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Original article

SENSITIVITY TESTING STUDY PROPOSED BY METHOD AND APPARATUS FOR DETERMINING MUSCLE IMBALANCES AT THE TRUNK LEVEL

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Abstract

Objective. The purpose of this study is to determine whether the measurements made with the device for determining muscle imbalances present in the trunk are significantly delimited by age, in order to demonstrate the sensitivity of the proposed tests.

Methods. The study was conducted on 120 subjects aged from 6 to 18 years. The total sample is divided into six groups, with age as the independent variable, as follows: 6, 7, 12, 14, 16 and 18 years old. 9 tests were applied to measure muscle strength in the trunk as follows: testing of the flexion muscle strength from sitting; testing of the flexion muscle strength on the left side slope from sitting; testing of the extension muscle strength from sitting; muscle strength testing on the right side slope, from sitting; flexion muscle strength testing of standing; muscle strength testing on left lateral tilt of standing; muscle strength testing the extension from standing; muscle strength testing on the right side slope of standing; lumbar muscle strength testing (classic test).

Unifactorial dispersion analysis is used (One Way ANOVA); the method by which the multiple comparisons are done by repeated measurements.

Result. Mauchly's test results Test of sphericity is not statistically significant ($p>0.05$) and therefore the spherical condition is met. All values of F are greater than 0.05 then the null hypothesis is rejected.

Conclusions. All tests have a significant sensitivity taking into account differences between subjects; in this case the independent variable is age. It highlights the differences between groups and differences between subjects in each group. Null hypothesis is rejected and the alternative hypothesis is accepted that media groups are significantly different from each other and not due to chance alone.

Keywords: sensitivity tests, muscle strength, patented method and apparatus.

Introduction

In the area of motor activities, the measurement is the primary source of obtaining information. Measurement enables quantitative determinations, and is the starting point in assessing self-regulation system, causing changes in the strategy used in business objectives. Evaluation of the trunk in all forms was an important research field of motor activities. The prevention of installation of spine deficiencies in children, by measuring muscle strength in the trunk, has become a permanent concern (Stan, 2006).

These studies support the idea of prophylactic application of physical exercise in order to achieve a harmonious development at an early age and to avoid extremely laborious recoveries later.

Sommer, Hofmeier, Berschin (2002) discusses a study on the importance of the muscles around the knee in static and dynamic status of the whole body. It is already known about the influence of posture of the head and cervical muscles over the extensor muscles of the knee.

In this study, it was demonstrated by measuring muscle strength around the knee in different body positions, the high influence of neck and pelvis area and especially the area of the thoracic and lumbar vertebrae body motility.

Voisin, Bibra, Goethals, Masse and Weissland (2002) was studying the concentric and eccentric isokinetic force of the trunk in men, by standing on the moments of maximum and average, taking into account the angular velocity and the number of repetitions.

Focusing only on extension gives details of neurophysiological model of muscles that are usually involved in the dysfunction of the spine.

These studies support the idea of prophylactic application of physical exercise in order to develop harmonious at an early age and to avoid extremely laborious recoveries later. Berschin and Sommer (2002) proposed a new method for active control of posture subjects have been applied sensors in the lumbar and thoracic area, data recorded in instrument being very useful for muscle development. Increased trunk strength with age is evidenced by Manini, Sagendorfa, Mayer and Ploutz-Snyder, 2005.

The way of how the erector muscle fatigue decreases correct positioning of the trunk is studied by Kazuhiko, Miyamotob and Katsuji, 2005. There are different ways to measure the trunk force which include power boards for leg strength and pelvic fixation (Mockova, Greenwood, Day, 2006, Rizescu, Georgescu, 2009). The importance of creating a stable foundation for limb movement is evidenced by Kane and Barden (2012).

In this study we present briefly a method and a device patented in Romania (Patent no. 123013/ 30.07.2010, *Method and apparatus for determining muscle imbalances present in the trunk*, issued by OSIM Bucharest, Romania, inventors: Stan, Baştiurea,

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Marcu, Chiculiţă). The new method of evaluation of trunk muscle strength or force measurement on the main directions of movement and objective evidence of the existence of muscle imbalances will provide a concrete application exercises enabling the a customized approach. The method and apparatus have been shown in exhibitions of inventions which have received awards and honours. Also, studies on how the influence of trunk muscle strength and exercise influents the capacity of effort and breathing (Baştiurea, Stan, Andronic, Gutiérrez, 2010; Stan, Baştiurea, 2008).

