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LUMBAR SPINE DYNAMIC STABILITY EVALUATION – A NEW FIELD TEST

EVALUACIJA DINAMIČKE STABILNOSTI LUMBALNOG DIJELA KRALJEŽNICE – NOVI TEST

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SUMMARY

The aim of this study was to design a new field test that measures dynamic stability of lumbar spine joints (controlled range of motion). It was also a goal to determine the metric characteristics of the newly designed test on two groups of subjects differing on their physical preparedness. The sample was composed of 35 girls aged 9-20 years from Zagreb, Croatia. Fifteen of them were rhythmic gymnasts who at average trained 8.93 hours per week, for at least 5 years. The other group consisted of 20 female pupils of the secondary school "Borovje" who were not engaged in any regular sport activity beside physical education classes. The subjects performed 2 tests for the evaluation of lumbar spine dynamic stability. One well known and with estabilished metric characteristics (F-1), and the other one, newly constructed (F-2). The normality of the distributions was examined using the Kolmogorov–Smirnov test (KS). Validity and reliability were estimated with the Factor analysis. The intraclass correlation coefficient (ICC) was used for homogeneity evaluation. *T-test* for independent samples was used to establish the capacity of the new test to discriminate the lumbar spine dynamic stability of trainees and nontrainees. The obtained results showed that the new test has high sensitivity, validity, reliability and homogeneity, tested on two groups of same age but different level of physical preparedness. Such results stress the wide applicability of the newly constructed test regardless on the level of physical preparedness or the work conditions. It is thus usable in sports as well as in physical therapy practice.

Key words: range of motion, dynamic stability, lumbar spine

SAŽETAK

Glavni cilj ovog istraživanja bila je konstrukcija i validacija mjernog instrumenta za procjenu dinamičke stabilnosti lumbalnog dijela kralježnice (kontrolirani opseg pokreta). Također je bilo u interesu ovog rada provjeriti njegovu valjanost na dva uzorka ispitanika koja su se razlikovala u razini fizičke pripremljenosti. Uzorak ispitanika činilo je 35 djevojaka iz Zagreba u dobi od 9-20 godina. Petnaest od njih bile su ritmičarke koje treniraju u prosjeku 8,93 sati tjedno, u period od najmanje 5 godina. Drugu je skupinu činilo 20 učenica Osnovne škole "Borovje" koje pored nastave tjelesne i zdravstvene kulture nisu aktivno sudjelovale u niti jednoj sportskoj aktivnosti. Provedena su dva testa za procjenu dinamičke stabilnosti lumbalnog dijela kralježnice. Jedan poznati (F-1), i drugi novokonstruirani test (F-2). Mjere asimetrije (*skewness*) i izduženosti (*kurtosis*) distribucije korištene su za provjeru osjetljivosti novog mjernog instrumenta. Normalnost distribucije provjerena je pomoću Kolmogorov–Smirnov (KS) testa. Valjanost i pouzdanost provjerene su pomoću Faktorske analize. Koeficijent interkorelacije uzet je kao pokazatelj homogenosti F-2 testa. *T-testom* za nezavisne uzorke provjerena je mogućnost novokonstruiranog testa za razlikovanjem dinamičke stabilnosti lumbalnog dijela kralježnice između trenirane i netrenirane populacije. Dobiveni rezultati pokazuju da je novo konstruirani (F-2) test osjetljiv, valjan i pouzdan bez obzira na razinu treniranosti izmjerenih pojedinaca. Test je također jednostavan i primjenjiv u svim uvjetima rada. Temeljem dobivenih rezultata moguće je preporučiti korištenje novokonstruiranog mjernog instrumenta za procjenu dinamičke stabilnosti lumbalnog dijela kralježnice u sportskoj i kliničkoj praksi.

Ključne riječi: opseg pokreta, dinamička stabilnost, lumbalni dio kralježnice

INTRODUCTION

Flexibility is the range of motion available in a joint or group of joints. It is usually classified as ballistic, dynamic (functional) or static (1). Research indicates that the range of motion is dependent upon the level of a person's physical activity, in favour for the active ones. It is also specific to sport groups and even within sports groups (6, 10). Although an optimal level of flexibility can improve sports performance and reduce injuries, a lack of flexibility, or excessive range of motion could cause acute as well as overuse injuries (22).

Joint laxity and hypermobility are not synonymous of flexibility (1, 2). Joint laxity refers to the degree of abnormal motion of a given joint and it can result from an injury. On the other hand, hypermobility is the range of motion in excess of the accepted normal motion in most of the joints without muscular control (1).

