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Effects of Gastrocnemius and Lumbar Back Muscle Exercise on Standing Balance

The purpose of this study was to test the effect of Gastrocnemius and Low Back-muscle isotonic exercise on static•dynamic standing balance during the period of 4 weeks. This study was two groups pretest-posttest design. Nineteen subjects who were over 22 years old were randomly assigned to either the experimental group that received the Gastrocnemius muscle exercise(n=9) or the low back muscle exercise(n=10) : The former group performed isotonic exercise(plantar flexion), the latter group performed isotonic exercise(trunk extension) a total of 18 times for three times per week for four weeks. Two groups also performed static and dynamic balance before the exercise and 4weeks after the exercise. The data were analyzed by using the paired t-test and independent t-test. The results were as follows: As compared with change of dynamic balance performance capacity at two groups, a significant difference was shown in the test(p<.05), but not in static balance(p>.05). Also, a significant difference of balance between groups was not shown in the test. In this study indicated that gastrocnemius and low back muscle isotonic exercise will have positive impact on standing balance.

Key words: *Muscular Strength; Gastrocnemius; Isotonic Exercise; Standing Balance.*

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INTRODUCTION

The wrong habits or posture, the decline of body activities and the increase of computer using have brought about physical imbalance of modern peoples and this physical imbalance is the main cause of muscular skeletal disease nowadays. The decline of balancing ability is pointed out to be the main phenomenon of physical imbalance and it is known that the improvement of balancing ability can correct body alignment and solve the muscular skeletal diseases(1).

Balancing means a process by which the stability of posture is consistently maintained and the balancing ability is basic in having purposeful activities performed by humans(2, 3). Balancing in daily living is a process where human center of gravity is consistently kept(2, 4) and it is consisted of joints' interaction and the compensation effect from other plane than that made by the posture of standing balance(2).

The factors related with balance control are divided into the neurological factors and the muscular skeletal factors(5). When the two types of factors interact effectively, good balance control comes but the balance control will be gone if any problem takes place on either side of the two types of factors(5, 6).

Muscular weakness is seen to give influence to balance control and is the cause of one's falling down. This falling down takes place because the proper strength of muscle can not be generated at the time of postural change(7).

If one loses balancing ability, his postural stability is to decline due to his weakened muscle strength of lower extremity and he can not shift his weight properly(8, 9). This may cause the increased danger of fall and lead to the dullness of physical activity(10). Also the rigidity of ankle plantar flexor interrupt the forward movement during gait, so the disability of balancing, the asymmetric posture, the decline of walking ability and loss of motor control ability might be caused(11, 12). As these problems may develop to the secondary health problems, it is very important to prevent them through strengthening the muscle strength of lower extremity(13).

On the other hand, the stability of waist is known to be important since it is the prerequisite for the invigoration of upper•lower limb, providing the foundation for the body to move efficiently and the stability of waist helps to enhance the stability of standing posture(14). Also the myotasis and contractility of paraspinal muscle maintain the harmony between stability and mobility of spine while standing and moving(15). These paraspinal muscles play a key role in holding the static posture and keeping balance(16).

However, the functional problem of spinal muscular skeletal system may give influence to postural stability and balance of static posture, restricting waist stability(14, 17). Therefore, it is necessary to strengthen the deep muscular part's strength of lumbar-pelvic-hip complex, in order to enhance the ability of body balancing(18, 19).

Seo reported that the low intensity muscle strength training for 12 weeks had enhanced muscle strength, body balancing and the stability of gait(20), and Buchner et al. reported that the muscle strength training for 24-26 weeks had enhanced muscle strength and balancing(21).

The aforementioned researches where the muscle strength training for long term was studied, have found that the possibility of falling was lessened after muscle strength training. As seen hereinbefore, many preceding researches have studied and investigated on how the lower extremity muscle strength training and waist muscle strength training influence on static balance but few researches have studied on which one out of the two kinds of training is more effective, upon comparing them.

Accordingly, the researcher intended to investigate how the gastrocnemius and low back-muscle exercise would influence on standing balance, through this research.