If we prove that the measurements made with the device for determining muscle imbalances present in the trunk are delimited significantly by age, we strengthen such idea of the patent by the proposed sensitivity tests.

Under the null hypothesis of differences in values obtained from tests according to age group are not significant.

Methods

Subjects

The study was conducted on 120 subjects aged 6 to 18 years. The total sample is divided into six groups with 20 members, with age as the independent variable, as follows: 6, 7, 12, 14, 16 and 18 years old.

Test Procedure

For all subjects where applied 9 tests; in table 1 are found the abbreviations used in this study: the flexion muscle strength testing, from sitting; muscle strength testing on the left side slope, from sitting; muscle strength testing the extension of sitting; muscle strength testing on the right side slope, from sitting; flexion muscle strength testing of standing; muscle strength testing on left lateral tilt of standing; muscle strength testing the extension from standing; muscle strength testing on the right side slope of standing; lumbar muscle strength testing (classic test)

Table 1. Testing muscle strength of the trunk (Marcu, Stan, Baştiurea, Chiculiţă, 2008; Stan, 2009)	**Abbreviations**
Flexion muscle strength testing of sitting	**T1**
Muscle strength testing on the left side slope, from sitting	**T2**
Muscle strength testing on extension of sitting	**T3**
Muscle strength testing on the right side slope of standing	**T4**
Testing flexion muscle strength in standing	**T5**
Testing muscle strength on the left lateral tilt of standing	**T6**
Testing the extension muscle strength in standing	**T7**
Muscle strength testing on the right side slope of standing	**T8**
Lumbar muscle strength testing (classic test)	**T9**

Description of test

<u>Sitting muscle strength testing in flexion</u>

To measure the muscle strength from sitting, the seat height set will be adjusted so that the subject's feet will be placed on the ground, and the legs are bent at 90°. The subject sits astride on the bench, back to stand tall feet are placed as described above, to not push into the soil and thus supplement thrust (figure 1). Fasten the belt then passes through acromial points and the middle belt coincides with the midline anterior chest. The trunk will be the vertical position.

Adjust the vertical transducer holder so that it will be in the T1-T2 vertebrae region.

The arms are crossed over the chest to keep the subject (especially children tend to grab something to help traction) to find a way to supplement thrust. At the signal, the subject will execute a strong traction trunk flexion, keeping a uniaxial direction (left-right swing is avoided during the action).

The computer will retain maximum traction force transducer and recorded transposed graphically in real time on the chart.

Figure 1. Sitting muscle strength testing in flexion

<u>Muscle strength testing on the left and right lateral tilt of sitting</u>

The subject sits on the bench, with left or right side to frame so that the soles are slightly apart, with feet resting on the ground, the leg is bent at 90° (figure 2). The legs are placed as described above, to not push into the soil and thus supplement thrust, then snaps belt which passes through the acromial point and will coincide with the mid-point belt.

Adjust the vertical (if necessary) the transducer support. The arms are crossed over the chest to keep the subject (especially children tend to grab something to help traction) to find a way to supplement thrust.

The stand 14 will slide horizontally and will be fixed next to pelvis, with screws, in the direction of bending of the trunk, to prevent the pelvis to move aside, and to add this this way. In the initial position, the trunk will be vertical. At the signal, the subject will execute a strong thrust movement of the trunk and lateral bending; keeping a uniaxial direction (avoids rocking back and forth during the action). The computer will retain maximum traction force transducer and recorded transposed graphically in real time on the chart.

Figure 2. Muscle strength testing on the left and right lateral tilt of sitting

<u>Muscle strength testing on extension of sitting</u>

The subject sits astride facing seat frame so that the soles of the subject will be placed on the ground; the leg is bent at 90° (figure 3). The legs are located as described above, not to push the ground and thus supplement the thrust. Fasten the belt then passes through acromial points while the middle belt line coincides with the spine. If the case, adjust vertically the transducer's support, so that it is in the T1-T2 vertebrae region.

The arms are crossed over the chest to keep the subject (especially children, tend to grab something to help traction) to find a way to supplement thrust. The support will slide horizontally and will be fixed with screws, stop prevent the pelvis to run backwards during the traction and to add thus this way. In the initial position, the trunk will be vertical.