The factor that differentiates optimal and excessive flexibility is not only the range of motion, yet the muscular strength and neural control of the movement plays an important role. All this factors together leads to *joint stability*. Stability is the dynamic process that includes both static position and controlled movement (3). It can also be referred as *dynamic stability* (2) or *active mobility* (23). Dynamic stability is especially important for the lumbar spine joints, where pure range of motion, without muscular control can lead to low back pain (LBS), sciatic nerve pain, and even more serious injuries (e.g. spinal disc herniation) (20). Lumbar spine dynamic stability encompasses the range of motion of the vertebral segments as well as the trunk muscles strength, thus their ability to control movement.

The factors that lead to dynamic stability of the human trunk have been extensively studied. Panjabi (1992) described a model for spine dynamic stability that consists of three components: a) the bones and ligament, b) muscle strength and endurance and c) neural control system. The focus of this model is the creation of the spinal stiffness and stability. According to Panjabi, movement is just as important to the spine as stiffness. Movement of the spine is required to dissipate forces and minimize energy expenditure, and a stiff and rigid spine is not the ideal. Research is ongoing that attempts to quantify spinal stability so that it can better be determined what affects it and to determine how clinically significant differences in stability are (12, 18).

Most of the tests used to assess lumbar spine dynamic stability are clinical tests dependent on expensive equipment. Such tests require the use of an electrogoniometer (4), special optoelectronic system (7), video-fluoroscopy technique (14), CT scanner (17) and magnetic resonance imaging (11).

On the other hand, field tests, most often used in gyms as well as in physical therapy ambulances are designed to determine pure lumbar spine range of motion, without taking in consideration muscular strength. Only few of them are metrically verified (15). Although other tests are widely used in sport practice (especially in aesthetic sports), their validity, reliability and homogeneity are not known. However, testing their metric characteristics is beyond the interest of this paper.

Metikoš, et al. (1989) constructed and verified a field test that measures dynamic stability of the lumbar spine (Figure 1). Since the test consists of a leg lift from prone position it measures mostly the activity of *m. gluteus maximus*. There is a need to design a new field test to measure lumbar spine dynamic stability by means of spine muscle activation. This is especially important knowing that the spine muscles (particularly the paravertebral muscles) plays an important role in the dynamic control of the human trunk.

The aim of this study was to design a new field test that measures dynamic stability of lumbar spine joints (controlled range of motion) stressing the activity of the spine muscles. It was also a goal to determine the metric characteristics of the newly designed test on two separate groups of subjects, one elite rhythmic gymnasts and the other who were just enrolled in regular physical education classes.

SUBJECTS AND METHODS

Subjects

The study included 35 girls, aged 9-20 (12.89 ± 2.32) years from Zagreb, Croatia. Fifteen of them were rhythmic gymnasts who at average trained 8.93 (±2.91) hours per week, for at least 5 years (7.9±2.55). The majority of them are medals winners at national competitions, and some of them are members of the Croatian national team. The second group consisted of 20 girls, pupils of the secondary school "Borovje" who were not engaged in any regular sport activity beside physical education classes. Basic characteristics of the subjects (means ± standard deviations) are presented in table 1. All the subjects gave their written informed consent, whereas parents gave written consent for the minor subjects.

Table 1. Basic characteristics of the subjects
Tablica 1. Osnovne karakteristike ispitanika.

	Nontrainees	Trainees
Age (yrs)	12.55±1.23	13.33±3.27
Height (cm)	161.45±8.39	156.37±14.26
Weight (kg)	47.15±11.49	44.27±12.61

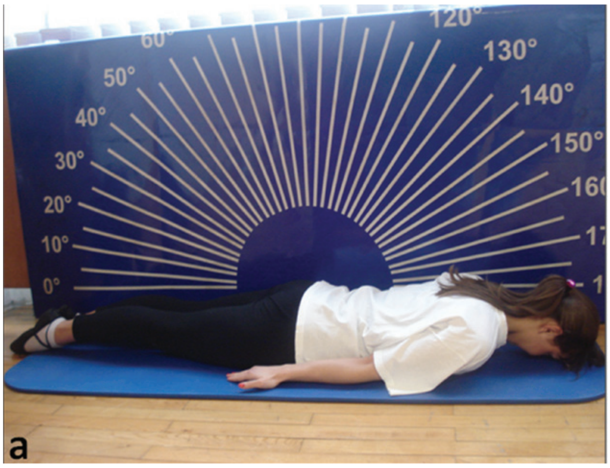
Motor tests

The subjects performed 2 tests for the evaluation of lumbar spine dynamic stability (Table 2).

