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The Usefulness of Performance Matrix Tests in Locomotor System Evaluation of Girls Attending a Ballet School — Preliminary Observation

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Abstract. [Purpose] Learning ballet is connected with continuous use of the locomotor system while subjecting it to high loads. Therefore, we conducted some research defining the appearance of weak links in the motor system, in order to eliminate the risk of injury. [Methods] Fifty-two female students of a ballet school were examined. To identify weak links, low-threshold Performance Matrix tests were performed. An analysis of weak link occurrence in the locomotor system was carried out, using two way analysis of variance ANOVA Tukey's HSD test, clustering methods and Principal Component Analysis (PCA). [Results] The average age of the subjects was 11.64±0.53 years (mean ± standard deviation), their average body height was 151.1±7.5 cm, their average body weight was 35.92±5.41 kg, and their average time of learning at ballet school was 2.17±0.65 years. We found that there were significant differences in weak links occurrence in the motor system of every girl examined. [Conclusions] Weak links were found in every location of the motor system. Our results show that the influence of weak link location is essentially different from their occurrence, and that learning ballet has a significantly different impact on the number of weak links in different locations.
Key words: Ballet, Injuries, Performance Matrix tests

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INTRODUCTION

Students of ballet schools learn the art of dance for years by exploiting their locomotor system, which is subjected to high loads of physical effort. Breaking the limit of the motor system adaptative skills contributes to the occurrence of motor system dysfunctions, leading to injury. The most common injuries experienced by dancers concern the foot and ankle and include problems with the first metatarsophalangeal joint, second metatarsal stress fractures, flexor hallucis longus tendinitis, and anterior and posterior ankle impingement syndromes, knee, and hip joints injuries, L-S segment injury, injuries of the upper limbs, and injuries of soft tissues[1–11)]. The characteristic joint hypermobility of dancers may also cause the occurrence of injuries[12)]. The element inseparable from dance learning, as well as doing the dancer's job, is pain[1, 13, 14)]. Pain warns the body against the influence of harmful activities and function disorders[15)]. Considering the very high risk of future injury appearance among ballet novices, functional assessment of the motor system as a form of injury prevention, ought to be done. Taking the practical aspect of this issue into consideration, research was started to determine the usefulness of Performance Matrix tests for the assessment of the motor system of girls attending ballet school. What is more, a trial to establish the possibility of weak links occurrence, in exact locations of the motor system, was done. The notion of a weak link should be comprehended as a place in the human organism which is characterized by disturbed motor control resulting from neuromuscular conduction disorders. The effect of weak links is improper functioning of the muscles involved in stabilizing movement.

SUBJECTS AND METHODS

In this study, we investigated whether there are significant differences in weak links in all girls by means of low-threshold activity tests. Our research hypotheses were: 1) In girls, there are low and high risk factor of weak link occurrence in the motor system, in low-threshold activity tests; 2) The presence of weak links is significantly different from their locations in low-threshold activity tests.

Fifty-two schoolgirls attending the Comprehensive Ballet School in the city of Poznan, Poland, participated in this research. The average age of the subjects was 11.64±0.53 years, their average body height was 151.10±7.54 cm, their average body mass was 35.92±5.41 kg and their average time of learning at ballet school was 2.17±0.65 years. The tools used to assess the presence of weak link were low-threshold

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Table 1. The mean and SD of low and high risk factors of weak links

Weak link appearance	Low risk factor		High risk factor	
	mean	SD	mean	SD
FCS	0.81	0.65	1.26	0.82
FTS	1	0.73	0.77	0.72
FLS	0.97	0.95	2.03	0.18
RTS	2.29	0.69	4	0
RLS	5.10	0.65	3.55	0.96
RKJ	2.26	0.51	0	0
PABJ	2.71	1.27	6.81	0.70
FGSJ	2	0	0	0
FGHJ	0.48	0.51	0.29	0.46
SFLS	1.16	0.93	0.48	0.85

FCS − Flexion Cervical Spine; FTS − Flexion Thoracic Spine; FLS − Flexion Lumbar Spine; RTS − Rotation Thoracic Spine; RLS − Rotation Lumbar Spine; RKJ − Rotation Knee Joint; PABJ − Pushing Aside the Brachioscapular Joint; FGSJ − Front Glide Shoulder Joint; FGHJ − Front Glide Hip Joint; SFLS − Side Flexion Lumbar Spine

