

- **Frequency of low back pain occurring after training (VAS3)**

Similarly to the above, nor this parameter showed significant differences between the groups (p=0.079), although hip-hop dancers reported about pain occurring after training in the highest ratio (16.25%), while among ballet dancers it was only 10.17% and 10.63% in the ballroom dance group. (Table 4)

Table 4. Assessment of low back pain intensity

Parameters	Ballet		Ballroom dance		Hip-hop		Total		p-value
	mean value	Std. deviation	mean value	Std. deviation	mean value	Std. deviation	mean value	Std. deviation	
VAS1	9,00	18,26	12,81	15,49	8,04	10,91	10,06	15,26	0,206
VAS2	7,67	14,00	19,06	21,45	5,89	10,63	11,17	17,14	0,019
VAS3	10,17	16,84	10,63	11,62	16,25	14,94	12,22	14,65	0,079

The Roland-Morris Questionnaire

The Roland-Morris questionnaire demonstrated significant differences (p=0.011) between the groups. The results show, that low back pain affects the everyday activities of 56.7% of ballet dancers, who are followed by 32.1% of hip-hop dancers, and only 18.8% of ballroom dancers, who assess low back pain as an obstacle in everyday life. Considering the whole sample, the result is the following: 35.6% of the dancers assume that low back pain is a hampering factor in everyday life.

Functional Status Assessment of the Spine - Lumbar Motor Control Skills Test

Sitting Forward Lean Test

Based on the results there was no significant difference (p=0.298) between the examined groups. The least deviation from the 10 cm was found among ballroom dancers, where the mean value of the group was 10.28 cm. They were followed by the ballroom dancers with 10.3 cm. Although, the lumbar motor control value in these groups is near the upper reference limit (10.4cm) it is still within the 'good' category. The biggest deviation was observed in the hip-hop group, where 10.45 cm was the mean value after the exercises.

This result exceeds the normal upper reference limit, therefore, it can be claimed that the lumbar motor control skills of this group should be improved. If all groups are considered as the total sample, the mean value is 10.35 cm, which is in the normal range, but only 0.05 cm lower than the upper reference limit.

Assessment of Core Muscle Strength

Core test

Significant difference was found (p=0.000) in the core muscle strength between the groups. The best performance was given by ballroom dancers, who could hold the plank position for 97.38s on average, which is evaluated as 'good' relying on the table. They were followed by the hip-hop dancers with 76.89 seconds, also belonging to the above-mentioned category. The worst result was observed among the ballet group, with 54.6s, which was evaluated as 'average'. The total sample could hold the required position for 76.74 s, and this means a 'good' result.

Discussion

Posture

The photogrammetric assessment of habitual posture revealed lumber lordosis in significant percent of all the groups assessed. The increased curvature was observed in the highest percent among ballet dancers, while the lowest ratio could be seen among ballroom dancers. In the assessment of posture considered correct classical ballet and ballroom dancers showed improvement, however, the hip-hop group showed even more aphysiological posture when it was considered correct, than during the assessment of the habitual one. Therefore, the instruction "Stand in a way you think is correct" resulted in a more inappropriate posture. In the lights of the results it can be claimed, that despite the common belief that dancing improves posture, that dancers are not aware of the parameters of physiological postures, and incorrect posture is frequent.

Professional literature also confirms the above. Iunes et al. performed photogrammetric examinations of lumbar lordosis in 52 female ballet dancers aged 7-24. Dancers were compared to 59 non-dancers as a control group. Tests and examinations were performed for a 3-year period to assess lumbar lordosis

deviations. Their findings proved the significant increase in the occurrence of excessive lumbar lordosis among ballet dancers (Iunes et al, 2015).

Assessment of Low Back Pain

Visual Analogue Scales (VAS) could help detecting low back pain in early ages among dancers, which affects their performance during training, and which also occurs during and after training. Among the examined groups, ballroom dancers reported to the highest degree about debilitating low back pain that interferes with their performance, and that often occurs during training. Low back pain occurring after training is reported by hip-hop dancers with the highest percentage.

