J Int Acad Phys Ther Res 2019; 10(1): 1717~1724
ISSN 2092-8475
www.iaptr.org
https://doi.org/10.20540/JIAPTR.2019.10.1.1711

Effects of Stretching Exercises and Core Muscle Exercises on Flexibility and Balance Ability

Background : Several studies have suggested different arguments for the effect of stretching exercises and core muscle exercises on flexibility and balance ability.
Objective : To determine the effects of stretching exercises and core muscle exercise on flexibility and balance ability.
Design : Quasi experimental research
Method : The study applied exercise interventions (three sessions per week for 6 weeks) on 40 subjects. The subjects were divided into stretching and core muscle exerciseing groups to identify the change of flexibility and balance ability. Sit- and- reach test results and hip hyperextension were measured for identifying changes in flexibility, and the Romberg test and Pedalo stabilizer were used for changes in balance ability.
Results : Both the stretching exercise and core muscle exercise groups showed a statistically significant increase in flexibility ($p<.05$). However, the stretching exercise group showed a statistically significant increase in balance ability ($p<.05$), whereas the core muscle exercise group showed partially statistically significant differences in this par t($p>.05$). In the analysis of the differences in the amount of change in flexibility, based on the types of exercise, stretching exercises showed a significant difference ($p<.05$), whereas a significant difference was not found in the amount of change in balance ability ($p>.05$).
Conclusions : These findings indicate that stretching exercises are the more effective intervention for improving and maintaining flexibility, whereas there is no difference between stretching and core muscle exercises with respect to improving balance ability.

Key words: *Stretching exercise, Core muscle exercise, Flexibility, Balance ability*

Hyunsook Hwang, Ph,D., Prof[a], Japung Koo, Ph,D., Prof.[b]

[a]Cheju Halla University, Jeju, [b]Pohang University, Pohang, Republic of Korea

Received : 22 January 2019
Revised : 25 February 2019
Accepted : 03 March 2019

Address for correspondence
Ja Pung Koo, PT, Ph.D
Department of Physical Therpay,
Pohang University, 60, Sinduk-ro,
Heunghae-eup, Pohang, Korea
Tel: 82-54-245-1295
E-mail: kjp@pohang.ac.kr

INTRODUCTION

Today, people engage in a relatively lower level of physical activities with more time spent on sedentary activities due to automated their living environment. This has led to the development of musculoskeletal imbalance and flexibility [1]. Decreased flexibility is a major cause of the increased risk of biomechanical injuries during physical activities, and it also causes a decrease in joint range of motion (ROM) and a decline in quality of life (QOL) [2]. Improper movement and habits during activities of daily living (ADL) may lead to poor posture, and when such poor posture is being sustained, it can cause pain, as well as physical imbalance and functional impairment, such as decreased flexibility and restricted movement [1].

Flexibility refers to the ability to move a single joint or many joints within their normal ROM, with no restriction or pain, as well as the ability to fully extend the muscles within the normal ROM of a single joint [3, 4, 5]. A decrease in the elastic components of muscles and muscle fibers due to changes in living environment, decrease in physical activity level, immobility, and aging, may lead to problems with extensibility of muscles [6]. Improving flexibility is essential for improving and maintaining proper posture

and preventing injuries during exercise or ADL [7]. Stretching could be considered as one of the most widely known, effective, and economical methods of exercise for improving flexibility [8].

Stretching refers to extension exercises that stretch the muscles, tendons, and/or ligaments around the joint. It is known to be effective for increasing joint ROM, improving postural imbalance, as well as for balancing the pelvis by relaxing the tension in the muscles near the pelvis and spine [9].

Balance ability refers to the process of continuing to maintain postural stability, which is the most fundamental and essential condition for performing purposeful activities or managing ADLs [10]. Mechanical imbalances and a decline in functional movement in the human body can act as major causes of injury during exercise or ADLs [11]. Decreased balance ability due to injury to the nervous and/or musculoskeletal system can create problems during the rehabilitation process, as well as other problems, such as delayed development of postural control function and restrictions in performing ADLs [12]. Therefore, among the various bodily functions, decreased balance ability and flexibility have been reported to be major factors that can cause a decline in QoL due to the increased risk of falls and gait impairment Thus, improving balance ability can be viewed as a very important factor for maintaining good QoL [13, 14].

