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The eurofit sit and reach suppleness test competence of ballet school students

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Objectives. **The aim of the study is to determine the relevance of the SR test for body suppleness testing.** Methods. **The study sample comprised 20 female students from a ballet school and 20 secondary school students who did not practice ballet, all aged 17. Their torso suppleness was tested using the SR test. The sectional mobility of the spine and hip joints was estimated with the Penny & Giles tensometric electrogoniometer. The material was analyzed statistically, and the percentage share of the respective spine and hip joint sections was determined in the performed SR test.** Results. **The ballet dancers were characterised by limited mobility of the cervical spine (6.5%) and the lumbar spine (49.5%) as well as an increase in the range of hip joint movement (47%) in comparison with the control group. Nevertheless, the SR test indicated greater torso suppleness in dancers (by 48%).** Conclusions. **In ballet dancers, unlike the controls, sit and reach test results are determined mostly by the mobility of hip joints. The disadvantage of the test is its global measurement without the percentage share of the joints. In comparison with persons without any disorders, individuals with spinal hypomobility may obtain better results owing to their hip joint hypermobility. Therefore, the above mentioned test should not be used in clinical diagnostics to assess joint mobility and muscle flexibility.**

KEY WORDS: spinal mobility, SR test, suppleness, ballet dancers, electrogoniometry.

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What is already known about this topic?
The sit and reach test is a commonly used measuring method for evaluation of flexibility and suppleness. Researchers stress the low cost and the easiness of SR test performance. On the other hand, the measurement of mobility of the joints, including sectional spinal mobility, is commonly performed by means of tensometric electrogoniometers.

Introduction

Suppleness is one of many features of the motor apparatus, which is of great significance in health prophylactics as it depends on the construction and function of the respective elements of the bone-joint-ligament system as well as muscle properties [1, 7, 8]. It contributes to the dynamics of movements necessary in many sports and helps prevent injuries related to the pulling and tearing of the soft tissues [22]. Suppleness also causes an increase in the tolerance of the body to physical effort, and as a consequence, delays the fatigue process.

In spite of the great significance of the above-mentioned features for the health and sporting effects of practitioners of the majority of sports, the application of mobility increasing training is insufficient. Dancers, especially those practicing ballet, can be classified as athletes as they devote a great part of their training to exercises increasing the range of movements of the spine joints, in particular, the joints of the lower limbs, and strengthening specific muscle groups [6]. In connection with this, there is a need to develop test methods and techniques aimed at a reliable suppleness assessment [3, 14]. In order to evaluate the aforementioned feature, many instruments are used, starting with the goniometer and inclinometer and finishing with the electrogoniometer and radiogoniometer. These methods are time-consuming and are used in clinical practice. On the other hand, a simpler and less time-consuming method for evaluation of suppleness is the sit and reach (SR) test [21]. Scientists from the Sport Research Committee in 1993 developed the EUROFIT 93 test battery consisting of 10 tests, serving the purpose of measurement of physical fitness components. The third test of this battery is the sit and reach test [9, 10]. It is applicable in various types of health programmes, and in diagnostics of spinal pain and evaluation of vulnerability to injuries [19, 22]. However, in the face of doubts that have appeared over recent years as to the accuracy and reliability of the SR test, it is worth reconsidering whether it is really a competent suppleness assessment technique. There is a risk of incorrect diagnosis [6, 14]. The aim of the paper is to determine the relevance of use of the SR (sit and reach) test for assessing suppleness.

Material and Methods

Participants

The participants were 20 students aged 17 years with seven years of ballet training experience, who attended a secondary ballet school. The control group comprised 20 students of the same age attending a standard secondary school. They were selected randomly from among 17-year-old second grade secondary school female students. The students in both groups did not experience any pathological changes within their motor apparatus.

