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The effect of eight weeks of flexibility training on step length, range of motion, and balance of middle-aged men and women with ectomorph and endomorph body types

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ABSTRACT

Since flexibility training can increase range of motion and prevent joint stiffness, the purpose of the present research was to examine the effect of eight weeks of flexibility training on step length, range of motion, and balance of middle-aged men and women with ectomorph and endomorph body types. 48 healthy, middle-aged men and women (40-60 years of age) volunteered for the study. Using Heath-Carter method of somatotyping, the participants were divided into Ectomorph (12 men and 12 women; 55.5 ±2.6 yrs.; weight of 72.5 ±3.3 kg; height of 170.1 ±0.04 cm; BMI of 25.40 ± 3.3 kg/m^2) and Endomorph (12 men and 12 women; 53.2 ± 2.4 yrs.; weight of 80.2 ± 2.1 kg; height of 167.8 ± 1.1 cm; BMI of 30.51 ± 2.5 kg/m^2) groups. Both groups participated in a flexibility training program for eight weeks, with three 30-minute sessions per week. The exercises focused on upper and lower body flexor and extensor muscles. Step length, range of motion, and dynamic balance were measured, and T-test was used for data analysis at the 0.05 significance level. There were no significant differences between the Ectomorph and Endomorph groups in the pre-test. However, significant post-test differences were observed between the two groups in step length, range of motion, and dynamic balance. The results showed that step length, range of motion, and balance were affected by somatotype. Therefore, body type must be accounted for in prescribing flexibility exercises for middle-aged people.

Keywords: Flexibility training, step length, dynamic balance, range of motion

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INTRODUCTION

Many organizations, institutions, and universities have recommended aerobic and flexibility training. After the publication of the national guidelines on physical activity and public health by the Center for Disease Control and Prevention, the number and diversity of recommendations for flexibility and cardiovascular exercises increased dramatically, leading to much confusion among health professionals [2, 3]. As a result, in 1998, the American College of Sports Medicine (ACSM) provided a comprehensive guideline for the quality and quantity of flexibility and cardiovascular exercise [1]. Of course there is still room for new findings in this regard with respect to different age groups, professions, demands, and social groups [1].

Flexibility has been defined as the range of motion of muscles and connective tissues at a joint or group of joints [4]. Flexibility exercises can increase the length and elasticity of muscles and periarticular tissues, and thus reduce the risk of injuries [5]. Bischoff and Roos (2003) found that performing regular exercisescan significantly increase the ROM of upper and lower extremities. The mechanisms for this are reduced pain and increased extensibility of periarticular tissues [6]. Woolstenhulme et al. (2006) showed that theflexibility of muscles, tendons, and ligaments decreases with age [7].

A well-established notion in sport and physical fitness is that insufficientrange of motion and joint stiffness can increase the individual's vulnerability during exercise and other physical activities [8]. Carvalho et al. (2009) found that women get better results from flexibility exercises than men do [9].

Step length is another kinematic measure that has received attention in evaluating the gait of middle-aged and elderly individuals. Increased step length and its regulation are important factors that are influenced by flexibility exercises [10]. Bird et al. (2010) considered step length and balance as the most important factors in preventing falls and maintaining the musculoskeletal health of older adults. They also reported that multi-component exercisesthat include strengthening and stretching can improve balance in the long run [11]. Newsom et al. (2004) reviewed more than 30 studies on prescription of physical fitness exercises for older adults and found that these exercises affect various mobility factors, including strength, resistance, and musculoskeletal balance [12].

Obesity is an important factorassociated with changes in lifestyle, mainly caused by high-calorie intake and insufficient physical activity. Thus, it is imperative to examine the causes of obesity and its relationship with physical activity [19]. Having reviewed the literature, there were no studies on balance and step length in older adultsthat accounted for body type. Therefore, the purpose of the present research was to examine the effect of eight weeks of flexibility training on step length, range of motion, and balance of middle-aged men and women with ectomorph and endomorph body types.

