J Int Acad Phys Ther Res 2020; 11(4): 2197~2202
ISSN 2092-8475

www.iaptr.org
https://doi.org/10.20540/JIAPTR.2020.11.4.2197

Effects of Self Exercise Program on Leg Length and Balance in Subjects with Leg-Length Discrepancy

Background: If there is a difference in leg length, the center of gravity shifts unilaterally toward the short leg, causing loss of balance and secondary postural imbalance, trunk muscle tone changes, gait abnormalities and pelvic imbalance.
Objectives: To investigate effects of self exercise program on leg length, balance in adults with leg-length discrepancy.
Design: Single blind randomized controlled trial.
Methods: Twenty-eight participants were selected and divided into resistance exercise, flexibility exercise, and core exercise. Each exercise was performed for 40 minutes, 3 times a week for 6 weeks. Leg length and balance before and after exercise were measured and analyzed.
Results: Following the interventions, resistance exercise group showed significant improvement in balance, but leg length difference did not show significant results. Flexibility exercise group showed significant improvement in leg length difference, but balance did not show significant results. Core exercise group showed significant improvement in leg length difference and balance. There was no significant difference in the comparison between the three groups.
Conclusion: This study suggests that customized exercise according to the patient's level is beneficial to the patients.

Keywords: *Resistance exercise, Flexibility exercise, Core exercise, Leg length, Balance*

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Received : 15 September 2020
Revised : 23 October 2020
Accepted : 28 October 2020

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INTRODUCTION

Incidents of improper body alignment are on the rise in recent years due to the frequent use of computers and mobile phones. Such habits lead to various body deformations and serious musculoskeletal abnormalities.[1] Leg length difference is a common problem found in 40 to 70% of the total population, also referred to as leg length discrepancy, is generally classified into two types: structural and functional. The difference in the actual length between the femur and tibia indicates structural leg length difference. Functional leg length difference is causing muscles shortening and the joints of the lower extremities contracting, thus causing an imbalance of the spine, pelvis, and lower extremities.[2,3]

If body malalignment occurs due to a leg length difference, the unilateral movement of the center of gravity toward the shorter leg, impairing one's ability to balance and causing secondary postural imbalance, changes in muscle tone of the trunk, gait abnormalities, and pelvic imbalance.[4-6]

When a resistance exercise is performed using an elastic band, the intensity control is manageable and the risk of injury is relatively small. It can be used in combination with various instruments, has the advantage of being portable, and effectively improves muscle strength, balance, and proprioception.[7,8] Leaning on a foam roller to perform a flexibility exercise relaxes one's fascia due to the pressure of the body weight and reduces muscle tension. This creates a massage effect and increases the range of joint

movement as well as the motor function and balance of proprioceptors, which improve coordination and put muscles to greater use.[9] A core exercise is an effective exercise for strengthening the pelvic floor muscles and one's ability to control the body (e.g., the balance required for the stability of the spine and trunk and maintaining correct posture). It is an integrated exercise that transmits the force generated to the whole body.[10,11]

Previous research has shown positive effects of resistance, flexibility, and core exercise on balance, flexibility, and muscle strength improvement. However, such studies are not sufficient to determine the effects on subjects with differences in leg length. Therefore, in this study, we sought to determine the effect of each exercise on the leg length and balance of subjects with different leg lengths.

SUBJECTS AND METHODS

Subjects and Study Period

This study was conducted by participants who voluntarily participated with receiving signed, informed consent from them, from September 16 to October 29, 2019. 28 male and female K university students in Gyeongsangbuk-do were randomly assigned to 9 elastic band resistance exercises, 9 flexibility exercises, and 10 core exercises. As for the inclusion criteria, students with a difference of more than 1 cm in length of both legs due to non-specific cause were selected as subjects. Exclusion criteria are those with physical defects and those who complain of pain during exercise. The sample size for this study was calculated using the G* Power program 3.1. The general features of the subjects are shown in Table 1. No significant difference in the general characteristics of the subjects (P>.05).