Measures

The test was conducted in two stages. The suppleness tests were carried out by means of the SR (Sit and Reach) test according to the EUROFIT 93 guidelines [9, 10]. The torso suppleness was tested using a box 35 cm long, 45 cm wide and 32 cm high. A 55 x 45 cm top was placed on the box. In the middle of the top, a centimetre scale ranging from 0 to 50 cm was drawn so as to obtain the value of 15 cm at the level of the feet of the person taking the test. The subject was sitting flat and resting their bare feet on the side wall of the box. The lower limbs were straightened out in front of them and rested entirely on the floor. In this position, the subject bent the torso forward and extended their arms forward as far as possible. After attaining the maximum forward flexure of the torso, the subject remained in such a position for about 2 seconds. The test was performed twice and the best result was taken into account. Any subject who reached the level at which their feet rested on the box with their fingertips attained the result of 15 cm.

The measurements of sectional mobility of the spine (cervical, thoracic or lumbar) and the angular values of physiological curvatures as well as measurements of ranges of movement of hip joints were performed with the use of Penny & Giles tensometric electrogoniometer (Biometrics, Ltd) as modified by Boocock, which eliminated any measurement error related to shifting skin and soft tissues [12]. The tests of mobility and physiological curvatures of the spine were performed according to the methodology by Lewandowski and Szulc [12].

The starting position was an easy body arrangement upright with the feet charged uniformly, the upper limbs parallel to the torso, and the head in the horizontal plane. All the sensors during the test were fixed to the skin along the long axis of the body in order to access the processus spinosus of the respective spinal vertebrae. The sensors were fixed with a double-sided adhesive bandage, and the protective spring with Omnifilm plaster. Before performing the physiological spine curvature tests, the sensor was zeroed in the position of 0-180 degrees (extended position). Before testing the sectional mobility of the spine, the sensor was zeroed in the position of physiological curvature of the tested section.

Cervical spine:
Tested movements: forward flexure.
Method of fixing the goniometer: the upper edge of the telescopic end is placed at the level of the spinal process C7; the lower edge of the stationary end is fixed on the occipital protuberance.
Thoracic spine:
Tested movements: forward flexure.

Method of fixing the goniometer: the upper edge of the telescopic end is placed at the level of the spinal process Th12; the lower edge of the stationary end is fixed on top of the spinosus process Th1.

Lumbar spine:
Tested movements: forward flexure.
Method of fixing the goniometer: the upper edge of the telescopic end is placed at the level of the sacral bone base; the lower edge of the stationary end is fixed on top of the spinal process Th12.
Hip joint mobility was tested according to the methodology of Marecki and Szulc [15].

Bending in the hip joint:
Starting position: supine position (extended hip joint); the pelvis stabilized with the subject's hand.
Method of fixing the goniometer: the stationary end is placed at the height of the crest of the pelvic girdle in the middle of the length on the side of the torso; the telescopic end is fixed to the side surface of the thigh so that its central axis covers the long axis of the thigh, running through the greater trochanter of the thigh bone.
Tested movement: the tested limb performs an active movement of maximum bending at the hip joint while the knee joint is also bent.
All the measurements of the spine and hip joints were made in the sagittal plane in accordance with the plane of the movement performed during the SR test. On top of this, measurements of mobility of the above-mentioned structures were also performed from the starting position to the final position during the SR test.

Procedures
The tests were conducted in the gym of the State Ballet School in Poznań by a team of experienced researchers from the University School of Physical Education in Poznań (the authors of this study). All the measurements related to the SR test and the functional parameters of the spine and hip joint mobility were carried out three times, at the same time by one researcher; the mean results were then calculated. The consent to conduct the above-mentioned tests had been obtained from the Local Ethics Committee.

Analysis
The basic statistics such as means ($\bar{x}$), standard deviations (s), minimum and maximum and coefficients of variation (V) were calculated. To examine the statistical significance of differences between the ranges of movement of the respective joints (in degrees) during the test and the test results (in cm), the Pearson product-moment correlation coefficient r was calculated followed by the calculation of the coefficient of determination ($R2 = r^2$).

