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Original research article

Evaluation of weak links of musculoskeletal system and experiencing pain in children and adolescents attending ballet school

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ARTICLE INFO

Article history:
Received 6 July 2016
Received in revised form
22 September 2016
Accepted 15 November 2016
Available online 25 May 2017

Keywords:
Ballet
Weak links
Pain

ABSTRACT

Introduction: During an education at ballet school the musculoskeletal system is exposed to high levels of physical stress. The bodies of children and adolescents throughout the period of dance education are exposed to frequent stretching and an increasing range of motion in the joints beyond their physical norm. Pain constitutes an integral part of dance education and dancer's profession.

Aim: The aim of the study was to verify whether the type of the school profile, region of the spine and the direction of the movement influence the incidence of weak link.

Material and methods: 346 subjects took part in the study, all of them students of three types of ballet schools – among them 293 females and 53 males. Prior to the study the following research hypothesis was formed: among the children and adolescents enrolled into the study there are no weak links in musculoskeletal system in the cervical, thoracic and lumbar region of the spine.

Results and discussion: Among 346 subjects on the day of the study 39 (11.27%) reported pain in cervical region, 55 (15.90%) in thoracic region, and 184 (53.18%) in lumbar region.

Conclusions: (1) Among the children and adolescents were weak links in their cervical, thoracic and lumbar region of the spine. (2) School type does not have a significant impact on the occurrence of weak links in musculoskeletal system while region of the spine and the direction of movement have a substantive influence on weak links occurrence.

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http://dx.doi.org/10.1016/j.poamed.2016.11.013

1. Introduction

Ballet is a form of art in which meaning and emotions are communicated through human movement. Ballet students study the art of dance at ballet schools in order to acquire the best dance and acting technical skills over many years. Classical ballet uses the same positions that were codified in 1760 and passed from generation to generation of dancers through observational learning.[1] The musculoskeletal system of these students is exposed to high level of physical stress during ballet training, which predisposes them to back pain. Among children and adolescents there might occur musculoskeletal dysfunctions and as a result injuries. Among the motor organ injuries most frequently encountered in dancers there are: foot and ankle problems at the first metatarsophalangeal joint, second metatarsal stress fractures, flexor hallucis longus tendinitis and anterior and posterior ankle impingement syndromes, knee joints, hip joints, lumbar and sacral spine, injuries of upper limbs and soft tissue injuries.[2–11] The bodies of children and adolescents during dance education are exposed to frequent stretching and an increasing of range of motion in the joints beyond their physiological norm, which aims to assist students in adopting proper positions and movement figures; this is very desirable in classical dance, which constitutes the basis of dance education at ballet schools in Poland and all over the world. Pain is an integral part of dance education, as well as the dancer's professional life.[5,12,13] Pain complaints evoke changes of tonus in individual muscle groups, which contributes to changes in posture, the weakening of motor control and in movement pattern disorders.[14,15] Due to a very high risk of future injuries among students of ballet, their motor organ functional analysis should have been already performed during their school education, as means of preventing future injuries. Many studies exist on the physiological and biomechanics characteristics of classical dancers but it requires use special measuring equipment.[16] This study using physical tests the people recruited for the study were evaluated for the weak links in their musculoskeletal system, the factors conditioning their occurrence and the presence of complaints of pain in individual regions of the spine.[17] By determining weak links one should understand deficits in the biomechanical chain that: disrupt neuromuscular control or stabilization, lower muscle strength, which might also predispose to pain complaints.

2. Aim

The aim of the study was to verify whether the type of the school profile (primary school, grammar school and secondary school), region of the spine (cervical, thoracic and lumbar) and the direction of the movement (flexion, side flexion, rotation, extension) influence the incidence of weak link. Moreover, during the study it was checked how many subjects reported pain in their cervical, thoracic and lumbar region of the spine following dance lessons on the day of the test. Prior to the study the following research hypothesis was formed: among the children and adolescents enrolled into the study there are no weak links in musculoskeletal system in the cervical, thoracic and lumbar region of the spine.