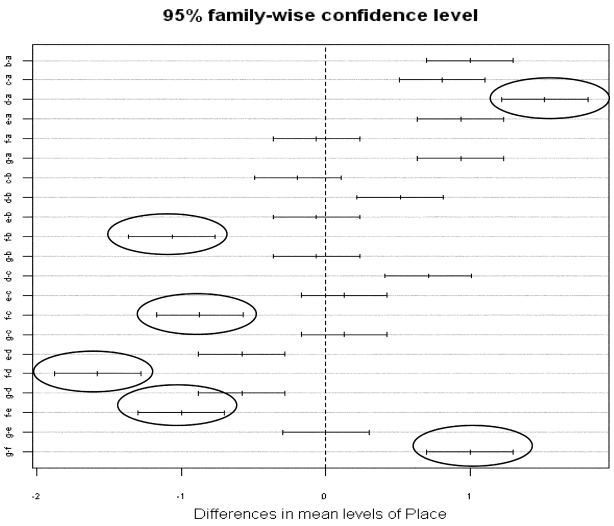

Fig. 1. Tukey's HSD test comparing the locations of weak links a − cervical spine, b − thoracic spine, c − brachioscapular joint, d − brachial joint, e − lumbar spine, f − hip joint, g − knee joint

Performance Matrix tests[16]. By analyzing and identifying movement performed by the subjects, the weakest links of the motor system were found. Before the testing, the whole procedure of it was explained, and a demonstration of how to perform the test was conducted. The results were recorded on a specially designed sheet. Five low-threshold tests were carried out (Test 1 − standing control on a slightly bent leg, Test 2 − spine dissociation, Test 3 − control of the brachial joint in standing, Test 4 − limbs control with bent knee joints while lying on the back, Test 5 − limbs control in lean kneeling). 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. The results obtained were statistically analyzed by means of the statistical package R[17].

RESULTS

Based on the results of the low-threshold Performance Matrix tests, the presence of low and high risk factors of weak links was observed. The action predisposing to the occurrence of low risk factors of weak link in the cervical, thoracic and lumbar segments, was flexion. For the cervical spine, low risk factors of weak links were found in 31 subjects: for the thoracic spine in 28 students, and for the lumbar spine in 30 girls. Low risk factors of weak link occurrence were also observed in the action of rotation of the thoracic spine in 5 girls, and for the action of rotation of the knee joint in 2 schoolgirls. For the brachioscapular joint, a low risk factor appeared in the action of protruding the shoulder blade in 5 girls. Low risk factors of weak link occurrence were noted in the lumbar spine in the direction of lateral flexion in 11 subjects as well. Whereas, no low risk factor of weak link was found for the knee joint in the action of rotation, there were low risk factors of a weak link for the brachioscapular joint in the action of protrusion and for the action of the front slip for the hip joint.

High risk factors were observed more frequently than low risk factors. The actions, having high risk factors, were rotation, protrusion, front slip and lateral flexion. For the action of rotation, high risk factors were found in 46 subjects, in the lumbar spine in 51 ballet dancers, and in the knee joint in 48 girls. The protrusion of the brachioscapular joint also showed a high risk factor in 45 subjects. High risk factors were seen for the front slip in the brachial joint in 50 ballet dancers, and in the hip joint in 16 girls. Lateral flexion of the lumbar spine was a high risk factor of weak link occurrence in 31 subjects. Only a few high risk factors of weak link were noticed for the action of flexion: in the cervical segment in 2 people, in the thoracic segment in 9 ballet dancers, and in the lumbar segment in 7 subjects.

The mean and standard devation of the occurrence of high and low risk factors weak link in the different actions and locations were calculated (Table 1).

In order to determine the influence of learning ballet on the location and occurrence of weak links, a two-way analysis of variance (ANOVA) was performed. The value of $p<0.000001$ for "Place" informs that the influence of location is statistical significantly different. Ballet learning influences, on weak links number in different locations $p<0.00042$ too.

In the next step of statistical analysis, a detailed analysis was conducted by making a comparison between the locations in pairs using Tukey's HSD test (Fig. 1). It is noticeable that different pairs have different influences on the place of the occurrence of weak links. In addition to which, the greatest impact was on the hip joint (f) (a − cervical spine, b − thoracic spine, c − brachioscapular joint, d − brachial joint, e − lumbar spine, f − hip joint, g − knee joint).

