2.	The length of the right sole (cm)	23,15±0,14	22,88±0,12	2,12	<0,05
3.	The left sole index (cm)	2,22±0,28	1,59±0,23	2,08	<0,05
4.	The right sole index (cm)	2,27±0,27	1,61±0,25	2,09	<0,05

Conclusion

The positive effects of the means and the exercise complexes conducted in the case study mentioned above allow the emphasis on the fallowing aspects:

- Fallowing the alteration results of the pupils' sole index from the first group, we have noticed that the pupils engaged in the study can be framed in the category of those with less pronounced bilateral flat foot.
- The pupils form the second group to whom the sole index has reached 1, 59+/-0, 23, respectively 1, 61+/-0, 25 can be framed in the category of those with flatten sole.

The forming of normal sole at puberty age is not possible, but obtaining the attenuation of the sole index, at the 1,5 parameter, represents a considerable improvement of the foot's state and respectively the confirmation of the conjectures of the research.

The exercise program applied in collaboration with the school's kinetic therapist which has consisted of associating physical exercises with kinetic patterns have lead to a sure method of recovering the sole's parameters.

In analyzing the flat foot, we have come to the conclusion that through the application of certain individualized programs, the fallowed parameters have evolved favourably bearing in mind the existence of all the articulate alterations which could have delayed or dragged out the success of the recovery treatment.

The conclusions one has reached, as well as the confirmation of the research conjectures can become valid arguments in supporting the application of prophylactic, therapeutically and recovery programs to the inferior extremities level.

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LIMBS UTILIZATION PREFERENCE EFFECT ON TRUNK MUSCLES MAXIMAL ISOMETRIC STRENGTH PRODUCTION IN ROMANIAN SPORTSWOMEN

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Abstract

Straton Alexandru, Deliu Dan, Gidu Diana. Limbs utilization preference effect on trunk muscles maximal isometric strength production in Romanian sportswomen.

Background: Most problems encountered at the level of vertebral column in sportswomen is generated by asymetrical movements at the level of the trunk directly linked by preferential utilization of either superior or inferior limbs in sports training and competition.

Aims: The aim of this study is to determine the effect of limbs utilization preference on trunk muscles maximal isometric strength production in Romanian sportswomen.

Methods: This study used 15 Romanian sportswomen, white caucasian, divided in 5 handball players, 5 soccer players, 5 track and field athletes (triple jump). Body height was estimated with an error of 0,5cm. and body weight was evaluated with a calibrated digital scale (Exacta, Germany), with an error of 0.25 kilograms. The body fat percentage was estimate using a bioelectric impedance method (Omron BF-306). Maximal isometric strength of the lumbar/thoracic column was measured with special machines in all three planes – flexion with David F130 Lumbar/Thoracic Flexion at 30º angle and extension with David F110 Lumbar/Thoracic Extension at 30º angle, in sagittal plane – right lateral flexion and left lateral flexion with David F150 Lumbar/Thoracic Lateral Flexion at 0º angle, in frontal plane – right lateral rotation and left lateral rotation with David F120 Lumbar/Thoracic Rotation at -30º angle, in transversal plane.

Results: Handball players have a significantly higher maximal isometric strength for left lateral flexion then right lateral flexion (t=6,816) and track and field athletes have a significantly higher maximal isometric strength for right lateral rotation then left lateral rotation (t=5,662).
Conclusions: Sportswomen will develop the trunk strength according to preferential utilization of either superior and inferior limbs, but only in sports with strong asymetrical movements.
Keywords: maximal isometric strength, muscles, flexion, extension, lateral flexion, lateral rotation, sportswomen.

Introduction

Superior limbs preferential utilization have a higher impact, then inferior limbs preferential utilization, on trunk muscles strength development, in sedentary peoples. Is well known that, the most complex and vary movements is obtained with the help of superior limbs, then inferior limbs which presents, in general, simetrical movements with the exception of movements realised in some sports.