Table 2. Applied tests
Tablica 2. Primijenjeni testovi.

Abbreviation	Measure and Test	Ability/Dimension
F-1_d, F-1_l	Right/Left leg lift backward	Lumbar spine dynamic stability
F-2	Back extension	Lumbar spine dynamic stability

Metric characteristics of the first test (F-1) are well known and previously reported (15, 16). The test consisted of a leg lift from prone position (Figure 1). The subjects performed the task three times with the right and left leg respectively.



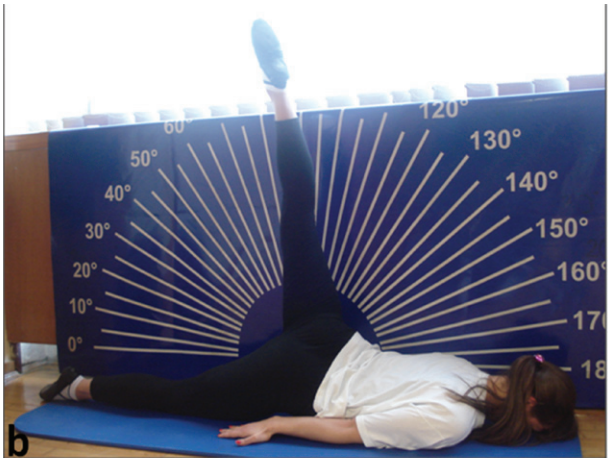


Figure 1a and 1b. Start (a) and the end (b) position for the F-1 test
Slika 1a i 1b. Početni (a) i završni (b) položaj za F-1 test.

The new *back extension* (F-2) test consisted in a hyperextension of the trunk while measuring the grades of the hyperextension (Figure 2).

2.1. F-2 TEST DESCRIPTION

- *number of examiners:* two examiners
- *Items:* three
- *Equipment:* a tarp with minimal 300 x 50 cm dimension with a grade scale from 0º to 180º.
- *Task:* trunk hyperextension with bend arms and fixated legs, from prone position. The back of hand with fingers crossed, should touch the chin. The elbows remain in line with the shoulders.
- *Instructions:* the task should be demonstrated and subjects encouraged to perform it continuously without hitch, and to hold the final position until the result is registered.
- *Unit of measure:* grades

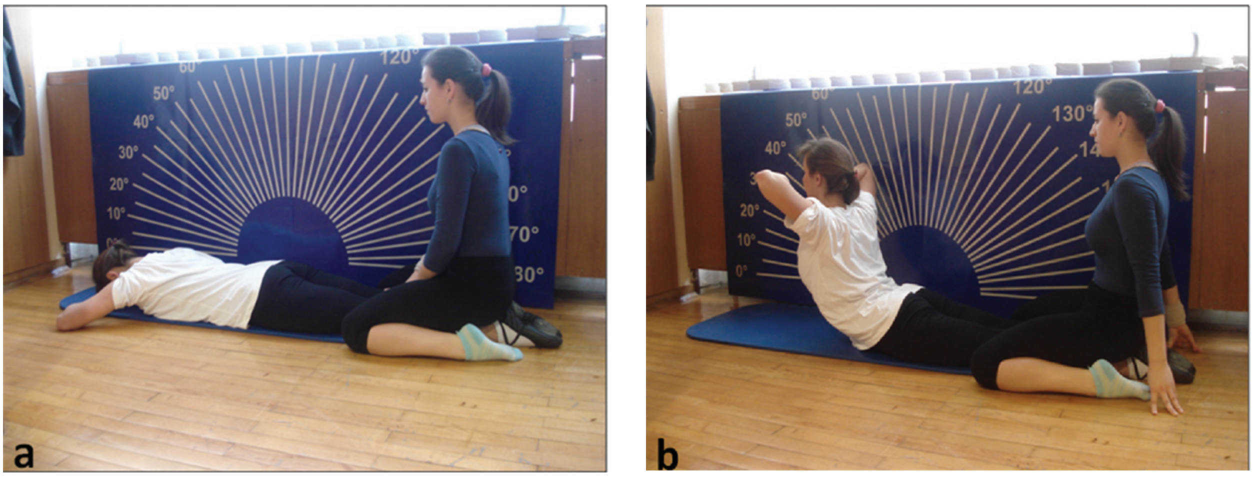


Figure 2a and 2b. Start (a), and end (b) position for the F-2 test
Slika 2a i 2b. Početni (a) i završni (b) položaj za F-2 test.