Core exercises use trunk muscles located in the center of the body and these muscles are involved in generating strength and mobility, and they play a role that contributes to stabilization of the body and holds the center of gravity when bodily movement occurs [15]. It is believed to have a positive effect on balance ability and spinal alignment through core strengthening [16].

Core exercise programs for maintaining physical balance include various sports activities, such as golf, gymnastics, and fencing, [17] with various balance and flexibility exercise programs used widely for improving proprioceptive functions and for protection against injuries [18, 19].

Previous studies have mostly examined the effects of stretching exercises on flexibility [2, 20, 21] and core muscle exercises on balance ability [22, 23, 24, 25]. Accordingly, the objective of the present study was to divide the subjects into stretching and core muscle exercise groups to investigate the effects of such exercises on flexibility and balance ability. The study aimed to conduct a comparative analysis of the two groups to present an exercise type that is more effective in preventing injuries and improving exercise performance in rehabilitation programs.

METHODS

Subjects

The study population consisted of 40 healthy adults(20 males and 20 females) in their 19–21 years who were enrolled at "C" University in "J" city (Korea). Each subject completed and signed an informed consent. People who were taking any medication or health supplements that may affect the experimental results and those with any musculoskeletal or neurological disease up to 6 months before the study were excluded. The subjects were instructed to refrain from participating in any strenuous physical activities for at least 1 week prior to the start of the exercise intervention. The intervention was carried out for approximately 6 weeks (September 1 to October 13, 2018) and the general characteristics of the subjects are as shown in Table 1.

Table 1. General characteristics of the subjects

Variable	Stretching exercise group M±SD	Core muscle exercise groupM±SD
Age (yr)	20.15±0.67	20.30±0.92
Height (cm)	164.60±7.84	165.40±6.02
Weight (kg)	65.60±14.90	65.45±10.21
Gender (Males/Females)	10/10	10/10
BMI (kg/㎡)	23.87±3.63	23.91±3.59

BMI : body mass index

Materials and outcome measure

In the present study, Sitting Trunk Flexion Meter (Expert, Seoul, Korea, SAT–116) was used to measure flexibility. The measurement system comprised an equipment 30 cm in height, on top of which, a measurement plate of 45 cm in length was attached. The measurement has 10–35cm of the range and 1 mm of the unit. The study also used the Pedalo stabilizer (Pedalo, Germany, 635 085–01) to measure balance ability. The measurement plate was suspended in air, 10 cm from the ground, with only 44–cm springs connecting the upper part of the four corners to the measurement plate below. The plate had an area of 58 × 58 cm and maximum load capacity of 150 kg.

In the sit and reach test, the subject assumed a long sitting position with their feet spread apart to the width of the pelvis and the ankles fixed at 90°. When the subject bent the waist as much as possible to the point of not being able to push the measurement plate any further and held that position for at least

five seconds, the distance from the toe to finger was measured [26]. For hip hyperextension measurement, when the subject stayed immobile in the prone position without lifting the pelvis and flexed the knee, hip hyperextension ROM was measured using a goniometer [27]. For the Romberg test, the subject stood barefoot on an even ground without any slope and performed this while standing on one leg, both left and right legs, with the eyes closed and the time of holding that position was measured. For the Pedalo stabilizer test, the subject stood barefoot on the Pedalo, performed standing on one leg, both left and right legs, with the eyes open and the time of holding that position was measured [28]. To increase the reliability of all measurements, the indoor temperature was maintained at 20-24℃ and all measurements were taken at the same location by the same researcher. To reduce measurement errors, an assistant helped the subjects maintain a proper posture for each test and the a mean value was calculated after three consecutive measurements were taken under the supervision of another researcher. To reduce measurement errors, an assistant helped the subjects maintain a proper posture for each test and three consecutive measurements were taken under the supervision of another researcher. The repeated measurement values were used to derive the mean value.

Experimental Procedures

After explaining the objective of the experiment to the subjects who consented to participate in the study, a pretest was performed two days prior to the start of exercise intervention after enough practice. The subjects were divided into stretching and core muscle exercise groups to identify the change of flexibility and balance ability. Sit and reach test results and hip hyperextension were measured for changes in flexibility, and the Romberg test and Pedalo stabilizer were used for changes in balance ability. The intervention for both the stretching and core muscle exercise groups consisted of a total of 18 sessions of training (three times per week for 6 weeks). A posttest was performed 2 days after the completion of the intervention. Both stretching and core muscle exercise groups performed four different motions. Each motion consisted of a 10-second hold and 5 seconds of rest, with one set consisting of five repetitions. After completing one set, the subjects were allowed to rest for 3 minutes; repeating this process to complete a total three of sets. The total exercise duration was approximately 1 hour, including warm up and cool down exercises.