E. Andersson, L. Swärd, A. Thorstensson, (1988), have shown significantly differences of maximal isometric strength for flexion, extension and lateral flexion, between sports subjects (soccer players, wrestlers, tennis players and gimnasts) and sedentary subjects (all the subjects had the age between 18 and 22 years old). In flexion and right and left lateral flexion, tennis players and wrestlers have developed an isometric strength significantly higher in the same part of the trunk, with the non-dominant superior limb. Those differences recorded between sports subjects and sedentary subjects, can be related with the specificity of sports, and also, with the sistematic practice of trainning for long periods of time.

Biomechanics of tennis predispose the player in lumbar neuromuscular disbalances (significant differences between right and left side of the lumbar extensor muscles), fact correlated with the use in tennis of dominant superior limb. Therefore, those disbalances can be corrected with application of physical exercises at the level of lumbar muscles (T. Renkawitz, D. Boluki, O. Linhardt, J. Grifka, 2007; T. Renkawitz, O. Linhardt, J.Grifka, 2008).

S. Parkin, A.V. Nowicky, O.M. Rutherford, A.H. McGregor, (2001), in a study realised on 19 rowers and 20 controls (almost identical in age, height and weight), has shown that, asimetrical mioelectric activity between right extensor muscles and left extensor muscles, in extension movements, is correlating with the side in which the athlete is rowing. Even if the maximal isometric strength for trunk flexion and extension isn't significantly different between rowers and controls, mioelectric activity of muscles has been significantly higher for rowers then controls.

Hypothesis Sportswomen will develop the strength of trunk muscles according to limbs preferential utilization in sports.

Research Methods and Procedures

Participants The transversal study was conducted between July 2009 and September 2009, in Constanta. The aims and methods of the study were explained to the participants, who chose freely to participate in this study. The study was performed on 15 Romanian sportswomen divided in 5 handball players, 5 soccer players, 5 track and field athletes (triple jump), white Caucasian, with age between 16 and 43 years old, with no acute or chronic back pain. The mean age for handbal players was 24 ^{6} ± 2 ^{10} (years ^{months}), for soccer players was 26 ^{9} ± 9 ^{11} (years ^{months}) and for track and field athletes was 22 ^{1} ± 6 ^{8} (years ^{months}).

Anthropometry

Body height was evaluated with an error of 0.5 centimeters and body weight was evaluated with a calibrated digital scale (Phillips HF-351, China), with an error of 0.05 kilograms. BMI was calculated to estimate the category of weight for each subject by using the Quetelet formula (G. Dumitru, 1997; G. Dumitru, A. Suciu, 1999). BF was estimated using bioelectrical impedance method, with Omron BF-306 (bodyfat analyser) (table 1). Omron BF-306 offers strong corelated results with DEXA (Dual-Energy X-ray Absorptiometry), for bodyfat estimation (M. Lintsi, H. Kaarma, I. Kull, 2004). Fat mass was calculated by dividing the product of body weight and BF at 100.

Table 1. Physical characteristics of sportswomen (n = 15)

	Handball (n = 5)		**Soccer (n = 5)**		**Track and field (triple jump) (n = 5)**	
Variables	**M ± SD**	**CV(%)**	**M ± SD**	**CV(%)**	**M ± SD**	**CV(%)**
Body height (cm.)	174,8 ± 7,43	10,316	166.8 ± 4,438	10,039	171,4 ± 1,949	1,137
Body weight (kg.)	71,1 ± 7,335	8,561	59,6 ± 5,983	2,661	55,1 ± 3,435	6,234
BMI (kg/m^2)	23,22 ±1,005	4,328	21,385 ± 1,394	6,519	18,751 ± 1,106	5,418
Body fat (%)	21,58 ±1,683	7,799	21,72 ± 1,574	7,247	15,92 ± 1,203	7,557
Fat mass (kg.)	12,909 ±2,07	16,035	15,489 ± 2,327	15,024	8,763 ± 0,737	8,41

BMI, body mass index; M, mean; SD, standard deviation; CV, coefficient of variability; n, number of subjects.