METHODS

Research Subject

Total 20 students who are attending the dept. of physical therapy of N university in Cheonan city(in korea), were selected as this research's subjects and they were composed of 10 healthy female and 10 healthy male students. No student has ever suffered from balance problem or vestibular and neurological disease, has limitation of articular motion and has recently undergone muscular skeletal injury, among those who were selected as subjects, agreeing to participate voluntarily in this research(7). In addition, no subject has ever participated in a test or experiment like this and even in a previous experiment, similar to this. All the subjects were briefed about the research method and aim before commencing research and the experiment was conducted only after the subjects had been well informed of the contents of experiment. 10 subjects were assigned to the group for gastrocnemius exercise and other 10 subjects were assigned to the group for back muscle exercise and the allocation of subjects to 2 groups was randomly made without considering gender. A subject among the gastrocnemius exercise group dropped out in the middle of experiment, appealing for the keen pain during the exercise.

Table 1. General features of research subjects

	Mean±SD
Age(yrs)	21.95±.42
Height(cm)	169.3±1.85
Weight(kg)	61.25±2.71

Procedure

The researcher intended to investigate which group exerts more influence on static and dynamic standing balance, after dividing the subjects into the gastrocnemius exercise group and low back muscle exercise group and having the two groups go through exercising. And the subjects' balancing ability was measured as a preparatory step to this investigation.

The experiment with which the subjects had concurred, was performed in the order of pre-test exercise post-test.

Measuring Equipment

The automatic anthropometer(BSM330. BIOSPACE) was used to check the general feature of subjects in this research and the expert evaluation/training system for balancing(BT4. HUR) was used to measure the subjects' balancing ability. Additionally, the functional motor rehabilitation treatment and evaluation apparatus(PRIMUS RS. BTE) was used to have the two exercise groups perform isotonic exercise(Table 2)

Table 2. Measuring Instrument

Measuring instrument	Product name	Manufacturing company/country
Automatic Anthropometer	BSM 330	BIOSPACE/Korea
The expert evaluation/ training system for balancing	BT4	HUR/Finland
Functional motor- rehabilitation treatment and evaluation apparatus	PRIMUS RS	BTE/U.S.A

Pre-test

The subjects' general features were measured by an auto-anthropometer and their maximum voluntary isometric contraction(MVIC) was measured by BTE equipment.

Also, the static • dynamic balance was measured by an expert balance evaluation/training system. The subjects were instructed to stand in tandem Romberg position, keeping the predominant foot dead-straight ahead of non-dominant foot and to try keeping their balance. Then, the tester checked the subjects' balancing ability while they keep their eyes open and that while they keep their eyes closed and the interval between the two checks was one minute. The balancing ability was judged by the size and length of subject's wavering, upon watching the subjects' wavering motion. If the size and length of a subjects' wavering dwindled, the subjects' static balancing ability was judged to be improved. As for dynamic balance, the measurement was made also twice; first when subjects keep their eyes open and later while they closed their eyes. This time, subjects were instructed to keep their feet in a V shape and to have their weight evenly distributed on both legs. And the tester watched the subjects' balancing when they shift the center of gravity forward and backward. This time, the shift extent was set as the measuring value by tester. If the shifting values of two checks(while opening and closing eyes) were added to be increased, it was considered the enhancement of dynamic balancing ability took place. If any extreme value was found in pretest, the subject was excluded and new subject was chosen again.

Exercise

The subjects of respective exercise group conducted isotonic exercise with BTE apparatus. The exercise was conducted in the method for enhancing muscle strength and the exercise load was set at 70% of each individual' s MVIC(maximal voluntary isometric contraction) value. Repetition maximum per set was 6 times and total 3 sets were assigned, establishing the rest interval of 60 seconds between sets. The isotonic exercise was carried out for 4 weeks and the subjects conducted it total 12 times as they were to conduct it 3 times per week(23).

For the isotonic exercise of gastrocnemius muscle, the subject set the ankle angle at 90˚, taking the long sitting position and repeated plantar flexion after making the 1st metatarsal bone feel the load. For the isotonic exercise of low back-muscle, the subject sat, taking the position of trunk flexion (keeping the hip joint angle of 90˚) in the beginning stage and pulled the load linked with the string by the motion of trunk extension in the following stage. In this way, repetition of this exercise was performed by the subject.