Statistical analyses

The data were analyzed using the Statistical Package for the Social Sciences (ver. 11.0). Descriptive statistics were calculated for all trials and variables. Skewness and Kurtosis indexes were used for sensitivity evaluation. The normality of the distributions was examined using the Kolmogorov–Smirnov test (KS). Validity and reliability of the tests were estimated with the Factor analysis. The intraclass correlation coefficient (ICC) was used for homogeneity evaluation. *T-test* for independent samples was used to establish the capacity of the new test to discriminate the lumbar spine dynamic stability of trainees and nontrainees.

RESULTS

Descriptive data for all variables are presented in Table 3. The results of the Kolmogorov–Smirnov normality test suggest that the scores were normally distributed (Max D). Skewness and Kurtosis indexes showed that the new test (F-2), as well as the old one (F-1) is sensitive in measuring the targeted dimension (dynamic stability of the lumbar spine).

Table 3. Descriptive statistics of the applied tests (F-1, F-2); (n= nontrainees, t= trainees)
Tablica 3. Deskriptivna statistika za primijenjene testove (F-1, F-2) (n= netrenirani, t= trenirani)

Variable	Valid N	Mean	Minimum	Maximum	St.dev.	Skewness	Kurtosis	Max D	K-S p
F-1_d –t	15	71,00	50,00	88,33	11,83	-0,23	-1,00	0,16	p > .20
F-1_1 –t	15	72,56	51,67	88,33	11,18	-0,41	-0,31	0,09	p > .20
F-2-t	15	85,00	65,00	125,00	17,75	1,01	0,37	0,20	p > .20
F-1_d -n	20	47,58	26,67	76,67	12,36	0,26	0,07	0,13	p > .20
F-1_1 -n	20	49,58	31,67	76,67	13,09	0,57	-0,65	0,14	p > .20
F-2-n	20	46,33	21,67	68,33	12,37	-0,32	0,02	0,16	p > .20

The homogeneity, verified with the intraclass correlation coefficient (ICC) of F-2 test is markedly high (Table 4), showing that the items are measuring the same dimension in all the three trials.

Table 4. Correlation between three measured items for the new (F-2) test (n= nontrainees, t= trainees)
Tablica 4. Korelacija između čestica novog (F-2) testa; (n= netrenirani, t= trenirani)

Variable	p< ,05000		
F-2_1-t	1,00	**0,95**	**0,88**
F-2_2-t	**0,95**	1,00	**0,91**
F-2_3-t	**0,88**	**0,91**	1,00
F-2_1-n	1,00	**0,87**	**0,79**
F-2_2-n	**0,87**	1,00	**0,91**
F-2_3-n	**0,79**	**0,91**	1,00

The Factor analysis resulted with the extraction of only one factor: the lumbar spine dynamic stability. All the applied tests had very high correlation with the isolated factor, showing good test validity (Table 5).

Table 5. Factor validity of the F-2 test (n= nontrainees, t= trainees)
Tablica 5. Faktorska valjanost F-2 testa (n= netrenirani, t= trenirani)

Variable	Factor
	1
F-1_d –t	**0,880634**
F-1_1 –t	**0,830066**
F-2-t	**0,817746**
Expl.Var	2,133235
Prp.Totl	0,711078
F-1_d –n	**0,880634**
F-1_1 –n	**0,830066**
F-2-n	**0,817746**
Expl.Var	2,133235
Prp.Totl	0,711078

Reliability of the new *F-2* test, verified with the Cronbach alpha is 0.97 for rhythmic gymnasts, and 0.95 for the nontrainees (Table 6).

Table 6. Factor reliability of the F-2 test
Tablica 6. Pouzdanost F-2 testa.

	Eigenvalue	% total variance	Cumulative Eigenvalue	Cumulative %	Cronbach's alpha
Trainees	2,829691	94,32303	2,829691	94,32303	0,969899244
Nontrainees	2,715310	90,51033	2,715310	90,51033	0,947526738

The *t-test* for independent samples showed marked statistical differences in arithmetic means between the two groups for the two applied tests (table 7).

Table 7. Results of the t-test for independent samples
Tablica 7. Rezultati t-testa za nezavisne uzorke.