Results
The assessment of results of the sectional mobility of the spine and hip joints of ballet dancers and controls indicated an increased movement range in the thoracic spine by 3.3° (18%) and hip joints by 26.2° (47%) in ballet dancers in comparison with the control group. The comparison of other results of the test showed that the ballet dancers' results were lower than the results of controls: in the cervical spine by 2° (by 6.5%), and in the lumbar spine by as much as 18.2° (49.5%). The result of the test amounted to 34 cm in ballet dancers, and 17.6 cm in controls. This meant the ballet dancers under study achieved the results 16.4 cm better than the controls (48%) (Table 1).
The comparison of the results of mobility of the sectional spine and hip joints before the suppleness test with the measurements of mobility in the Eurofit 93 test indicates that the ballet school students use the mobility range of the thoracic spine in 99% and of the hip joint in 117%. The ranges of the remaining sections of the motor apparatus organ were not used even up to 50% of its pre-test mobility (cervical spine – 47.5%, lumbar spine – 31%).
The comparison of the same measurements in controls before and during the test indicates a higher (60%) contribution of the cervical spine, 50% of the lumbar spine and as much as 118% of the hip joints to the final suppleness test result. The mobility range of hip joint flexibility in both groups during the test performance exceeds the active mobility range by about 20° in dancers and by 19° in controls. The increased mobility range is caused by a different starting position used in the measurements with the Eurofit 93 test. During the suppleness measurement the range of forward flexure of the torso is increased by the influence of the weight of the upper body falling on the front surface of the thighs. In order to determine the percentage contribution of the mobility of respective sections of the spine and hip joints in tested groups, the Pearson product-moment correlation coefficient r was calculated, and the coefficient of determination (R2) in percent (%). When evaluating the calculated

Table 1. Statistical characteristics of ballet school students and controls from secondary school

Variable		Ballet school students		Secondary school students	
		$\bar{x} \pm SD$	(min.; max)	$\bar{x} \pm SD$	(min.; max)
Age		17.25 ± 0.622	(17 ; 18)	17.00 ± 0.471	(17 ; 18)
Body mass		51.04 ± 3.720	(43 ; 57)	60.30 ± 6.464	(51 ; 73)
Body height		167.33 ± 6.005	(156 ; 177)	171.70 ± 4.347	(164 ; 180)
EUROFIT		34.63 ± 4.628	(24 ; 41)	17.60 ± 5.892	(7 ; 27)
Cervical spine	FF	60.58 ± 7.090	(52 ; 76)	51.40 ± 12.903	(32 ; 69)
	BF	68.25 ± 7.325	(52 ; 76)	68.90 ± 8.359	(56 ; 80)
	RSF	50.00 ± 5.705	(35 ; 57)	45.90 ± 7.094	(37 ; 62)
	LSF	50.92 ± 5.680	(35 ; 57)	46.80 ± 5.770	(41 ; 60)
	RSR	72.17 ± 7.346	(52 ; 78)	72.9 ± 3.755	(67 ; 79)
	LSR	73.00 ± 5.461	(59 ; 79)	72.2 ± 2.974	(70 ; 78)
Thoracic spine	FF	20.58 ± 4.542	(15 ; 30)	26.3 ± 4.900	(21 ; 36)
	BF	29.08 ± 7.728	(17 ; 42)	23.80 ± 4.050	(17 ; 30)
	RSF	31.08 ± 4.776	(21 ; 38)	31.80 ± 4.849	(24 ; 40)
	LSF	30.83 ± 4.324	(22 ; 38)	31.20 ± 4.803	(22 ; 39)
	RSR	22.67 ± 2.708	(16 ; 27)	23 ± 2.944	(19 ; 29)
	LSR	24.08 ± 2.109	(19 ; 27)	22.5 ± 2.273	(20 ; 26)
Lumbar spine	FF	60.58 ± 4.010	(54 ; 66)	74.8 ± 5.371	(68 ; 86)
	BF	49.50 ± 12.638	(19 ; 66)	32.70 ± 8.499	(20 ; 46)
	RSF	32.17 ± 6.308	(18 ; 37)	30.80 ± 3.293	(26 ; 35)
	LSF	33.17 ± 5.424	(22 ; 39)	31.10 ± 3.872	(24 ; 36)
	RSR	4.83 ± 1.642	(3 ; 8)	8.2 ± 1.476	(6 ; 10)
	LSR	4.17 ± 1.115	(3 ; 6)	7.8 ± 1.135	(6 ; 10)
LHJ	FF	125.42 ± 8.415	(107 ; 140)	101.80 ± 5.116	(94 ; 111)
	BF	26.25 ± 7.990	(15 ; 43)	17.00 ± 3.528	(13 ; 26)
RHJ	FF	126.42 ± 6.934	(112 ; 140)	100.90 ± 5.763	(92 ; 110)
	BF	27.00 ± 8.034	(13 ; 45)	16.80 ± 3.425	(14 ; 25)
Curvatures	C	32.33 ± 6.880	(25 ; 42)	37.30 ± 6.075	(30 ; 48)
	Th	12.33 ± 3.055	(7 ; 16)	19.40 ± 4.971	(12 ; 27)
	L	31.50 ± 4.945	(24 ; 39)	41.00 ± 6.600	(29 ; 50)
EUROFIT components	C	28.75 ± 8.170	(15 ; 46)	30.80 ± 4.872	(24 ; 40)
	Th	20.67 ± 4.228	(10 ; 27)	16.90 ± 3.900	(10 ; 24)
	L	18.75 ± 4.693	(13 ; 30)	37.00 ± 9.684	(21 ; 55)
	Hips	56.00 ± 6.368	(45 ; 68)	29.80 ± 4.417	(24 ; 37)