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With one exception of one track and field athlete, which has an underweight BMI, the rest of the sportswomen have a normal weight BMI.

Preferential utilization estimation of superior and inferior limb

For the calculation of preferential utilization (dominance) of superior and inferior limb, was used Hildreth laterality index formula, which has two extremities for values: +1 for consequent right and -1 for consequent left. Also, the values between -1 and 0 is linked to left tendencies of preferential utilization, the values between +1 and 0 is linked to right tendencies of preferential utilization and 0 is linked to mixt preferential utilization. Zero value is obtained, only if the number of tests is paired. Hildreth laterality index formula is (R-L)/(R+L), where R represent the number of tests executed with the superior or inferior right limb and L represent the number of tests executed with the superior or inferior left limb (M. Dougas, 1965; D.V.M. Bishop, 2001).

As a fundamental condition, to realise the superior and inferior preferential utilization estimation, the subjects will not be informed about the tests aims, after the tests application, so that the data cannot be altered, as a consequence of physiologic influences of the subjects, regarding the final aims of these tests.

Tests for estimation of superior limb dominance

Test no. 1 Handclap.

Test no. 2 Cut with scissor a model (square) from the paper.

Test no. 3 Tennis ball throwing, form above the head, with one hand to a target.

Test no. 4 Write your name, surname, address, telephone number and e-mail on your paper sheet.

Tests for estimation of inferior limb dominance

Test no. 1 Kicking a tennis ball with the foot, between two landmarks.

Test no. 2 Executing a big step forward.

Test no. 3 Running and takeoff on a single leg to execute a high plyometric skipping (pop-up).

Test no. 4 Stair climbing.

Maximal isometric strength estimations and analysis for lumbar-thoracic column

Maximal isometric strength, at the level of lumbar-thoracic column, was estimated, for extension at 30 degrees, using F 110 Lumbar/Thoracic Extension device (Fig. 1) (David Fitness & Medical Ltd., Karitie 9, 01530 Vantaa, Finland), for flexion at 30 degrees, using David F 130 Lumbar/Thoracic Flexion device (Fig. 2), for lateral flexion at 0 degrees, using David F 150 Lumbar/Thoracic Lateral Flexion device (Fig. 3) and for lateral rotation (by moving the inferior limbs) at -30 degrees, using David F 120 Lumbar/Thoracic Rotation device (Fig. 4).

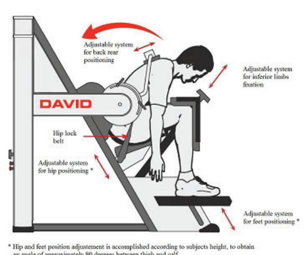
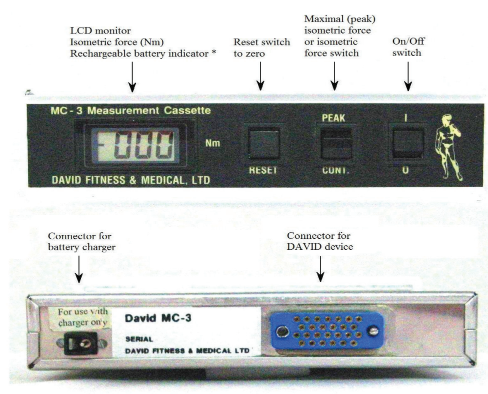


Figure 1. David F110 Lumbar/Thoracic Extension device

Figure 2. David F130 Lumbar/Thoracic Flexion device

Figure 3. David F150 Lumbar/Thoracic Lateral Flexion device

Figure 4. David F120 Lumbar/Thoracic Rotation device



* When rechargeable battery symbol appears on LCD monitor, the battery will hold approximately for one hour. When rechargeable battery symbol flashes, it must be recharged. Recharging the battery will take approximately six hours. Full recharged battery will function approximately 40 hours.

