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The Effect of Core Muscle Training Program on Balance Ability

The purpose of this study was to investigate the effects of core muscle training on balance ability. Forty subjects in their 20s participated in a 6 week core muscle training program. Balance ability before and after the intervention were assessed and analyzed using the Romberg test, which was conducted on the floor, pedalo, and balancefit. The differences between the measurement methods of balance ability using varied platforms was also compared and analyzed.
After the 6-week core exercise training program, the training group represented statistically significant increases in all 3 methods for static balance ability. In the control group, all 3 methods represented no statistically significant increases. Upon comparing the different methods of the Romberg test, there were no notable differences between conducting the test on varying platforms for both groups.
This study suggests that the core muscle exercise training program increased the balance ability.

Key words: *Core muscle training, Balance ability, Romberg test*

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INTRODUCTION

Injuries resulting from unexpected loss in balance is a common occurrence in today's society where daily life is filled with a myriad of activities. Balance is a process of maintaining constant postural stability and as such, during specialized and general movements [1)], the role of the core muscles, the body's central protective muscle, is critical [2)].

The core muscles aggregate to form a box-like structure: anteriorly lie the abdominal muscles, posteriorly lie the nearby spinal muscles and gluteal muscles, superiorly lies the diaphragm, and posteriorly lie the pelvic as well as pelvic floor muscles [3)]. The core muscles generate most of the strength and motility in the body; as such, during movement, they secure the center of gravity and accordingly maintain the musculoskeletal integrity [4)]. The core muscles also contribute towards cooperative action [5)],prevention of pain and injury, as well as increase in exercise capacity [2,6)]. Stabilization of the core muscle requires considerable effort from the deep abdominal muscles [7,8)]. By strengthening the muscles around the abdominal, lumbar, and pelvic region, the body is able to control lumbar stability during movement [9)]. Furthermore, neural activity during muscle contractions are improved [10)] and the sense of balance as well as walking ability is also improved due to the role of the muscles in trunk stability and postural control [4, 9, 11-14)].

There are two types of balance maintenance; one is static balance which is the ability to maintain posture on a fixed surface and the other is dynamic balance which is the ability to maintain posture without falling during movement [15, 16)]. This ability to maintain balance requires an appropriate response from both the central nervous system and the musculoskeletal system; the core muscle that are activated during functional movement then stabilize the spine, pelvis, and kinetic chain [17]. For physiotherapists in a clinical setting who intend to carry out physical examinations or a treatment plan, the instability of the core muscles in patients with nervous system damage or musculoskeletal injuries should take priority as it may lead to not only loss of balance, but also ability to maintain posture and gait, as well as lowered upper and lower extremity function.

The previous researches until now have been devoted to the verification of the exercise effect targeting the elderly people, patients, and specific persons. It is important to understand and practice the correct physical activities from a young age for preventing and managing the musculoskeletal disease. In this context, I think it is important to apply and observe the strengthening exercise of core muscle in order to enhance the balance ability aimed at the people in their twenties.

In this study, those in their healthy 20s are put through a core muscle training program and the change in static balance between pre- and post-intervention are investigated by dividing the subjects into a training group and a control group. The balance ability between the two groups will be examined and the measurement methods will also be scrutinized for any differences.

METHODS

Subjects

The subjects in this study are residents of J city and are enrolled in C University. All subjects are healthy male and female individuals in their 20s. All 40 participants (21 male, 19 female) were thoroughly briefed and provided written consent. Individuals who were taking prescriptions or supplements that would affect the experiment, as well as those who had experienced musculoskeletal or neurological disorders in the previous 6 months were excluded from the study. 1 week before the start of the exercise program, subjects were informed of the physically rigorous nature of the program and during the program, were restricted from pursuing other physical activities. The study lasted 7 weeks starting from 07/10/2017 and ending on 21/11/2017.

Table 1. General characteristics of the subjects

Variable	Training GroupM±SD	Control GroupM±SD
Age(yr)	20.70±1.41	18.90±0.56
Height(cm)	168.10±10.52	167.50±6.16
Weight(kg)	67.30±18.45	63.90±7.70
Gender	Males 10	Males 11
	Females 10	Females 9
BMI(kg/m^2)	23.45±4.67	22.70±2.31

Experimental method

The subjects in this study were divided into a training group and a control group in order to investigate the change in balance ability after undergoing core muscle training. Subjects who had given consent and been briefed were given a pretest 2 days before commencing the program. Those in the training group received thorough education before starting the study; taking part in 3 sessions every week for 6 weeks. The control group did not participate in any exercises. After a total of 18 core muscle training session during the 6 weeks, a post-test was conducted.