RHJ – right hip joint, LHJ – left hip joint, FF – forward flexure, BF – backward flexure, RSF – right side flexure, LSF – left side flexure, RSR – right side rotation, LSR – left side rotation

coefficient of determination, it can be observed that the mobility of hip joints in dancers exerted the greatest influence on the results of the performed test (34%), whereas the lowest percentage contribution was observed in the lumbar spine mobility (2%). In controls, a reverse tendency was observed, i.e. the percentage share of the lumbar spine during the test was estimated at 34% and of the hip joints only at 8%. The remaining joints and other factors that could affect the final SR test results (e.g. body mass, height, etc.) demonstrate similar coefficient of determination values in both groups (Fig. 1, 2).

What this study adds?

The study compares the results of flexibility measurements with the use of sit and reach test with the measurements of sectional mobility of the spine and hip joints (sagittal plane) performed with the tensometric electrogoniometer. The measurements of mobility determine the percentage share of the respective sections of the spine and hip joints during the performance of the SR test. The analysis of the results of movement ranges and the SR test measurements allow determination of the usefulness of the sit and reach test.

Discussion

In spite of the observed limitations in the lumbar spine mobility by 21° and thoracic spine by 8°, the ballet school students achieved very good suppleness test results, i.e. 16.4 cm (48%) higher than the girls from the control group. The SR test measurement results also

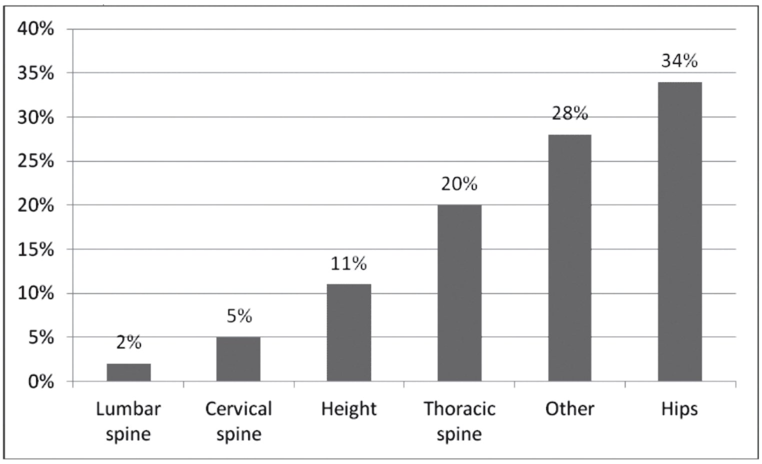

Figure 1. The values of the coefficient of determination (R2) for the tested joints in reference to the result of the EUROFIT suppleness test for the students of the Ballet School