Next, cluster analysis was performed, in order to determine similar and dissimilar groups of weak link locations

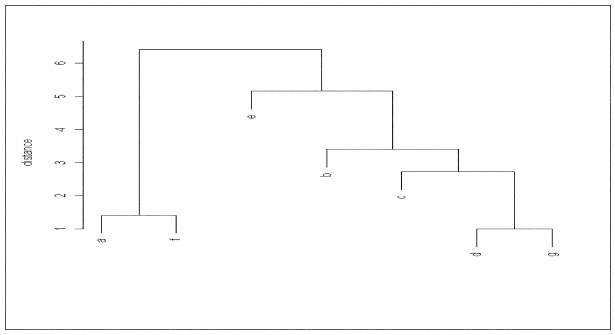

Fig. 2. A dendrogram of the occurrence of similar and dissimilar groups of weak links locations
a − cervical spine, b − thoracic spine, c − brachioscapular joint, d − brachial joint, e − lumbar spine, f − hip joint, g − knee joint

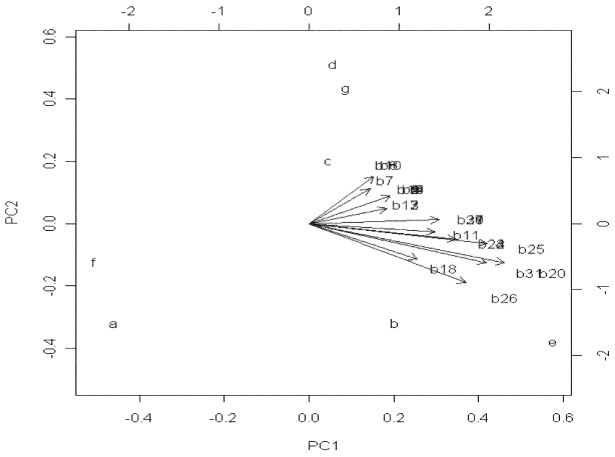

Fig. 3. PCA
a − cervical spine, b − thoracic spine, c -brachioscapular joint, d − brachial joint, e − lumbar spine, f − hip joint, g − knee joint; b1, b2, …, b52 − ballet dancers

in girls (Fig. 2).

The results of the cluster analysis show that the most dissimilar locations of the occurrence of weak links in the subjects were: the lumbar spine, the thoracic spine and the brachioscapular joint. In contrast, the group of similar locations for the occurrence of weak links were: the cervical spine, the hip joint, the brachial joint and the knee joint.

We subsequently performed a principal component analysis (PCA) (Fig. 3). It can be stated that such locations as: the brachioscapular joint, the brachial joint, the lumbar spine, and the knee joint were the most important and distinctive locations. The remaining locations, the cervical spine, the thoracic spine and the hip joint, did not constitute a group of similar locations.

DISCUSSION

The results obtained in this research, have proved our first hypothesis, namely, that girls learning ballet have low and high risk factors of weak link occurrence in their locomotor systems, at all locations.

The presence of the low but especially the high risk factors of weak links provides information about lack of motor control at a given location, and about predisposition to locomotor system injury. The highest risk factors were observed for the action of rotation in the thoracic and lumbar spine, the action of protrusion of the brachioscapular joint, the action of front slip of the brachial and hip joints and lateral flexion lumbar spine.

The results of two-way ANOVA show that the influence of weak links location is essentially difrent from their occurrence and that learning ballet has a significantly different impact on the number of weak links in different locations. Different pairs of locations have different effects on the locus of weak links, and the most affected location was the hip joint (f) (Fig. 1). Further analysis of the results confirmed our second research hypothesis, namely, that the presence of weak links, is significantly different from their locations in low-threshold activity tests (Figs. 2, 3). The most dissimilar locations on the group of similar locations of the occurrence of weak links are shown, also. Probably the cause of the weak links at the lumbar spine, brachial joint, knee joint and hip joint is impaired motor control. Impaired motor control, translating to abnormal motor pattern, adversely affects the quality of performed movement, and thus the final effect of training of ballets techniques. Abnormal motor pattern increases the risk of injury, the appearance of which is often preceded by biokinematics chain dysfunction. Normal motor control is a factor affecting the quality of movement.

Both for students attending performing arts schools and artists, it is important to create a prophylactic program for the prevention of injuries and their treatment[18]. The cheapest way is prophylaxis, hence it is extremely important to prevent the occurrence of injuries among novices of ballet at the level of school education. Such measures would unquestionably influence the future career development of young practicing dancers and, would protect them against injuries which in turn, could shorten their professional careers. It is very important to create specialized groups based on professional education in Performing Arts Medicine. Such groups could be formed by people professionally teaching different fields of performing arts, by people treating health problems and by a group of researchers scientifically working on the health issues of performing artists[19]. An example of health-oriented actions in music schools is a project called the Health Promotion in Schools of Music, the aim of which is the health education and injury prevention of students[20].

Applying the Performance Matrix tests in functional assessment, as well as introducing an appropriate stabilization training, would undoubtedly contribute to the reduction of the presence of weak links in the motor systems of the students who took part in this research[15, 21–24]. A strong "core" allows one to more effectively move the distal parts of the body[25].

On account of the practical significance of the issues, these measures seem to be justified in the greatest possible way.

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