Figure 5. Digital test module MC-3

Maximal isometric strength results were recorded on MC-3 microcomputer (Fig. 5), which was connected on each DAVID device.

Maximal isometric strength estimation, for all DAVID devices, at the level of lumbar-thoracic column, was estimated with hip and inferior limbs locked in a sitting position. Subjects were instructed to execute all the movements (flexion, extension, lateral flexion and lateral rotation), at the level of lumbar-thoracic column, by developing a progresive isometric strength, avoiding sudden or uncontrollable movements (which could lead to eronated values of maximal isometric force), for 5 seconds, maximal isometric strength being recorded in the last second of the test.

Statistical analisys

Data are presented as the mean (M) ± standard deviation (SD). Dependent student t test was used to examine the differences of maximal isometric strength between flexion and extension at 30 degrees, between right lateral flexion and left lateral flexion at 0 degrees and between right lateral rotation and left lateral rotation at -30 degrees, for all sports. Independent student t test was used to examine the differences between all lateral movements strength ratios and strength ratio perfectly balanced (when all strength ratios are equals to 1).

Independent one-way ANOVA test and TUKEY HSD post independent one-way ANOVA test were used to examine the differences of maximal isometric strength between handbal players, soccer players and track and field (triple jump) athletes, for all movements. The same tests were used to examine the differences between handbal players, soccer players and track and field (triple jump) athletes, for all strength ratios (R. Lowry, 2000; R.J. Thomas, J.K. Nelson, 1996; D.J. Sheskin, 2004).

The significance level (α – alfa) was set at $p < 0.05$ (R.L. Lieber, 1990a; R.L. Lieber, 1990b; R.J. Thomas, J.K. Nelson, 1996).

Results

Table 2. Mean results of Hildreth laterality index for sportswomen (n=15)

Sports		Hildreth Laterality Index Superior limb	Inferior limb
Handball (n = 5)	M ± SD	0,6 ± 0,894	0,2 ± 0,758
	CV(%)	149	379
Soccer (n = 5)	M ± SD	0,9 ± 0,224	0,6 ± 0,418
	CV(%)	24,889	69,667
Track and field (triple jump) (n = 5)	M ± SD	0,9 ± 0,224	0,8 ± 0,274
	CV(%)	24,889	34,25

M, mean; SD, standard deviation; CV, coefficient of variability; n, number of subjects.

Table 3. Means of maximal isometric strength results for flexion, extension, lateral flexion and lateral rotation for sportswomen (n=15)

Sports		F130 Flexion (Nm) 30º	F110 Extension (Nm) 30º
Handball (n = 5)	M ± SD	149,2 ± 20,117 [a d]	257,8 ± 44,724
	CV(%)	13,483	17,348
Soccer (n = 5)	M ± SD	110 ± 22,372 [b]	197,8 ± 30,866
	CV(%)	20,338	15,605
Track and field (triple jump) (n = 5)	M ± SD	137,8 ± 23,805 [c]	246,6 ± 52,828
	CV(%)	17,275	21,423

		F150 Lateral flexion (Nm)	
Sports		**Right 0º**	**Left 0º**
Handball (n = 5)	M ± SD	154,6 ± 17,271 [e]	182 ± 20,236 [g]
	CV(%)	11,171	11,119
Soccer (n = 5)	M ± SD	125,8 ± 30,499	133 ± 28,373
	CV(%)	24,244	21,333
Track and field (triple jump) (n = 5)	M ± SD	118,4 ± 16,622 [f]	128,8 ± 17,712
	CV(%)	14,039	13,752
		F120 Lateral rotation (Nm)	
Sports		**Right -30º**	**Left -30º**
Handball (n = 5)	M ± SD	103,6 ± 27,628 [i]	106 ± 25,05 [j]
	CV(%)	26,668	23,632
Soccer (n = 5)	M ± SD	52,8 ± 20,981	64,8 ± 21,933
	CV(%)	39,737	33,94
Track and field (triple jump) (n = 5)	M ± SD	93 ± 10,223 [h]	88,4 ± 9,343
	CV(%)	10,992	10,569