At the signal, the subject will execute a strong traction trunk extension keeping a uniaxial direction (left-right swing is avoided during the action). The computer will retain maximum traction force transducer and recorded transposed graphically in real time on the chart.

Figure 3. Testing muscle strength on extension of sitting

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Muscle strength testing on the right side slope of standing

To have this measurement done, the height is adjusted so that the pelvis is supported during testing in the sacral region. The subject sits upright on the plate back to the stand with your feet slightly apart, parallel to each other, with basin supported by the support plate, the vertical trunk and arms crossed over the chest (figure 4).

Fasten the belt then passes through acromial points and the middle belt coincides with the midline anterior chest. Adjust the vertical transducer holder so that it will be in the T1-T2 vertebrae region. At the signal, the subject will execute a strong traction trunk flexion keeping a uniaxial direction (left-right swing is avoided during the action), taking as a support for the basin, especially support 7.

The computer will retain maximum traction force recorded transducer and implemented in real time chart.

Figure 4. Muscle strength testing on the right side slope of standing

Testing muscle strength on the right and left lateral tilt of standing

The subject is standing on the plate, with the shoulder toward the support, feet slightly apart, parallel to each other, the pelvis supported by the support plate, the trunk in vertical position and arms crossed over the chest (figure 5). Fasten the belt then passes through the acromial point and will coincide with the mid-point belt. Adjust the vertical transducer holder. At the signal, the subject will execute a strong tensile lateral bending of the trunk, keeping a uniaxial direction (avoids rocking back and forth during the action), taking as a foothold for pool, specialty media. The computer will retain maximum traction force transducer and recorded transposed graphically in real time on the chart.

Figure 5. Testing muscle strength on the right and left lateral tilt of standing

Testing the extension muscle strength in standing

The subject should stand upright facing the support plate with feet slightly apart, parallel to each other, with the pelvis supported by support plate, the trunk in vertical position and arms crossed over the chest (figure 6).

Fasten the belt then passes through the acromial points until the middle belt coincides with posterior midline of the thorax.

Vertical support of the transducer is adjusted so as to be in the region of the vertebrae T1-T2.

At the signal, the subject will execute a strong traction trunk extension, keeping a uniaxial direction (left-right swing is avoided during the action), taking as a foothold for pool, specialty media.

The computer will retain maximum traction force transducer and recorded transposed graphically in real time on the chart.

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Figure 6. Testing the extension muscle strength in standing

<u>Lumbar muscle strength testing (classic test)</u>

The subject should stand upright facing the support plate with feet slightly apart, parallel to each other, the trunk horizontally bends so hands to reach the knees and grabbed the handle attached to the transducer (figure 7).

At the signal, the subject will execute a strong traction trunk extension, keeping a uniaxial direction (left-right swing is avoided during the action).

The computer will remember the thrust, the maximum value recorded by the transducer and implemented in real time chart diagram.

The final graph shown in figure 8.

Figure 7. Testing lumbar muscle strength (classic test)