Measurement methods and tools involved conducting the Romberg test on the floor, pedalo, and balancefit; the duration of posture maintenance was measured in seconds. Subjects wore comfortable clothing and were barefoot during measurement. Subjects were made to stand on one foot each side with open eyes on a flat floor, pedalo and balancefit. To increase validity, all measurements were taken in the same location and to decrease the margin for error, measurements were taken 3 consecutive times so as to extract an accurate average. Before beginning the study, the height, weight, and BMI were measured. The pre-test measurements were taken 2 days before commencing the experiment and the post-test was conducted 2 days after the 6 week experiment.

The core muscle training program consisted of 11 actions. Each action was held for 10 seconds followed by a 3 second rest period. The action was repeated 5 times and the completion of all 11 actions in this manner was considered as a set. After the completion of a set, subjects were given a 3 minute rest and this pattern was repeated for a total of 3 sets. Together with the warm-up and cool-down exercises, the total length of time taken per session took more than 1 hour.

Table 2. Core muscle training program

Position	Exercise	Time	
	Warm-up stretching	10min	
Hook-lying	① Tail tuck	Hold 10sec Rest 3sec 5 times	1set
	② Bridge		
	③ Sit-up Right		
	④ Sit-up Left		
	⑤ Sit-up Straight		
Quadruped	⑥ Right Arm/Left Leg raising		
	⑦ Left Arm/Right Leg raising		
	⑧ Plank		
Prone	⑨ Both Arm raising		
	⑩ Both Leg raising		
	⑪ Both Arm/Both Leg raising		
	Cool-down stretching	10min	

Data analysis

The SPSS WIN 18.0 was used for statistical analysis. A non-parametric analysis method was used as there were areas with no normal distribution during the Kolmogorov-Smirnov test ($p<.05$). Comparison of homogeneity between both groups was analyzed using the Mann-Whitney test. Comparison between pre- and post-intervention was done using the Wilcoxon signed-rank test. Difference in degree of change between the various measurement methods were done using the Wilcoxon analysis.

RESULTS

Table 3. Homogeneity tests between Training and Control group

Variable	Floor M±SD		Pedalo M±SD		Balancefit M±SD	
	Rt	Lt	Rt	Lt	Rt	Lt
Training Group	13.10±14.81	17.70±18.01	2.10±1.28	1.50±0.52	16.00±11.09	8.70±8.17
Control Group	25.30±28.07	17.10±21.59	18.90±51.39	5.50±10.03	31.20±46.89	21.00±38.45
Z	-1.221	-.076	-.357	-.835	-.416	-.799
P	.222	.940	.721	.404	.677	.424

Conducting the Mann-Whitney test before the study, the homogeneity of both groups showed no statistically significant difference ($p>.05$) (Table 3).

Table 4. Balance ability difference according to measurement method pre and post application of core muscle training

(Unit: sec)

Variable		Floor M±SD		Pedalo M±SD		Balancefit M±SD	
		Rt	Lt	Rt	Lt	Rt	Lt
Training Group	pre	13.10±14.81	17.70±18.01	2.10±1.28	1.50±0.52	16.00±11.09	8.70±8.17
	post	64.90±54.40	64.70±43.66	53.30±59.02	38.90±64.51	52.00±26.94	66.80±50.73
	Z	−2.803	−2.805	−2.810	−2.803	−2.805	−2.805
	P	.005	.005	.005	.005	.005	.005
Control Group	pre	25.30±28.07	17.10±21.59	18.90±51.39	5.50±10.03	31.20±46.89	21.00±38.45
	post	23.80±25.75	20.20±13.50	18.80±48.62	16.30±43.50	36.50±42.59	27.00±27.45
	Z	−.153	−.889	−1.006	−.689	−.765	−1.580
	P	.878	.374	.314	.491	.444	.114

Comparing the balance ability between pre- and post-intervention, the training group showed statistically significant increases in all 3 measurement methods ($p<.05$). The control group did not show notable changes any of the measurements ($p>.05$) (Table 4).

Table 5. Analysis of variation of balance ability between measuring methods after applying core muscles training

(Unit: sec)

Variable		Floor M±SD	Pedalo M±SD	Balancefit M±SD	χ^2	P
Training Group	Rt	51.80±46.95	51.20±59.01	36.00±24.10	0.742	0.690
	Lt	47.00±35.51	37.40±64.45	58.10±45.35	5.031	0.081
Control Group	Rt	−1.50±37.92	−0.10±2.92	5.30±21.97	0.571	0.752
	Lt	3.10±22.73	10.80±33.84	6.00±25.29	2.588	0.274

Conducting the Kruskal-Wallis test revealed that in both the training group and control group, there were no large differences between the measurement outcome of the three methods ($p>.05$) (Table 5).