a – significantly different than F110 Extension, 30º, for handball players, t=5,857;
b – significantly different than F110 Extension, 30º, for soccer players, t=9,845;
c – significantly different than F110 Extension, 30º, for track and field (triple jump) athletes, t=7,649;
d – significantly different than F130 Flexion, 30º, for soccer players and track and field (triple jump) athletes, $F(2, 12) = 4,143$; critical value of Tukey HSD test is 37,345, $p<0,05$; significantly difference between handball players and soccer players for F130 Flexion, $t_{TukeyHSD} = 39,2$.
e – significantly different than F150 Left lateral flexion, 0º, for handball players, t=6,816;
f – significantly different than F150 Left lateral flexion, 0º, for track and field (triple jump) athletes, t=5,674;
g – significantly different than F150 Left lateral flexion, 0º, for soccer players and track and field (triple jump) athletes, $F(2, 12) = 8,587$; critical value of Tukey HSD test is 38,053, $p<0,05$; significantly difference between handball players and soccer players for F150 Left lateral flexion, $t_{TukeyHSD} = 49$; significantly difference between handball players and track and field (triple jump) athletes for F150 Left lateral flexion, $t_{TukeyHSD} = 53,2$.
h – significantly different than F120 Left lateral rotation, -30º, for track and field (triple jump) athletes, t=5,662;
i – significantly different than F120 Right lateral rotation, -30º, for soccer players and track and field (triple jump) athletes, $F(2, 12) = 8,236$; critical value of Tukey HSD test is 35,205, $p<0,05$; significantly difference between handball players and soccer players for F120 Right lateral rotation, $t_{TukeyHSD} = 50,8$; significantly difference between soccer players and track and field (triple jump) athletes for F120 Right lateral rotation, $t_{TukeyHSD} = 40,2$.
j – significantly different than F120 Left lateral rotation, -30º, for soccer players and track and field (triple jump) athletes, $F(2, 12) = 5,349$; critical value of Tukey HSD test is 33,699, $p<0,05$; significantly difference between handball players and soccer players for F120 Left lateral rotation, $t_{TukeyHSD} = 41,2$.

Significance level set at $p<0,05$.

M, mean; SD, standard deviation; CV, coefficient of variability; n, number of subjects; t, student t test; Nm, Newton*metre.

Table 4. Means of maximal isometric strength ratios results for sportswomen (n = 15)

Strength ratios		**Handball (n = 5)**	**Soccer (n = 5)**	**Track and field (triple jump) (n = 5)**
F130 Flexion/ F110 Extension (**30º**)	M ± SD	0,589 ± 0,109	0,556 ± 0,075	0,565 ± 0,05
	CV(%)	18,506	13,489	8,85
F150 Right lateral flexion/ F150 Left lateral flexion (**0º**)	M ± SD	0,851 ± 0,044 [a b]	0,942 ± 0,056 [c]	0,919 ± 0,03 [d]
	CV(%)	5,17	5,945	3,264
F120 Right lateral	M ± SD	0,972 ± 0,07	0,825 ± 0,227	1,052 ± 0,019 [e]