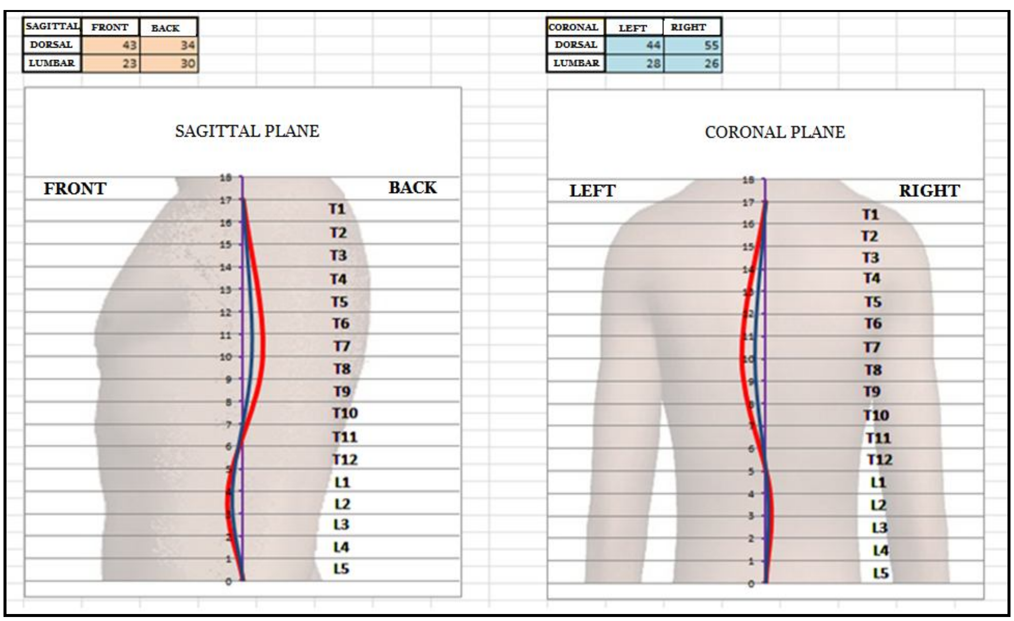

Figure 8. The graph muscle imbalances presented in coronal and sagittal plane

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Results

The data collected were processed using SPSS v. 20 for Windows. Unifactorial dispersion analysis is used (One Way ANOVA), the method by which the multiple comparisons is the one with repeated measurements. The report compares the variation between Fisher groups and intra-group variation. In table 2 are the internal variations in each group for each test. The ratio of the number of cases and variables should be 5-1 (some analysts go up to 2-1). With a ratio of 3.33 to 1 we fit between the two values. There is a standard deviation increase with age differences are highlighted in the group of subjects.

Table 2. Descriptive Statistics

		6 years	7 years	12 years	14 years	16 years	18 years
T1	Mean	6.35	8.50	13.85	18.20	17.30	20.50
	Std. Deviation	1.927	1.318	4.017	4.008	2.975	3.086
	N	20	20	20	20	20	20
T2	Mean	6.55	8.45	10.05	14.00	13.90	18.35
	Std. Deviation	1.669	1.669	3.017	4.039	2.989	3.297
	N	20	20	20	20	20	20
T3	Mean	7.50	10.85	21.30	29.65	30.50	23.50
	Std. Deviation	1.732	3.297	7.234	8.683	8.172	5.790
	N	20	20	20	20	20	20
T4	Mean	6.30	8.55	10.05	13.35	14.60	17.35
	Std. Deviation	1.976	1.849	3.000	4.209	3.251	3.014
	N	20	20	20	20	20	20
T5	Mean	9.95	13.60	25.50	29.00	32.40	50.65
	Std. Deviation	2.874	3.424	7.837	6.061	9.372	13.712
	N	20	20	20	20	20	20
T6	Mean	9.85	12.00	22.20	29.45	26.90	42.25
	Std. Deviation	2.961	2.974	6.371	5.414	5.757	8.765
	N	20	20	20	20	20	20
T7	Mean	12.20	14.25	28.85	35.60	34.63	50.65
	Std. Deviation	3.518	3.432	6.401	9.011	9.622	14.225
	N	20	20	20	20	20	20
T8	Mean	9.45	12.10	22.15	29.05	28.00	45.25
	Std. Deviation	2.523	3.478	5.923	4.751	6.139	7.960
	N	20	20	20	20	20	20
T9	Mean	22.35	28.15	53.10	69.65	75.80	126.25
	Std. Deviation	5.019	6.352	13.611	18.712	12.051	13.935
	N	20	20	20	20	20	20

Values shown if the condition of sphericity; $p>0.05$.

T1, the flexion muscle strength testing, from sitting; **T2**, testing muscle strength on the left side slope, from sitting; **T3**, muscle strength testing the extension of sitting; **T4**, muscle strength testing on the right side slope, from sitting; **T5** flexion muscle strength testing of standing; **T6**, testing muscle strength on the left lateral tilt of standing; **T7**, muscle strength testing the extension from standing; **T8**, muscle strength testing on the right side slope of standing; **T9**, lumbar muscle strength testing; **Mean**; arithmetic mean; **Std. Deviation**; standard deviation; **N**, the number of cases.

For repeated measures with ANOVA, appears an additional condition called sphericity condition. This implies the assumption of a similar relationship between each pair of experimental conditions; it is a more general condition of complex symmetry. The latter is satisfied if the variance is equal in all experimental situations (homogeneity of variance).

In practice it is noted that it is very difficult to meet the double condition, in the majority ANOVA method with repeated measures more than two groups were violating this condition.

It is noted that Mauchly's test result Test of Sphericity is not statistically significant ($p>0.05$) and therefore the spherical condition is met. The tests most "sensitive" are T5 and T7 (table 3).