Outcome Measures

Leg length

In a supine position using a tape measure (Karas international, China), leg length is measured from the umbilicus to the medial malleolus and the measurement has a high reliability of r=.88 in a study (Figure 1).[12]

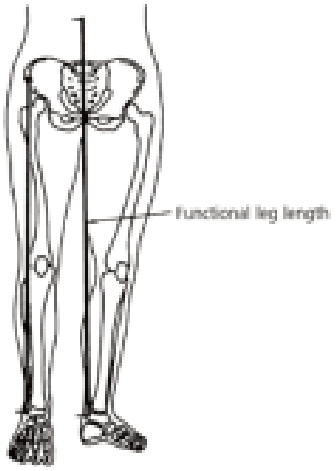

Figure 1. Functional leg length measurement[13]

Balance

To measure the change in balance at standing postures, subject was placed on the Gym plate (TECHNO CONCEPT, France) and a balance exercise program was conducted (Figure 2). The standing posture was maintained for 30 seconds with the eyes open to measure the balance of the body front, back, left and right and the measurement tool has a high reliability of r=.86 in a study.[14]

Table 1. Characteristics of subjects

(Mean ± SD)

	Resistance exercise group (n=9)	Flexibility exercise group (n=9)	Core exercise group (n=10)
Sex (male/female)	4 / 5	5 / 4	4 / 6
Age (years)	20.11 ± .43	20.01 ± .00	20.21 ± .60
Height (cm)	167.54 ± 7.21	166.54 ± 8.12	167.30 ± 9.13
Weight (kg)	69.40 ± 16.78	67.76 ± 14.34	67.00 ± 16.36
Leg length difference (cm)	1.31 ± 1.13	1.06 ± .28	1.19 ± .52

M±SD: Mean ± Standard deviation

Figure 2. Balance measurement

Interventions

Each exercise was performed for 40 minutes, 3 times a week for 6 weeks, and was performed as warm up exercises, main exercises, and cool down exercises. The contents of self exercise program are shown in Table 2.

Data and Statistical Analysis

All the statistical analyses were performed using IBM SPSS Statistics version 20.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was used to demonstrate the normal distribution. For general characteristics of the subjects, an independent t-test was performed, and a paired t-test was performed to determine the difference in leg length and balance. To find out the difference between each group, one-way ANOVA was performed, and the statistical significance level of the data was set to $\alpha=.05$.

RESULTS

Comparison of the results of outcome measures before and after the self-exercise program in the three group

A significant decrease in leg length difference was

Table 2. Self-exercise program

	Self-exercise program		Time
Warm up and cool down exercises	1. High knee walking 2. Leg Adductor stretching 3. Reverse Lunge 4. Hamstring stretching 5. Arm Swing		5 min.
Main exercises	Resistance exercise group	1. Band leg raise 2. Hip abduction 3. Bridging exercise 4. Hip extension	30 min.
	Flexibility exercise group	1. Rolling up & down the back 2. Rolling up & down the front tightness 3. Rolling up & down extensor spine 4. Rolling vastus lateralis	30 min.
	Core exercise group	1. One leg raise bridge 2. Flank 3. Side flank 4. Wall squat	30 min.

found after flexibility exercise and core exercise (P<.05). But resistive exercise did not show significant results. A significant increase in blalnce ability was found after resistive exercise and core exercise (P<.05). But flexibility exercise did not show significant results.

Comparison of the results of changes in outcome measures before and after the self-exercise program between the three group

One-way analysis of variance for comparison of the three groups showed no significant difference (P>.05).

DISCUSSION

In this study, 28 adults with differences in leg length were divided into three groups: a resistance exercise group using an elastic band, a flexible exercise group using a foam roller, and a core exercise group. We tried to determine the impact of the exercises. As a result of the study, the intra-group change of the leg length variable was significant in the flexible exercise group and the core exercise group (P<.05). The intra-group change of balance showed significant results in the resistance exercise group and the core exercise group (P<.05). The change between the three groups was not significant for all variables(P>.05).