rotation/ F120 Left lateral rotation **(-30º)**	CV(%)	7,202	27,515	1,806

a – significantly different than strength ratios mean F150 Right lateral flexion/ F150 Left lateral flexion, 0º, for soccer players and track and field (triple jump) athletes, $F(2, 12) = 5,5$; critical value of Tukey HSD test is 0,075, $p<0,05$; significantly difference between handball players and soccer players for strength ratios mean F150 Right lateral flexion/ F150 Left lateral flexion, $t_{TukeyHSD} = 0,091$.
b – significantly different than strength ratios mean F150 Right lateral flexion/ F150 Left lateral flexion perfectly balanced (when all strength ratios are equals to 1), 0º, t=7,572;
c – significantly different than strength ratios mean F150 Right lateral flexion/ F150 Left lateral flexion perfectly balanced (when all strength ratios are equals to 1), 0º, t=2,316;
d – significantly different than strength ratios mean F150 Right lateral flexion/ F150 Left lateral flexion perfectly balanced (when all strength ratios are equals to 1), 0º, t=6,037;
e – significantly different than strength ratios mean F120 Right lateral rotation/ F120 Left lateral rotation perfectly balanced (when all strength ratios are equals to 1), -30º, t=6,12;
Significance level set at $p<0,05$.
M, mean; SD, standard deviation; CV, coefficient of variability; n, number of subjects; t, student t test.

Discussion

Sportswomen had generated a maximal isometric strength significantly higher in extension, then flexion (table 3, a, b, c). In flexion handball players had generated a maximal isometric strength significantly higher then soccer players, fact generated by different specific and general training per sports.

Preferential utilization of superior and inferior limbs means (table 2), per sports, is showing a mjority orientation of sportswomen for right consequent and right allmost consequent preferential utilization (with two exceptions – one handball player who has left consequent preferential utilization of superior and inferior limbs and one soccer players who has mixt preferential utilization of inferior limbs).

Handball players and track and fields athletes had a maximal isometric strength for left lateral flexion significantly higher then maximal isometric strength for right lateral flexion (table 3, e, f; table 4, b, d). Soccer players had a slight disbalance for lateral flexion movements (table 4, c). The biggest disbalance of leteral flexion movements, was recorted in handball players, fact generated by right superior limb preferential utilization (a pronounced right superior limb preferential utilization) in training and competition. Also, maximal isometric strength for left lateral flexion in handball players is significantly higher then maximal isometric strength for left lateral flexion in soccer players and track and field athletes (table 3, g). The difference of lateral flexion strength ratios between handball players and soccer players and, respectively, track and field athletes, is strengthening the disbalance between right and left lateral flexion strengths in handball players (table 4, a).

For right lateral rotation, handball players and track and field athletes had generated a maximal isometric strength significantly higher then soccer players (table 3, i) and for left lateral rotation only handball players had generated a maximal isometric strength significantly higher then soccer players (table 3, j). Track and field athletes had generated a maximal isometric strength significantly higher for right lateral rotation then left lateral rotation (table 3, h), fact also sustained by the difference recorded between the right and left lateral rotation ratios and perfect right and left lateral rotation ratios (when all strength ratios are equals to 1) (table 4, e). The specificity of triple jump training can be the main reason for this asymetrical development of strength for lateral rotation.

Small levels of maximal isometric strength recorded in soccer players, is showing a weak general and specific physical preparation for strength. Even if there is a small level of strength generated by soccer players, the training in soccer, implies a development of strength at the level of lumbar-thoracic column, almost balanced. However, right and mixt preferential utilization of inferior limbs in soccer players, implies a typical development of strength for lateral rotation (a powerful development of strength for left lateral rotation).

Preferential utilization of right superior limb in almost all handball players, generates a major disbalance of strength for lateral rotation. Also, from all sportswomen, handball players had generated the most powerful strength in all movements, fact generated by general and specific training from handball.

Preferential utilization of superior and inferior limbs for track and field athletes, implies a generation of strength almost similar as sedentary subjects with right superior and inferior limbs pereferential utilization.

As a result of global analysis of these data recorded, preferential utilization of superior limbs, have the tedency to produce disbalances of antagonistic muscles at the level of vertebral column, much more accentuated, then preferential utilization of inferior limbs. Anyway, these facts are yet disputable, from which is resulting the necesity of doing more experimental studies on this topic.

Conclusion

Sportswomen will develop the trunk strength according to preferential utilization of either superior and inferior limbs, but only in sports with strong asymetrical movements.

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