3. Material and methods

In total, 346 students of ballet schools participated in the study among them 293 females and 53 males. Those enrolled for the study were the students of Polish public ballet schools in Poznań, Łódź and Gdańsk which educational programme embraced elementary stage, grammar school and secondary school. The level of elementary school was represented by 117 subjects, 106 females and 11 males. Their average age is equal to 11.65 ± 0.48, the average number of years spent at ballet school is 2.28 ± 0.57. The lower secondary school level was represented by 144 subjects: 121 females and 23 males. Their average age is 13.88 ± 0.79, the average length of ballet education is equal to 4.8 ± 0.95 years. The high school level was represented by 85 subjects: 66 females and 19 males. Their average age is 17.04 ± 0.81, the average period of ballet education is 7.95 ± 1.03 years.

To determine weak links in the musculoskeletal system of the study subjects, specially designed tests were used.[17] Prior to the application of each test the students were carefully explained the nature of the test. The subjects were tested in their underwear by the same examiner. The tests results were subsequently recorded in the evaluation sheet. The analysis of the following types of activity was carried out: (1) standing small knee bend control; (2) standing arm control; (3) hands and knees limb control; (4) modified push-up; (5) lunge loading.[17] Additionally the subjects self-recorded in a specially prepared study sheet whether on the day following dance lessons they felt pain in their cervical, thoracic or lumbar regions.

In order to verify the research hypothesis, the results were analyzed using three-factor variance analysis ANOVA as well as Tukey multiple test. The results obtained were statistically analyzed by means of the statistical package R.[18] This research was carried out with the permission of the Local Bioethics Committee of Poznan University of Medical Sciences, and after receiving the consent of the subjects' parents or guardians.

4. Results

Among 346 subjects on the day of the study 39 reported pain in cervical region, 55 in thoracic region, and 184 in lumbar region. Among the 117 elementary school participants in the test, 9 reported pain in the cervical spine, 19 reported pain in the thoracic spine and the pain in lumbar spine was reported by 58 children. At the lower secondary school level, among 144 children 24 felt pain in cervical spine, 18 felt pain in thoracic spine – the same number of students felt that pain at high school level. Pain in lumbar region was reported by 73 children at the lower secondary school. At high school level, among the 85 participants, 6 reported pain in cervical spine and 53 felt pain in lumbar spine. In order to determine the impact of school level (elementary, lower secondary and high school), spine region (cervical, thoracic and lumbar) and the direction of the movement performed (flexion, extension, rotation and

Table 1 – Three-factor variance analysis ANOVA.

Source	Df	Sum Sq	Mean Sq	F value	P value
Type of school	2	3 435	1 717	2.14	0.1415
Spine region	2	20 551	10 275	12.80	0.0002*
Movement direction	3	26 129	8 710	10.85	0.0001*
Residuals	22	17 654	802		

* $P < 0.001$.

Table 2 – Tukey multiple test comparisons locations.

	Compared locations		
	Thoracic-cervical	Lumbar-cervical	Lumbar-thoracic
P value	0.0474*	0.0001**	0.0704

* $P < 0.05$.
** $P < 0.001$.

side flexion) a three-factor variance analysis ANOVA was used (Table 1).

The results show that the type of school does not influence the occurrence of a weak link in musculoskeletal system in the cervical, thoracic and lumbar regions of the spine ($P = 0.1415$), while the spinal region ($P = 0.0002$) as well as the direction of the movement performed ($P = 0.0001$) significantly influence the prevalence of weak links in musculoskeletal system in cervical, thoracic and lumbar regions of the spine. Subsequently in order to verify which spinal regions have a significant impact on the incidence of weak links in the musculoskeletal system in cervical, thoracic and lumbar region, a Tukey multiple test was applied (Table 2).

The values obtained during the test indicate that the cervical region has the most significant impact on the occurrence of weak links in the musculoskeletal system. In comparing the thoracic region with the cervical region the $P = 0.0474$; and in comparing the lumbar region with the cervical region the $P = 0.0001$. The lumbar and thoracic region impact on the occurrence of weak links in the musculoskeletal system does not differ. The next stage of the statistical analysis was a detailed investigation on which directions of movement substantially influence the incidence of weak links in the musculoskeletal system in the cervical, thoracic and lumbar region. To achieve that a Tukey multiple test was applied (Table 3).

The results indicate that extension has the most critical impact on the occurrence of weak links in the musculoskeletal system in the cervical, thoracic and lumbar region. When comparing flexion with extension the $P = 0.0064$; when comparing rotation with extension the $P = 0.0002$ while when comparing side-flexion with extension the $P = 0.0052$. The remaining directions of movement do not bear a substantive impact on the incidence of weak links.