Data analysis

SPSS 18.0 was used for statistical analysis, and according to the fact that some values did not show normal distribution in the Kolmogorov-Smirnov test, the analysis was performed by a non-parametric method ($p<.05$). Comparison of homogeneity between the two groups was performed using the Mann-Whitney test. For pretest/posttest comparison based on exercise type, the Wilcoxon sign rank test was used. For comparison of amount of pretest/posttest change based on exercise type, the Mann-Whitney test was used ($p<.05$).

Table 2. stretching exercise and core muscle exercise program

Type	Position	Exercise	Hold+Rest	Time	Set	Set+Rest
Type		Warm-up stretching	5 min			
Stretching exercise	Standing Kneeling Long sitting Prone	① Hamstring stretching ② Ustrasana ③ Toe touch (Rt, Lt, Both) ④ Quadriceps stretching	10 hold + 5 sec	5	1 set	3 set + 3 min
Core muscle exercise	Supine Supine Prone Prone	① Bridge ② Abdominal hollowing ③ Plank ④ Superman back exercise				
		Cool-down stretching	5 min			

RESULTS

Table 3. Homogeneity tests between the two groups

	Flexibility(M±SD)		Balance ability(M±SD)			
	Sit and reach test	Hip hyperextension	Romberg test		Pedalo stabilizer	
			Rt	Lt	Rt	Lt
Stretching exercise group	12.82±7.35	18.90±3.83	3.69±1.67	5.79±3.32	2.49±0.74	2.38±1.20
Core exercise group	10.55±8.20	20.85±3.84	6.21±4.81	7.04±4.01	2.78±0.75	2.39±0.99
Z	−.788	−1.294	−1.382	−.731	−1.056	−.596
P	.431	.196	.167	.465	.291	.551

The Mann−Whitney test was performed to check for pretest homogeneity between the stretching and core muscle exercise groups and the results were statistically homogeneous ($p>.05$; Table 3).

Table 4. Effect of flexibility and balance ability according to exercise type

		Flexibility(M±SD)		Balance ability(M±SD)			
		Sit and reach test	Hip hyperextension	Romberg test		Pedalo stabilizer	
				Rt	Lt	Rt	Lt
Stretching exercise group	pre	12.82±7.35	18.90±3.83	3.69±1.67	5.79±3.32	2.49±0.74	2.38±1.20
	post	20.72±5.24	28.20±5.44	7.69±4.13	15.99±9.95	24.68±34.42	17.17±20.11
	Z	−3.926	−3.940	−3.289	−3.738	−3.923	−3.737
	P	.000	.000	.001	.000	.000	.000
Core exercise group	pre	10.55±8.20	20.85±3.84	6.21±4.81	7.04±4.01	2.78±0.75	2.39±0.99
	post	15.85±6.60	24.50±2.76	9.76±10.08	12.89±8.94	16.80±13.66	8.94±8.93
	Z	−3.894	−3.168	−1.234	−3.326	−3.923	−3.922
	P	.000	.002	.217	.001	.000	.000

In the pretest/posttest comparison of flexibility and balance ability based on application of stretching and core muscle exercise interventions, the stretching exercise group showed a statistically significant increase in both flexibility and balance ability at 6 weeks after the application of stretching exercise intervention ($p<.05$).

Core muscle exercise group also showed a statistically significant increase in sit and reach test results, hip hyperextension, Romberg test results, and Pedalo stabilizer results ($p<.05$), but no significant difference in Romberg test Rt ($p>.05$) at 6 weeks after the application of core muscle exercise intervention (Table 4).

In the analysis of amount of change in flexibility and balance ability after stretching and core muscle exercise interventions, the Mann−Whitney test results indicated that the stretching exercise group showed a significantly higher amount of change in sit and reach test and hip hyperextension measurements as compared to the core exercise group ($p<.05$). Meanwhile, there were no significant differences between the two groups with respect to amount of change in Romberg test and Pedalo stabilizer measurements ($p>.05$; Table 5).

