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EFFECTS OF SPECIFIC MUSCLE IMBALANCE IMPROVEMENT TRAINING ON THE BALANCE ABILITY IN ELITE FENCERS

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The purpose of this study was to investigate the effects of specific muscle imbalance improvement training (SMIIT) on the balance ability. Subjects were 9 male national team fencers with 28.2±2.2 yrs, 182.3±4.0 cm, and 76.5±8.2 kg. The SMIIT included flexibility training, Pilates, muscle balance training and was conducted for 12 weeks with 4 times per week. As a result, there was no significant difference in COM dispersion among static balance maintaining abilities, but reduction in the COP dispersion was shown. In conclusion, SMIIT seemed to affect in improving dynamic balance maintaining abilities especially in non-dominant leg.

KEY WORDS: fencing, muscle imbalance, training, dispersion.

INTRODUCTION: According to a study by Harmer (2008), injury positions of 78,223 fencers from 2001 to 2006 were mostly on the knees and ankles, and over 73% reported that their injuries on the knees were related to quadriceps. Murgu & Buschbacher (2006) also reported that fencers often complained of anterior knee pains and suggested good knee alignment and strong muscles would be helpful for the stability of the knees to prevent from re-occurring injuries. The types of injuries differ somewhat depending on event, but occur in various ways such as on the head, upper or lower limbs. Jacobsson et al. (2012) and Junge et al. (2009) investigated that the cause of either temporary or multiple injury frequency was rather the decline of physical efficiency during activities than excessive uses of the body. Yang (2008) also reported that the body parts with the frequent occurrences of injuries due to the decline of physical efficiency are concentrated on the lower limbs, and the main risk includes muscle imbalance. It seems that fencers' muscle imbalance should be resolved. Therefore, the purpose of this study was to develop the Specific Muscle Imbalance Improvement Training (SMIIT) and investigates the effects of SMIIT on the balance ability of national team fencers.

METHODS

Subjects

Nine right-handed male Korean national team fencers in (epee: 4, sabre: 5) participated in the study (28.2±2.2 yrs in age, 182.3±4.0 cm in height, 76.5±8.2 kg in weight, 12.4±3.0 yrs in career).

Experimental Devices

Both kinetic and kinematic movement of the fencers were recorded by a motion analysis system (Eagle) and force platforms (Kistler9287BA). For motion analysis, Helen hayes marker set was used. Balance testing was performed on a Biodex Balance System (Biodex SD). And post processing was performed by Cortex 3.0, Matlab (2009b), Visual3D (Standard v.4.91.0).

Procedures

Pre-measurement was carried out at the Korea Institutes of Sports Science in Seoul in April 2012, and all the subjects warmed up and stretched for about 30 minutes to prevent injuries during the experiment. After reflective markers were attached, the subjects were required to stand on the force platform as still as possible while the measurement was taken. Balancing was measured after carrying out deep squat motions, and all the motions were carried out three times. Then static, dynamic and passive stretching, pilates exercise, SMIIT, additional

core and lower limbs strengthening training program were conducted for 12 weeks (Table 2). Post-measurement was carried out at the same place in August after participating in the 2012 London Olympics.

Table 2. Training Program

	Training details	Intensity& frequency
Flexibility training	-To increase joint range of motion through muscular isolation training -Rotate the joint or move rhythmically -Extra training for the fingers, wrists, knees, and ankles and toes	- 30~40 min, 3 sets, 4 times/ 12 weeks, 10~20 min. Stretching before and after exercise - At the Olympic Training Center: Using BOSU & Medicine Ball with 60~75% of 1 RM - During Games: Using tubing and foam pad.
Pilates training	Stage 1: Consists of basic motions focused on core strengthening and correcting left-right imbalance. Stage 2: Adds more complicated movements to focus on enhancing coordination or rhythmic movements. Stage 3: Increases the core muscular strength and adds endurance exercises to focus on enhancing stamina.	
Muscle balance training	-5 exercises for upper limbs, 4 for core and 4 for lower limbs Upper limbs: biceps curl, arm pushing, dumbbell raises, dumbbell pronation, back extension Core: side band, side sit-up, side lunge, leg raise Lower limbs: single leg-extension, single leg curl, single leg press, single calf raise	

Data analysis

Dispersion X, Y and Z of COM refer to sway in medio-lateral, antero-posterior and superior-inferior directions, respectively during a fixed posture. And they can be divided into the mean medio-lateral distance of movement (A_x) of COM, the mean antero-posterior distance of movement (A_y) of COM, and the mean superior-inferior distance of movement (A_z) of COM. In addition, the mean distances of movement and changes of location coordinate of COM were calculated in the absolute value during the time required for each trial in which measurements were carried out as follows:

$$\text{dispersion X} = \frac{\sum_{i=1}^{n} Absolute\ value\ of\ (A_x\,(i) - AverageA_x)}{n},$$

$$\text{dispersion Y} = \frac{\sum_{i=1}^{n} Absolute\ value\ of\ (A_y\,(i) - AverageA_y)}{n},$$

$$\text{dispersion Z} = \frac{\sum_{i=1}^{n} Absolute\ value\ of\ (A_z\,(i) - AverageA_z)}{n}$$