Table 3 – Tukey multiple test comparison of directions of movement.

Compared directions	P value	Compared directions	P value
Flexion–extension	0.0064*	Rotation–flexion	0.4652
Rotation–extension	0.0002**	Side-flexion–flexion	0.6486
Side-flexion–extension	0.0052*	Side-flexion–rotation	0.9992

* $P < 0.01$.
** $P < 0.001$.

5. Discussion

Jones and Macfarlane writes that incidence of pain complaints increases with age.[19] The obtained analyses do not confirm the above conclusion as among the subjects attending elementary school 9 reported pain in cervical region, among those attending lower secondary school 24 reported pain in cervical region and among high school students participating in the study 6 reported pain occurring in cervical region of the spine. Pain in lumbar region of the spine was reported by 58 elementary school pupils, 73 lower secondary school students and 53 high school students. Pain may be the cause of paraspinal muscles wasting, while the prevalence of those pain sensations in the cervical spine has a detrimental effect on proper standing posture.[20,21] Most frequently pain in the lumbar spine is associated with sports such as: judo, golf, rugby, basketball, baseball, soccer, athletics, and volleyball, as well as ballet training and the playing of wind-instruments.[22] Wedderkopp and the co-authors did not observe the link between the level of physical activity and back pain incidence.[23] Pain occurrence in the lumbar region of the spine was more frequently observed in females.[22,24] While in ballet, pain in lumbar region is more often reported by males due to partner lifting and supporting.[13] The research that has been done so far indicates that ballet as a form of physical activity is a cause of pain in the lumbar spine.[22] Headaches, stomach aches and sleeping problems might have a significant impact on pain complaints in the spine in children.[25–28] Ballet school students are exposed to numerous soft tissue injuries e.g. fascia. Lumbar fascia micro injuries are a frequent cause of low back pain, and among 346 study subjects 184 reported pain in lumbar region of the spine. In people with chronic low back pain there are fewer mechanoreceptors in their lumbar fascia and thus their motor coordination is disrupted.[29,30]

The research carried out did not confirm the hypothesis that among the children and adolescents participating in the study there are no weak links in their musculoskeletal system, in the cervical, thoracic and lumbar region of the spine. The obtained results show that the type of school does not have an impact on the occurrence of weak links in the musculoskeletal system, in its cervical, thoracic and lumbar spine regions (Table 1). Spinal region and the type of movement have a

critical impact on the prevalence of weak links in musculoskeletal system (Table 1). The thoracic-cervical region and lumbar-cervical region of the spine have a substantive influence on the occurrence of weak links in the musculoskeletal system while the lumbar-thoracic region does not have a significant impact on weak links incidence (Table 2). The remaining results also show that some directions of movement have a significant influence on the occurrence of weak links in musculoskeletal system. Those are: flexion–extension, rotation–extension, side-flexion–extension. Rotation–flexion, side-flexion–flexion and side-flexion–rotation do not present a significant on the occurrence of weak links (Table 3).

The human structure and function of the human body can be looked at from the perspective of myofascial chains.[31] The explanation for the occurrence of weak links in cervical, thoracic and lumbar region of the spine in children and adolescents learning at ballet schools can be sought by examining for muscle tone disorders (that is restrictions) in myofascial chains that contribute to the disruption of structural integration.[32] Future students of ballet schools are taught various forms of dance, hence their bodies are often exposed to movements and positions which exceed physiological norm; therefore it seems likely that the cause of the occurrence of weak links is their sensory-motor amnesia, which appears when the whole human body is inadequately introduced to conscious sensing, organization and movement.[32] In such cases those regions of the human body which are not fully used in movement induce excessive compensation in other regions which leads to patterns of bodily strain which evokes pain.[32] Certainly more research is required to provide an unequivocal answer to the question as to why there are weak links in the spinal regions and back pain in the group of healthy children and adolescents attending ballet schools who participated in the study.

6. Conclusions

The results provide evidence that the location and the direction of movement have a significant impact on the prevalence of weak links, and that among those participating in the study experienced back pain. The use of simple and cheap methods (physical tests and a pain scale) provides important information in the evaluation of musculoskeletal system ballet school students.

Conflict of interest

None declared.

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