MATERIALS AND METHODS

The population consisted of randomly selected healthy adults. The sample included 48 adults (40-60 years of age) who were divided into Ectomorph (12 men and 12 women; 55.5 ± 2.6 yrs.; weight of 72.5 ± 3.3 kg; height of 170.1 ± 0.04 cm; BMI of 25.40 ± 3.3 kg/m^2) and Endomorph (12 men and 12 women; 53.2 ± 2.4 yrs.; weight of 80.2 ± 2.1 kg; height of 167.8 ± 1.1 cm; BMI of 30.51 ± 2.5 kg/m^2) groups.

After obtaining informed consent from the participants, their age, height, and weight were measured, and Heath-Carter method of somatotyping was used to determine their body type. This method involves 10 anthropometric measurements: height, weight, triceps skinfold, subscapular skinfold, supraspinale skinfold, medial calf skinfold, biepicondylar breadth of the humerus, biepicondylar breadth of the femur, upper arm girth, and calf girth.A sliding caliper, skinfold caliper, tape measure, and weighting scale were used for measuring these variables. Moreover, range of motion (goniometer), dynamic balance (Biodex System), and step length (tape measure) were measured.

The participants were divided into Ectomorph and Endomorph groups based on Heath-Carter method, and they performed the ACSM exercise protocol (2010) for eight weeks, with three 30-minute sessions per week. In these sessions, basic warm-up and stretching exercises were performed on flexor and extensor muscles of the upper and lower limbs and the trunk. The participants began each session with a 30-minute warm-up, which included: neck extension, flexion, lateral flexion, and rotation;trunk flexion, extension, and lateral bending; and squat, bending the knee toward the chest, and bending the knee and bringing the heel toward the hips. The main exercise consisted of stretching the major muscles of the trunk and limbs (20 minutes). Finally, the same warm-up exercises were performed as cool-down (20 minutes). Range of motion, step length, and dynamic balance were again measured at the end of the training period.

- Dynamic balance was measured using the Biodex Balance System (BSS). Before training, the participants were convened at a biomechanics laboratory and were given an overview of the testing procedure. BSS has 5 levels of difficulty, with 1 being the easiest and 5 being the most difficult. Based on the instructions of the system's manual, Level 2 was considered appropriate for the middle-age participants of this study.According to the Level 2 protocol, the individual has to maintain balance on an unstable platform in horizontal (X), vertical (Y), and diagonal (Z_1 and Z_2) axes. During the test, BSS provides feedbacks using which the individual can correct their stance. This test was performed three times with half an hour intervals in order to diminish the learning effect. Then, the participants performed the test for the fourth time and their score was recorded as the pretest. After the eight-week training period, the participants performed the posttest.
- Range of motion was measured using a goniometer. The test was elaborated for the participants and they were instructed to perform ankle flexion, ankle extension, hip abduction, and lumbar flexion (finger-ground distance). Then, the range of motion in these movements were recorded using a goniometer before and after training.
- Step length was measured using talcum powder and tape measure. Leg length (from anterior superior iliac spine to the medial malleolus) was measured in order to normalize the data. After providing the instructions, each participant

passed along a 10-meter line drawn on the ground six times to become familiar with the test procedure. The sole of the participants was covered with talcum powder and the examinerrecorded the distance between the heel strike of one foot and the heel strike of the opposite foot. The same procedure was followed in the pretest and posttest.

Descriptive statistics were used to provide the mean and standard deviation of the data. Kolmogorov-Smirnov test was applied to examine the normal distribution of data. Also dependent and independent t-tests were used for within-group and between-group differences at the 0.05 significance level.