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Table 3. Mauchly's Test of Sphericity

	Mauchly's W	Approx. Chi-Square	df	sig.
T1	0.319	19.564	14	0.148
T2	0.295	20.901	14	0.107
T3	0.105	38.519	14	0.000
T4	0.247	23.928	14	0.49
T5	0.065	46.747	14	0.000
T6	0.186	28.792	14	0.012
T7	0.060	48.059	14	0.000
T8	0.229	25.195	14	0.034
T9	0.130	34.879	14	0.002

Values shown if the condition of sphericity; p>0.05.

T1, the flexion muscle strength testing, from sitting; **T2**, testing muscle strength on the left side slope, from sitting; **T3**, muscle strength testing the extension of sitting; **T4**, muscle strength testing on the right side slope, from sitting; **T5,** flexion muscle strength testing of standing; **T6**, testing muscle strength on the left lateral tilt of standing; **T7**, muscle strength testing the extension from standing; **T8**, muscle strength testing on the right side slope of standing; **T9**, lumbar muscle strength testing; **Mauchly's W**, Mauchly's Test of Sphericity; Approx. Chi-Square; **df**, degrees of freedom; **sig**, p> 0.05;

Fisher report has significant value at p<0.05. It is observed in table 4 that all values of F are greater than 0.05 so the null hypothesis is rejected. The F value will increase over, the probability of being wrong in rejecting the null hypothesis will decrease. In all cases the variation explained by differences between groups is greater than the variation due to random errors.

Table 4. Tests of Within-Subjects Effects

	Sphericity Assumed				
	Type III Sum of Squares	df	Mean Square	F	**sig.**
T1	3189.867	5	637.973	66.592	0.000
T2	1879.167	5	375.833	42.581	0.000
T3	9109.400	5	1821.880	44.762	0.000
T4	1697.200	5	339.440	39.239	0.000
T5	21297.200	5	4259.440	61.774	0.000
T6	14366.675	5	2873.335	89.055	0.000
T7	20860.247	5	4172.049	59.799	0.000
T8	16982.667	5	3396.533	109.306	0.000
T9	143447.300	5	28689.460	176.103	0.000

Values represent the results of analysis of variance.

T1, the flexion muscle strength testing, from sitting; **T2**, testing muscle strength on the left side slope, from sitting; **T3**, muscle strength testing the extension of sitting; **T4**, muscle strength testing on the right side slope, from sitting; **T5** flexion muscle strength testing of standing; **T6**, testing muscle strength on the left lateral tilt of standing; **T7**, muscle strength testing the extension from standing; **T8**, muscle strength testing on the right side slope of standing; **T9**, lumbar muscle strength testing; **Type III Sum of Squares**, Sum of squares; **df**, degrees of freedom; **Mean Square**, the mean square; **F**, fisher report; **sig.**, p>0.05.

Discussions

A sensitive problem of achieving measurements with dynamometers, meaning the influence of gravity on their accuracy and correction made to dynamometers for trunk muscle strength during measurements on different degrees of motion is studied by Bygott, McMeeken, Carroll and Story (2001). Researchers have assumed that while performing correction by this method, the gravitational force acting on the trunk is being treated as a vertical vector forces that influence the process. To correct this shortcoming is proposed a method of establishing a predetermined angle (as a formula) to be placed in the trunk during testing, thereby cancelling the influence of gravity. Six Ways gravity correction was found that the method is not reliable enough to be trusted, being influenced by the strain relaxation and subjects.

With this method and the apparatus shown in this study, the method of testing includes fixed positions on the starting traction on the dynamometer, following that trunk not to use too much leverage to amplify the values obtained. It was intended to adopt a position as close to normal.

On this principle were corrected to athletes from the trunk muscle imbalances (Baştiurea, Stan, Andronic, 2009). It was conceived as a way of primary prevention of physical deficiencies attitude (Stan, 2006).

Conclusions

All tests have a significant sensitivity taking into account differences between subjects; in this case study is the age factor. It highlights the differences between groups and differences between subjects in each group.

The lower is the T4, muscle strength testing on the right side slope, which means that independent factor affecting less dependent factor here laterality intervening trunk influenced by skilful arm. This influence increases with age.

Differences between groups justifies a significant part of the variation in the independent variable, the results are not accidental.

Null hypothesis is rejected and the alternative hypothesis is accepted that media groups are significantly different from each other and not due to chance alone. The conclusions must be accepted with care, as it concerns only this group of subjects.

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