Where Dispersion X, Y and Z refer to the distances of the medio-lateral, antero-posterior and superior-inferior movements (cm) of COM, respectively and (A_x), (A_y) and (A_z) refer to the medio-lateral, antero-posterior and superior-inferior samples of COM (i=1through n), respectively. The COP X, Y is the same as the above formula was calculated.

The balance measurement was carried out by using Biodex Balance System SD (BBS; USA), to measure the ability of maintaining dynamic balance. The participant was required to stand still standing on both feet on a dynamic measuring instrument spreading with both arms spread out for 1 minute. The device inclines in various directions and imbalances are scored by the amount of inclination they can perform without movement. It has a 6-point scale, in which the lower the score is, the better the balance gets. It presents results classified into medio-lateral and antero-posterior directions

RESULTS: The results are shown in the Table 3.

Table3. Result of balance test

				Pre (n=9)	Post (n=8)	t	p
				Mean±SD	Mean±SD		
One leg stand	Dispersion of COM (cm/ht)	R	AP	7.34±6.99	5.64±3.17	0.909	.197
			ML	4.52±1.17	4.33±1.55	0.589	.287
			SI	3.52±1.72	4.30±2.64	0.184	.430
		L	AP	7.27±9.48	4.24±2.71	0.817	.221
			ML	5.32±3.54	4.59±1.25	0.381	.358
			SI	2.28±1.48	2.17±1.26	-0.810	.223
	Dispersion of COP (cm/fl)	R	AP	11.84±8.64	6.85±1.30	0.514	.312
			ML	8.46±2.78	6.64±1.96	0.446	.335
		L	AP	8.18±6.13	7.16±1.52	1.839	.054
			ML	8.55±4.46	7.95±1.52	2.469	.022*
Deep squat	Dispersion of COP (cm/fl)	P1	AP	5.66±3.23	5.51±0.97	0.118	.455
			ML	14.76±7.18	9.95±2.54	1.953	.046*
		P2	AP	8.39±7.25	5.09±1.36	1.401	.102
			ML	7.73±3.57	8.62±4.64	-0.372	.361
Balance scale		R	AP	2.71±1.60	1.90±1.11	1.394	.103
			ML	1.96±0.92	1.55±0.85	0.991	.197
		L	AP	3.14±1.72	1.81±0.92	2.512	.020*
			ML	2.55±1.23	1.75±0.93	1.591	.078

note: One leg stand and Deep squat mean result of motion analysis system, Balance scale means result of Biodex Balance System.

DISCUSSION: The COM dispersion was normalized and presented according to the individual fencers' heights, and in all medio-lateral, antero-posterior and superior-inferior directions, there was no significant difference between pre-measurements and post-measurements in left feet standing and right feet standing motions. In the COP dispersions, there was no significance difference in the antero-posterior direction of the left feet standing, but in medio-lateral direction, it decreased from 8.55 cm/foot length to 7.95 cm/foot length after. A study by Cheng et al. (2001) reported that weight distribution training that provided visual feedback of the COP enhanced balance maintaining ability. Similar with this study, the COP dispersion after the SMIIT also decreased. This result implies that the fencers' balance maintaining ability improved. For the trajectory of the COP during deep squat, the vectors of the COP on the left foot and the right foot were analyzed and converted to one vector (Zatsiorsky, 2002), and it was normalized and presented normalized according

to the foot length and performance time of individual subjects. Phase 1 means the sitting phase while phase 2 means standing. There was a significant difference in the medio-lateral direction in P1 between the times of measurement ($p<0.05$). For balance scale, there was no significant difference between the times of measurement in medio-lateral direction and antero-posterior direction on the right foot standing. On left foot standing, there was a significant difference between before(3.14) and after(1.81) the SMIIT($p<0.05$).

CONCLUSION: 1) In one leg stand motion, COM dispersion factor did not change after SMIIT; 2) Since COP dispersion in medio-lateral direction of the left foot standing motion and the deep squat motion decreased after the application of the SMIIT, it can be stated that the balance maintaining ability was enhanced; 3) Since antero-posterior scale of the left foot standing motion decreased after the application of SMIIT, the dynamic balance maintaining ability was enhanced. Therefore, the muscle imbalance was improved after the application of SMIIT especially in the non-dominant leg.

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