In order to avoid the effects of motor adaptation, the MVIC value of each subject was measured again when 2 weeks had elapsed since the start of exercise and the exercise was performed in same way upon setting 70% of re-measured value as the new level of exercise load(24).

Post-test

In order to check the subjects' improvement of balancing ability as post test, the subjects' balancing ability was measured again, using the expert evaluation/training system for balancing after four weeks had passed since the start of experiment.

Data Analysis

The statistical analysis was carried by SPSS version 18.0 program. After the normality of data was certified through K-S test(Kolmogorov-Smirnov Test), the paired T test was implemented in order to compare the balancing ability before exercise with that after exercise for two respective exercise groups. And Independent T test was conducted to investigate which exercise group gives more influence to static and dynamic balancing, out of gastrocnemius exercise and low back muscle exercise. The statistical significance level was set at α=.05.

RESULTS

Comparison of balancing ability between pre-exercise and post-exercise for gastrocnemius exercise group and back muscle exercise group

When comparison of balancing ability between pre-exercise and post-exercise for gastrocnemius exercise group and back-muscle exercise group was made, having the subjects' sight uncontrolled, the dynamic balancing ability of gastrocnemius exercise group increased significantly from 9.57±.93 to 11.07 ±.49(p<.05) and that of low back muscle exercise group also significantly increased from 9.02±1.52 to 10.64±1.07(p<.05). The dynamic balancing ability of gastrocnemius exercise group also increased significantly from 9.49±1.12 to 10.85±.97 when comparison was made, having the subjects sight controlled(p<.05), and that of back muscle exercise group also increased significantly from 8.75±1.15 to 10.92±.77(p<.05), when the subjects' sight was controlled. However, there was no significant difference in terms of static balancing ability(p.>05).

Comparison of balancing ability between measurements with and without sight control

Both the static balancing ability and dynamic balancing ability of two groups did not show any significant difference between the measurement with sight control and that without sight control(p>.05).

Table 3. Comparison of dynamic balancing ability between pre-exercise and post-exercise for gastrocnemius exercise group and back-muscle exercise group

	Exercise group	Pre(Mean±SD)	Post(Mean±SD)	t	p
Dynamic balancing without sight control(cm)	Low back muscle	9.02±1.52	10.64±1.07	-6.69	.00**
	Gastrocnemius	9.57±0.93	11.07±0.49	-.03	.00**
Dynamic balancing with sight control(cm)	Low back muscle	8.75±1.15	10.92±0.77	-7.61	.00**
	Gastrocnemius	9.49±1.12	10.85±0.97	-2.60	.03*

*p<.05; **p<.01

Table 4. Comparison of static balancing ability between pre-exercise and post-exercise for gastrocnemius exercise group and low back-muscle exercise group

	Exercise group	Pre(Mean±SD)	Post(Mean±SD)	t	p
Static balancing without sight control(mm)	Low back muscle	731.68±213.03	642.51±163.26	-.40	.10
	Gastrocnemius	813.01±356.29	715.95±176.56	.97	.36
Static balancing without sight control(mm^2)	Low back muscle	510.36±352.89	335.51±189.69	2.43	.06
	Gastrocnemius	601.48±382.13	361.63±79.56	2.08	.07
Static balancing with sight control(mm)	Low back muscle	1594.61±734.03	1357.28±436.57	1.12	.29
	Gastrocnemius	1534.24±700.21	1381.23±359.78	.65	.53
Static balancing with sight control(mm^2)	Low back muscle	1800.03±1189.43	1180.31±701.69	1.39	.20
	Gastrocnemius	1876.81±1263.71	1283.67±437.18	1.41	.20

Table 5. Comparison of dynamic balancing ability between measurements with and without sight control

	Exercise group(Mean±SD)		t	p
	Low back muscle exercising	Gastrocnemius exercising		
Dynamic balancing without sight control(cm)	1.62±.77	1.50±.89	.32	.75
Dynamic balancing with sight control(cm)	2.17±.90	1.54±1.37	1.19	.25

Table 6. Comparison of static balancing ability between measurements with and without sight control

	Exercise group(Mean±SD)		t	p
	Low back muscle exercising	Gastrocnemius exercising		
Static balancing without sight control(mm)	103.22±78.45	225.80±210.22	-1.72	.10
Static balancing without sight control(mm^2)	231.31±193.78	299.54±289.27	-.61	.55
Static balancing with sight control(mm)	462.91±526.09	523.82±461.18	-.27	.79
Static balancing with sight control(mm^2)	1065.09±1072.09	1111.85±774.47	-.11	.92

DISCUSSION

This research was conducted to investigate whether the exercise of gastrocnemius and back-muscle exercise would improve the static and dynamic standing balance or not.