A small tool exercise program using elastic bands, foam rollers, and gym balls was previously conducted with 24 elderly people for 12 weeks, and a significant effect of the difference in leg length was reported.[15] Compared to the results of this study, only the flexibility and core exercise groups showed similar results. In the case of the previous study,[15] the core muscles were strengthened by sitting on a gym ball, as in the present study. However, in the previous study, the gradual exercise intensity was set during the resistance exercise, and an elastic band with an intensity

Table 3. Outcome measures before and after the self-exercise program in the three group

Test (variable)	Group	Pre-test	Post-test	t	*P*
Leg length difference (cm)	Resistance exercise	1.31 ± 1.13	.41 ± .46	2.115	.068
	Flexibility exercise	1.06 ± .28	.31 ± .30	3.894	.006*
	Core exercise	1.19 ± .52	.30 ± .18	5.316	.000*
Front and back balance (%)	Resistance exercise	3.22 ± 2.21	1.22 ± .76	2.755	.025*
	Flexibility exercise	3.05 ± 2.82	1.92 ± .80	1.585	.144
	Core exercise	3.05 ± 1.66	1.60 ± 1.09	3.408	.011*
Left and right balance (%)	Resistance exercise	1.82 ± 1.19	.97 ± .63	2.617	.031*
	Flexibility exercise	1.80 ± 1.11	1.14 ± .73	1.537	.156
	Core exercise	2.27 ± .85	1.02 ± .95	2.502	.040*

M±SD: Mean ± Standard deviation
*P<.05

Table 4. Changes in outcome measures before and after the self-exercise program between the three group

Test (variable)	Resistance exercise group	Flexibility exercise group	Core exercise group	F	*P*
Leg length difference (cm)	1.01 ± 1.18	.65 ± .47	.80 ± .50	.457	.638
Front and back balance (%)	2.00 ± 2.18	1.12 ± 2.35	1.45 ± 1.20	.431	.536
Left and right balance (%)	.71 ± 1.27	.61 ± .80	1.90 ± 2.05	2.240	.127

M±SD: Mean ± Standard deviation
*P<.05

suitable for the subject's strength level was used. In this study, the same low-intensity elastic band was consistently used.

In a single case study of subjects with body malalignment in their 30s, the results of exercise rehabilitation programs significantly reduced body malalignment, including differences in leg length,[16] as in the present study. However, It was reported that the difference in leg length decreased significantly when women who had given birth to a child performed resistance exercises using an elastic band for 12 weeks,[17] which was not consistent with the results of this study. The subject selection conditions are different for women with leg length discrepancies from pelvic imbalances due to childbirth and young adult men and women with differences in leg length from unspecified causes. These differences affected the results accordingly. Body malalignment from leg length differences causes hypertension in the muscles and soft tissues.[18] Researchers found that the difference in leg length was reduced by improving the hypertonic tissue that occurred in the lower extremities through flexibility exercises. It is also important to note that the greater the difference in leg length, the more one's pelvis may be malaligned.[19] When performing core exercise, referring to the results of previous study that improved the alignment of the pelvis and leg length differences,[20] the core exercises of this study significantly reduced pelvic deformities due to leg length differences.

The exercise to strengthen the hip abductor using an elastic band had significantly improved subjects' static balance.[21] As a result of performing core exercise six times a week for eight weeks, 19 healthy adults decreased postural sway (on the front, back, left and right) and were able to maintain balance for a longer period of time.[22] If there were a difference in leg length, the abnormal exercise pattern was corrected to a normal exercise pattern in order to minimize functional problems caused by body imbalance during movement.[23] Therefore, Subjects seemingly improved their balance by changing abnormal exercise patterns to normal ones.

The reason why there was no difference between the three groups is assumed to be that not all variables were significant but showed positive changes.

This study was limited by the low number of subjects and the fact that the reasons behind the differences in leg length were not clearly identified when selecting subjects, so it is difficult to generalize the results. A more comprehensive future study would compensate for these shortcomings.

CONCLUSION

In this study, it was found that flexibility exercise and core exercise had significant effects in reducing leg length among self-exercise programs, and resistance exercise and core exercise had significant effects on balance. However, since there is no difference in the effect of exercise between the three exercise groups, it is considered effective to exercise appropriately according to the patient's level and situation. And this study is expected to be able to expand to various age groups by developing self-exercise programs that can be easily applied everywhere.

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