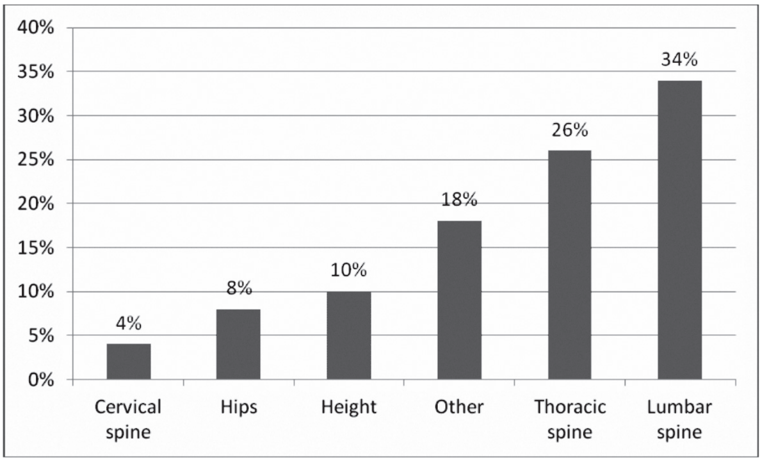

Figure 2. The values of the determination coefficient (R2) for the tested joint in reference to the result of the EUROFIT agility test for the students of the 1st Secondary School

exceeded the values of suppleness standards provided by Stupnicki – these results are the highest on a five-point scale [20]. It may be supposed that in spite of the significant hypomobility of the hip joints of the lumbar spine in the dancers, some compensation takes place owing to the hypermobility of the hip joints and an almost one hundred percent share of the thoracic spine in the final SR test results. Thus, the SR suppleness test result may not be a representative measurement of mobility of all the hip joints in the assessed test [14, 16]. Similar conclusions were also drawn by other authors, who revealed a low correlation between the results of the above-mentioned test and the mobility measurement of the lower section of the spine. They also noticed a low correlation between the SR test and the degree of muscle tensility of the rear part of the thigh [1, 9, 13, 17]. Because of this, the usefulness of the described suppleness test in the evaluation of the thoracic-lumbar spine is also undermined.

The sectional hypomobility of the spine may be compensated for by other hip joints taking part in the movement [11, 16]. In connection with this, the test may not be representative in the assessment of the health condition of the spine. Also, the risk of damaging the ligament apparatus of the lower spine by stretching it to its maximum during the performed forward bend is also present, which is increased even more by the impact of the torso gravity force [5, 22]. Plowmann also concludes that forward flexure of the torso above 45° during the SR test involves a rotation of the pelvis and sacral bone until the inhibition of movement through stretching the buttock muscles and tibial-sciatic muscles [18]. The lack of flexibility of the above-mentioned muscles may constitute additional exposure of the lumbar spine ligaments to damage. Thus, the SR test is an inaccurate marker of suppleness of the lower part of the spine, but it is moderately useful in the assessment of the flexibility of muscles of the rear part of the thigh [11].

The results of our tests confirm the above observations. Many authors also prove that the disproportion in the length of lower and upper limbs has a decisive impact on the SR test results. A person with long upper limbs and short lower limbs may attain higher measurements in the suppleness test in spite of low mobility of the lumbar spine and hip joints. This is a clear disadvantage of the sit and reach test [4, 8, 10]. During the processing of the SR test measurement results of ballet dancers and controls the coefficient of determination R2 revealed an insignificant impact of other factors on the mobility of the spine and hip joints. This may prove the lack of disproportion in such measurements as body height, body mass, and limb length limbs in the examined girls from both groups. Also, a modification of the SR test is proposed consisting of performance of a forward bend with one of the lower limbs bent, and with plantar flexion of the limb straightened at the knee. These changes are supposed to increase the reliability of the suppleness test. However, in spite of these modifications, the SR test remains still unreliable for suppleness evaluation [13].

Conclusion

1. A disadvantage of the SR suppleness test is the global measurement of suppleness of all examined joints, without any estimation of the percentage contribution of the respective spinal sections and hip joints.
2. Persons with hypomobility of the respective parts of the spine and hypermobility of the hip joints can achieve better SR test results than persons without such disorders.
3. The SR test proves to be more useful in the evaluation of the flexibility of the tibial-sciatic muscles and hip joint ligaments than in evaluation of the lumbar spine suppleness.

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