Motor test	Mean trainees	Mean nontrainees	t-value	df	p	Std.Dev. trainees	Std.Dev. nontrainees	F-ratio	p
$F\text{-}4_R$	71.00	47.58	5.65	33	0.00000	11.83	12.36	1.09	0.8833
$F\text{-}4_L$	72.56	49.58	5.46	33	0.00000	11.18	13.09	1.37	0.5535
F-5	85.00	46.33	7.60	33	0.00000	17.75	12.37	2.06	0.1434

DISCUSSION AND CONCLUSIONS

According to the Max D values (Table 3), the results of the subjects in all the measured tests are normally distributed. We can therefore assume that the tasks are not easy or too complicated for the trained as well as for the non-trained population. This is accentuated by the Skewness and Kurtosis indexes.

For what concerns the new proposed (F-2) test, the results suggests that it can be applied for clinical or sports scopes regardless on the level of physical preparation of the examines. It can be stated that the F-2 test is sensitive in measuring the segmental dynamic stability of the lumbar spine.

The homogeneity of F-2 test, verified with the intraclass correlation coefficient (ICC) is markedly high (Table 3) in trainees and nontrainees. The correlation between items (0.88 - 0.95 for trainees and 0.79 - 0.91 for nontrainees respectively), is positive and statistically significant, showing that the test is measuring the same dimension in all the three trials. This confirms the good internal validity of the new test. Such results are in line with the showed descriptive statistics and confirm the wide applicability of F-2 test no matter on the physical preparedness of the subjects.

The extraction of only one main component (factor) by means of Factor analysis (Table 5) emphasizes the fact that the new test has only one object of measurement. This object represents the factor of lumbar spine dynamic stability. Such high saturation of the new test with the extracted factor for trainees and nontrainees shows its good validity in both clusters.

Taking into account that the first main component covers 94% of the total variance of the correlation matrix for the trainees and 90% for nontrainees (Table 6), it is clear that the targeted dimension is measured in every trial of both groups.

Since the Cronbach alpha index is 0.97 for rhythmic gymnasts, and 0.95 for the nontrainees (Table 6) the conclusion that F-2 test has high factorial reliability can be drawn. High reliability of the new test demonstrates that the construct always measures lumbar spine dynamic stability.

There is an obvious difference in the level of sport preparedness between trainees and nontrainees. Trainees practice rhythmic gymnastics at averaged 8.9 (±2.91) hours per week for 7.9 (±2.55) years, while the nontrainees are not engaged in any regular sport activity beside physical education classes. It is therefore natural to expect that the two groups will differ in the level of their lumbar spine mobility. Since flexibility is a very important dimension for rhythmic gymnasts, the mentioned difference should be in favour of the trained subjects.

Besides the evaluation of basic metric characteristics of the new proposed F-2 test, it was also in the interest of this investigation to found out if this new test is able to distinguish trainees of nontrainees in the measured dimension (lumbar spine dynamic stability). The *t-test* for independent samples showed marked statistical differences in arithmetic means between trainees and nontrainees for the old well known test, as well as for the newly presented test (p= 0.0000) (Table 7).

According to the above presented results it can be concluded that the new test has high sensitivity, validity, reliability and homogeneity, tested on two groups of same age (p=0.33), but different level of physical preparation.

Practical implication

Most of the tests used to assess lumbar spine dynamic stability depend on expensive equipment or measures only the lumbar spine range of motion, without taking in consideration the muscular strength. Studies have generally failed to support the validity and reliability of mobility field testing procedures (13). The proposed (F-2) field test has good metric characteristics when applied on trainees or nontrainees. It is also efficient because of its wide applicability regardless on the level of physical preparation of the subjects or the work conditions. It is thus usable in sports as well as in physical therapy practice. It measures the lumbar spine dynamic stability and not just passive range of motion without muscle control. Such test should be applied in measuring young athletes (especially in sports where flexibility is highly important) from the very beginning of the practise with children. This is especially important when taking in consideration that rhythmic gymnasts (8), artistic gymnasts (5) figure skaters (9), but even soccer players (21), rowers (19), weight lifters (3) and other athletes are at risk of suffering of low back pain. Measuring dynamic trunk stability from the very beginning of sport practice could stress the importance of its development. Developing muscular strength and flexibility together should provide a smaller rate of low back pain in athletes. It could also result in a better posture, as well as better performance. Finally, this approach can prolong an athlete's career and assure a higher level of competition.

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