RESULTS

Based on the data in Table 1, an increase was observed between the pretest and posttest data of the Ectomorph group in ankle flexion (4.43%), ankle extension (3.05%), hip abduction (2.45%), balance in the X (1.37%), Y axis (1.29%), Z_1 (1.95%), and Z_2 (2.31%) axes, and step length (0.29%). However, finger-ground distance decreased in the posttest (8.91%). In the Endomorph group, an increase was observed between the pretest and posttest ankle flexion (4.17%), ankle extension (1.31%), hip abduction (3.35%), balance in the X (0.57%), Y axis (0.65%), Z_1 (0.49%), and Z_2 (0.77%) axes, and step length (0.51%), while finger-ground distance decreased in the posttest (10.99%).

Table 1. Mean and standard deviation of kinematic parameters (step length, range of motion, and balance) in the pretest and the posttest

Variables	Ectomorph Group		Endomorph Group	
	Pretest	Posttest	Pretest	Posttest
Ankle flexion (cm)	23.82 ± 1.41	26.03 ± 1.81	23.75 ± 1.29	25.82 ± 1.41
Ankle extension (cm)	52.25 ± 1.81	55.53 ± 1.64	50.89 ± 1.16	52.25 ± 1.81
Hip flexion (cm)	47.71 ± 3.50	50.10 ± 3.80	43.64 ± 1.54	46.67 ± 1.58
Finger-ground distance (cm)	9.17 ± 1.80	7.67 ± 2.45	12.78 ± 1.28	10.25 ± 1.23
Balance in the X axis (cm)	74.65 ± 2.97	76.71 ± 3.21	73.62 ± 2.90	74.46 ± 2.85
Balance in the Y axis (cm)	77.48 ± 3.27	79.50 ± 3.86	77.59 ± 1.52	78.59 ± 1.09
Balance in the Z_1 axis (cm)	50.68 ± 4.40	52.69 ± 4.33	48.92 ± 1.66	49.40 ± 2.20
Balance in the Z_2 axis (cm)	55.98 ± 3.08	58.62 ± 3.01	52.85 ± 1.23	53.66 ± 1.94
Step length (cm)	18.39 ± 1.10	18.50 ± 1.17	21.78 ± 1.28	22.00 ± 1.36

Table 2. Comparison of the pretest and posttest data of the Endomorph and Ectomorph groups using dependent t-test

Variable	Group	Mean Difference	t	Sig.
Step length	Ectomorph	-0.11	-3.44	0.002
	Endomorph	-0.22	-4.29	0.001
Ankle flexion	Ectomorph	-2.21	-4.29	0.001
	Endomorph	-2.07	0.04	0.01
Ankle extension	Ectomorph	-3.28	-2.20	0.005
	Endomorph	-1.36	-0.82	0.045
Hip abduction	Ectomorph	-2.39	2.22	0.003
	Endomorph	-3.03	0.11	0.030
Finger-ground distance	Ectomorph	1.5	1.16	0.003
	Endomorph	2.53	2.13	0.040
Balance in the X axis	Ectomorph	-2.06	-3.04	0.001
	Endomorph	-1.02	-1.46	0.045
Balance in the Y axis	Ectomorph	-2.02	-2.81	0.001
	Endomorph	-1	-1.13	0.045
Balance in the Z_1 axis	Ectomorph	-2.01	-3.31	0.001
	Endomorph	-0.48	-0.01	0.01
Balance in the Z_2 axis	Ectomorph	-2.64	-4.50	0.001
	Endomorph	-0.81	-0.98	0.040

Based on the data in Table 2, the training period has had a significant effect on ankle flexion, ankle extension, hip abduction, finger-ground distance, and balance in the X, Y, Z_1, and Z_2 axes in both the Ectomorph and the Endomorph groups.

The results of independent t-test in Table 3 indicate significant differences between the Ectomorph and Endomorph groups in step length, range of motion, and dynamic balance.