DISCUSSION

Decline in core muscle stability leads to a decrease in efficient breathing, increased burden on the lumbar vertebrae, misalignment of the lower extremity and change in pelvic structure [18]. Stability and mobility exercises training programs for the core muscles have shown to increase kinematic balance, posture, muscle strength, and agility [19] as well as maintain the balance between the upper and lower body [20]. Training core muscle stability involves strengthening the erector spinae muscles which maintain correct alignment of the body [2, 21, 24]. It has also been reported that weakness in trunk movement may be improved through relaxing and strengthening the body, thus correcting body alignment and increasing spinal stability which also reduces the risk of injury [23, 24]. This topic has been approached from various fields of thought [25, 26, 27, 28].

In this study the training group underwent a 6 week core muscle training program. Afterwards, the Romberg test was conducted and subjects were instructed to have eyes closed and be barefoot whilst alternating standing on one leg. On the floor, pre-intervention measurement of the right leg was 13.10 ± 14.81 and post-intervention the value rose to 64.90 ± 54.40. The left leg had a pre-intervention value of 17.70 ± 18.01 and a post-intervention value of 64.70 ± 43.66. On the pedalo, pre-intervention measurement of the right leg was 2.10 ± 1.28 and post-intervention the value was 53.30 ± 59.02. The pre-intervention value of the left leg was 1.50 ± .52 and post-intervention value was 38.90 ± 64.51. Measurement on the balancefit was done with eyes open. Pre-intervention value on the balancefit of the right leg was 16.00 ± 11.09 and post-intervention measurement showed a value of 52.00 ± 26.94. The left leg had a pre-intervention value of 8.70 ± 8.17 and post-intervention value of 66.80 ± 50.73. All three measurement modalities displayed an increase in balance ability and the difference between pre- and post-intervention was shown to be statistically significant.

In a study done by Park Young Jin et. al., female subjects in their 20s underwent a 9 week core muscle strengthening exercise program in order to investigate the effect on static balance ability, gait balance ability, and maximum gait speed [29]. All participants had their eyes covered in order to remove visual feedback and had their static balance ability measured on top of a force plate (AMTI OR-6, AMTI, USA) which revealed that there was an increase in the balance ability in the training group that received core strengthening exercises [29]. Kim Gyu Young et. al. observed the correlation between static and active balance ability of patients in their 20s with lower back pain for 5 weeks as subjects performed 30 minute 3 dimensional lumbar stabilization exercises twice a week for 5 weeks [30]. The results revealed increased balance ability in the training group that had underwent lumbar stabilization exercises which is line with other studies [30]. Using the Good balance System, Hwang Sung Joon et al. measured the static balance of female subjects in their 20s that had participated in a muscle strengthening program 3 times a week for 4 weeks [31]. Post-intervention measurement taken with the eyes of the subjects closed showed that the swing index in both the x and y axis was reduced for both right and left single leg stands [31]. Measurement taken with eyes open also showed a reduction in the swing index [31]. Kim Nam Jeong conducted a study on female high school soccer players which lasted 12 weeks [27]. The subjects received core muscle strengthening training which lasted 50 minutes and had 3 sessions a week [27]. The aim of the study was to investigate the correlation between isokinetic strength and balance ability for which the Balance system was used to obtain measurements [27]. Results revealed that the training group that underwent the core muscle strengthening training experienced increase in the open eye stability index as well as in the left and right stability index; which shares similarity with the results of this study as the subjects of this study also experienced improved balance ability after undergoing a core muscle training program.

The 3 types of Romberg tests conducted revealed that the control group within this study showed no statistically significant change in balance ability for both left and right legs after the 6 weeks. This result is identical to the results of Kim Nam Jeong [27], Park Young Jin [29], Bae Young Hyun [32], and other studies which also reported no statistically significant changes in the control group. When looking at the results of this study aside previous studies, there are differences observed regarding the subjects receiving core muscle training interventions, type of exercise, and duration of exercise. However, it is clear cut that the the training groups are all more effective in increasing the balance ability than the control groups that do not perform any exercises. Furthermore, analysis of the measurement outcome difference between the Romberg test conducted on the floor, pedalo, and balancefit revealed that there were no notable variations between the three modalities for both groups. To this regard, it can be understood that concerning the Romberg test, measurement method does not largely influence accuracy of balance ability as long as the surface in which the test is conducted is identical for both pre- and post-intervention.

CONCLUSIONS

The subjects in this study involved 40 male and female individuals in their 20s. The study consisted of two groups, the training group and the control group, each with 20 subjects. After undergoing a 6 week core muscle training program, the change in static balance ability and the difference in outcome between the varying measurement methods were analyzed. The training group which received intervention showed an increase in balance whereas the control group which received no intervention, did not. There were no notable differences in measurement outcome of balance ability between the floor, pedalo, and balancefit.

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