What keeps the human body balanced is the proper integrative regulation and sense of balance in cerebral cortex and the supporting role of muscular · skeletal system, the biomechanical subject, is also necessary for balancing(25, 26).

As per the result of this research, both the exercise of gastrocnemius and that of back muscle have significantly enhanced the dynamic balance($p<.05$). A similar result to this was produced in a previous research by Kim and Oh. That research had reported that the lower leg muscle strength exercise for the elderly, brought about a significant difference of standing balance(27). The muscle focused in previous research was not same as the muscle focused in this research. However, it can be educed that the strengthened gastrocnemius, one of the erector muscle group members enhanced the ability of dynamic standing balance, influencing standing posture. On the other hand, the low back stabilization exercise for the patients with low back pain did not produce any salient difference between pre-exercise and post-exercise when the extent of the to and fro movement of body was measured after conducting the low back exercises, in the research by Nam et al.($p.>05$)(28). As the subjects in this research were normal persons without low back pain, they could show a significant improvement of dynamic standing balance after exercising and this is why the result of previous research of which the subjects were patients with low back pain, was different from this research's.

As far as the static balance is concerned, both gastrocnemius and low back muscle did not show any significant difference in area and length($p.>05$). This result is supported by the research by Kim, where the lower-leg muscle exercise showed the difference of static balance between the conditions with sight control and without sight control(29). Also the result of this research can be interpreted to be similar to that of the research by Choi and Kim, where the effects of low back stabilization exercise on balancing ability was investigated(30). Though the exercising method adopted in this research was different from that of previous research, the results of two researches were similar. The reason for this similarity is because this research concentrated on a single muscle, putting aside the other muscles that give influence to the static balancing.

Also it was noticed that the low back muscle exercise gave more influence to dynamic and static balancing than the gastrocnemius exercise, however the difference between the two groups was not so significant($p>.05$). Such a result was reported in a research by Kim that studied how the exercise of lumbo-pelvic and lower limbs muscle affects the balancing(25). It can be deduced that the isotonic exercise in this research gave much strength to low back muscle, because that muscle is not used much at usual times while the gastrocnemius already gained strength through walking activity of daily living. Accordingly, it is fair that the low back muscle exercise group is considered to have gained better balancing than gastrocnemius exercise group.

CONCLUSION

This research intended to investigate how much the exercise of gastrocnemius and low back muscle would influence on static and dynamic balancing, aiming at 20 male • female students attending at N university in Choong-nam province.

The dynamic balancing was significantly improved by gastrocnemius exercise, regardless of whether or not the sight was controlled. The static balancing showed no significant difference by gastrocnemius exercise, regardless of sight control.

The exercise of low back muscle enhanced significantly the dynamic balancing, irrespective of sight control. As seen in gastrocnemius exercise group, the low back muscle group showed no significant difference between the measurement with sight control and that without sight control. It was noticed that the exercise of low back muscle exhibited higher numerical values in terms of balancing ability than the exercise of gastrocnemius, but the difference between them was not significant.

It was seen from the results of above researches including this that the balancing sense could be kept through the strengthening exercise of lower limbs and trunk muscle. Consequently, it is considered that the dynamic balancing can be enhanced and the risk to muscular skeletal system can be decreased, if we align the patient' s body of balancing problem correctly through muscle strengthening exercise.

The limit of this research was that the subjects were confined to the students of N university in Choong-nam Province and the experimental period of 4 weeks was too short to bring up the ability of static and dynamic balancing. Hence, the researcher anticipates that the future researches would be conducted over a long period of time through diverse exercising methods, setting people from various age brackets as subjects.

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