Professional literature has not mentioned VAS studies conducted among dancers, but visual analogue scales were used to reveal low back pain in sportsmen experienced during training. Külling et al. conducted examinations using VAS on professional male beach volleyball players to detect already existing and newly occurring low back pain. Based on their results 79% of the sportsmen (mean age: 28) reported low back pain during training (Külling et al, 2014).

The Roland-Morris Questionnaire

Existing low back pain has a significant effect on everyday activities of dancers. It is mostly observed in ballet dancers, and the least among ballroom dancers. Considering the total sample, we have seen, that despite young ages of the dancers, a remarkable number reported low back pain as an influential factor in everyday life.

Professional literature has not mentioned studies conducted among dancers with that questionnaire. Most articles-concerning the questionnaire - mainly introduce assessments of severe stage spinal patients, which detected the degree of functional loss and the symptoms interfering with everyday life. Nevertheless, articles with studies of sportsmen are available. These examinations using the Oswestry Disability Index showed that back pain, as well as low back pain, are frequent due to exertion, and they have adverse effect on routine activities (Fairbank & Pynsent, 2000; Gillis et al., 2015; Vela et al, 2011;).

Lumbar Motor Control Skills

Based on the results of the Sitting Forward Lean Test we can say that the results of the groups do not exceed the upper reference limit of the 10.4cm, yet,

they are only 0.5 cm below that, therefore, the number of the sample was higher, the assumed category for all the groups would most probably be the one as designated 'inappropriate' lumbar motor control skills. When dancers are differentiated by genres, the biggest deviation is observed among hip-hop dancers; they have the worst lumbar motor control skills. It may be due to inadequate attention paid to improving correct stage posture resulting from the genre-specific features that means 'stage' posture is rather sloppy (Garofoli, 2011). On the other hand, movements of classical ballet and ballroom include training and pole exercises that contribute to the development of correct lumbar motor control (Bretus, 1998; Moore, 1994).

Assessment of Core Muscle Strength

Applying the Core test we could receive information about the degree of core muscle strength that proved to be 'good' in all the groups. However, when groups assessed alone, ballroom dancers were observed to have the most outstanding core muscle strength; the mean values indicate a 'good' category based on the 'plank test'. The choreographer of the group informed us, that occasional core muscle exercises are included in the training. Besides these, the genre itself requires strong core muscles to execute a specific stage pose. The weakest core muscles could be observed among ballet dancers with the mean values pertaining to the 'average' category. Although classical ballet techniques demand a stage posture that seems to equal the physiological one, the technique – due to its characteristic features- does not focus on strengthening core muscles.

Previous research carried out among dancers assessed core muscle endurance by a side plank test. Those findings also confirm that core muscle endurance is inappropriate among dancers. Side plank tests often result in a significant difference between the sides, but it is a natural phenomenon, and can occur in anyone (Swain & Redding, 2014).

Conclusion

Each dance genre requires specific physical demands. One of the most frequent complaints that occur mostly in adults, but among professional dancers already during their studies is low back pain. Although literature mentions extremity injuries as the 1st place injuries affecting dancers, they are followed by spinal injuries caused by the weakness of core muscles, necessary for correct

posture (Campoy et al., 2011). When different spinal regions observed, lumbar region is the most vulnerable due to its muscle weakness, bad lumbar motor control skills and incorrect ingrained posture (Eustergerling & Emery, 2015; Twitchett et al., 2011).

Aphysiological posture often occurs in dancers, let it be either habitual or stage posture. Among them increased lumbar lordosis may be observed to the highest degree leading to low back pain, that already occurs in professional dancers at a young age. They may be rooted in core muscle weakness and inadequate lumbar motor control skills. Thus, neither the habitual posture, nor the posture considered correct is in accord with the biomechanically normal posture. Low back pain occurs early affecting their performance. Despite regular exercise lumbar motor control skills and core muscle strength are inappropriate.

In the light of the study, designing a core prevention program for dancers – already in use among sportsmen- may be needed to develop and raise awareness about biomechanically normal posture, core muscle strength and flexibility, as well as to improve lumbar motor control skills (Hill & Leiszler, 2011; Saeterbakken et al, 2011).

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