Table 3. Comparison of the posttest data of Ectomorph and Endomorph groups using independent t-test

Variable	df	Mean Difference	t	Sig.
Step length	46	-3.50	-5.67	0.001
Ankle flexion	46	2.21	-0.04	0.03
Ankle extension	46	3.28	0.82	0.040
Hip abduction	46	6.43	-0.24	0.020
Finger-ground distance	46	-2.58	2.40	0.045
Balance in the X axis	46	2.25	-1.04	0.01
Balance in the Y axis	46	1.91	0.70	0.001
Balance in the Z_1 axis	46	3.29	2.24	0.012
Balance in the Z_2 axis	46	4.96	-3.01	0.003

DISCUSSION

The purpose of the present research was to examine the effects of eight weeks of flexibility training on a selected kinematic parameters (step length, range of motion, and balance) in middle-aged men and women with ectomorph and endomorph body types. The results indicatedthat all these parameters improved in the posttest in both groups. The Endomorph group outperformed the Ectomorph group in step length, while the Ectomorph group outperformed the Endomorph group in range of motion and dynamic balance.

In many studies on the importance and improvement of flexibility, range of motion can temporarily increase following flexibility exercises. However, long-term increase in range of motion can be expected after at least 3 to 4 weeks of flexibility training [13, 14, 15]. The results of the present research showed that the range of motion of ankle flexors, ankle extensors, and hip abductors significantly increased in the posttest (after 8 weeks of training). Due to the importance of these muscles in measuring flexibility [14], increased ROM of these muscles indicates increased flexibility in middle-aged individuals as a result of flexibility training.

Lumbar flexion is another important measure in flexibility [16], and in the present research it was measured by recording the distance between fingers and the ground. The results indicated a significant decrease in finger-ground distance in the posttest, suggesting that the participants were able to bend the trunk further toward the floor. Therefore, lumbar flexion also increased in the posttest.

The present findings are consistent with the results of Bischoff and Roos (2003), Hunter et al. (2004), and Woolstenhulme et al. (2006) [6, 17, 7]. There has been no study on flexibility training that focuses on somatotype. The reason for greater range of motion in ectomorphs compared to endomorphs is probably due to lower muscle component, higher height-weight ratio, and an elevated position of the body's center of mass in ectomorphs [18, 19]. Step length was another kinematic parameter that has received attention in the study of gait in older adults [10]. The ability to take longer, more regular steps has always been considered as a positive factor in evaluating the effects of flexibility exercises [10]. The results of the present research showed that step length significantly improved in the posttest, and an increase in the walking speed of the participants is also expected. This is consistent with the results of Bird (2010) and Bell (2010) [11, 20], and there are no studies that prove otherwise.

Balance is an important issue in evaluating the effectiveness of flexibility training. In this research, balance was measured using the Biodex Balance System (BSS). BSS has several protocols for measuring balance, but considering the age of the participants and the risk of falling, the easiest protocol was used in the present research. The participants stood on the unstable surface of BSS and tried to maintain their balance for 3 minutes. Balance was measured in the horizontal, vertical, and diagonal (45° and 135°) axes. The findings suggested that balance improved in all directions after the training period. This clearly shows that stretching andflexibility training can improve balance in middle-aged individuals. Of course this is not a new finding and many studies have reported similar results [1, 10, 11]. The reason is that physical activities improve balance by changing the systems involved in maintaining balance [21]. Changes in body composition following a successful training program (decrease in body mass or weight) can also be effective in maintaining balance. Furthermore, many studies have shown that any form of physical exercise improves postural control. Thus, training programs can improve balance by affecting other physical factors, changing the mechanisms involved in maintaining balance, and improving divided attention and focus [21, 22]. The present findings are also consistent with the results of Bird et al. (2010), McMillan (2006), Blair et al. (2001), and Newsom (2004) [23, 16, 11, 12]. However, Swaney and Hess (2003) and Lewarchick (2003) concluded that core stability training has no effect on balance [24, 25]. This inconsistency can be attributed to differences in training protocols, subjects, and subjects' interest in the protocols.

CONCLUSION

In sum, the results of the present research suggested that flexibility training can improve step length, balance, and range of motion in ectomorphs and endomorphs. The endomorphs achieved better results in step length, while the ectomorphs achieved better results in balance and range of motion. A significant difference was observed between men and women, with women obtaining better results than men.

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