Table 5. An analysis of variance in flexibility and balance ability by exercise type

	Flexibility(M±SD)		Balance ability(M±SD)			
	Sit and reach test	Hip hyperextension	Romberg test		Pedalo stabilizer	
			Rt	Lt	Rt	Lt
Stretching exercise group	7.90±3.78	9.30±3.34	3.99±4.45	10.20±9.89	22.19±34.12	14.78±19.84
Core exercise group	5.30±4.26	3.65±3.31	3.55±7.94	5.84±7.89	14.01±13.43	6.55±8.61
Z	−2.174	−4.563	−1.029	−1.544	−1.299	−1.124
P	.030	.000	.303	.123	.194	.261

DISCUSSION

Muscle tension and weakening may cause muscle injury and exercise therapy is essential for preventing such injuries. Therefore, the present study was conducted to identify the effects of stretching and core muscle exercises on flexibility and balance ability of university students.

In the previous studies, the results of the sit and reach test performed to test flexibility showed a significant increase in the stretching exercise group. Such findings were supported by the results reported in previous studies by Kim [2], who performed sit and reach test after six weeks of stretching exercises on 39 college students, and Kim [29], who performed sit and reach test on 16 college students who performed stretching exercises every day for 2 weeks. These results suggest that the stretching exercise method of this study is applied mainly to the hamstring and Q-muscle, and it is improved the flexibility by applying the stretching exercise to the problems of limited muscle movement, muscle weakness, and postureal maintenance. Meanwhile, the core muscle exercise group in the present study also showed statistically significant sit and reach test results. This finding was supported by the results from a previous study by Lee [30], which showed a statistically significant difference in sit and reach test results after applying core muscle exercises on female college students. Although a direct comparison may be difficult due to different study populations, a study by Jeng [24] also reported similar sit and reach test results after 12 weeks of core muscle exercises on 21 male amateur golfers aged 65 years or older. However, a study by Kim [31] reported no statistically significant improvement in sit and reach test results after 12 weeks of core muscle exercise on nine female pro golfers, which contradicted the findings in the present study. Such differences may attribute to the fact that the exercise program used in the study by Kim [31], consisted mostly of motions that required the upper torso to be flexed backwards or rotated to the side, and as a result, a significant improvement was found in the backward flex, but little improvement in the forward flex. Therefore, when applying core muscle exercise, focusing on exercise that considers posture, movement, and muscle strengthening can be an effective method.

In the flexibility test performed in the present study, hip hyperextension ROM results showed statistically significant differences in both stretching and core muscle exercise groups.

For the balance ability test, the Romberg test results showed a statistically significant increase in both left and right sides in the stretching exercise group. This finding was similar to the results reported from a study by Ahn [32], which applied eight weeks of stretching exercises on 35 male tennis players, aged 10-19 years. Moreover, although a direct comparison may be difficult due to different study populations, a study by Nam [33] also reported a statistically significant increase after 16 weeks of stretching exercises on 30 elderly females, aged 65 years or older. This is becausesince the stretching exercise is a positive factor in the balance ability through stimulation of neuromuscular activity [34].

Meanwhile, the core muscle exercise group showed a significant increase in the left side, but no significant difference in the right side. It is believed that the reason for this was due to six weeks of exercise not being enough to show a significant difference in people with a life habit of predominantly using their right leg. In previous studies, significant differences were found after nine and 12 weeks of intervention [35, 36]; whereas, a study by Choi [37] that used 4 weeks of intervention did not show a statistically significant difference. Therefore, setting the proper duration of exercise intervention for specific subject populations

should be an important consideration for improving balance ability by applying core muscle exercise.

In the balance ability test, the Pedalo stabilizer test results showed statistically significant differences in both left and right sides in the stretching exercise group. Direct comparison could not be made due to lack of precedent studies that tested balance ability after applying stretching exercises, but other studies have reported that flexibility and muscle strength improved after stretching [38, 39]. A study by Kim [23] reported that flexibility and muscle strength increased after applying stretching exercises, which in turn helped improve balance ability. Such results indicated that stretching exercises were effective for improving balance ability by improving flexibility and lower extremity muscle strength, which would be similar to the findings in the present study.

The Pedalo stabilizer test results also showed statistically significant differences in both left and right sides of the core muscle exercise group, which was consistent with the findings in a study by Hwang [28], which applied six weeks of a core program to 20 subjects, aged 20–29 years. In the present study, balance ability was measured by time. However, because balance could be measured by different methods, direct comparison may be difficult. Nevertheless, there are precedent studies that use the commonality of testing balance ability on a non-fixed plate. In a study by Hwang [40], applying four weeks of a core program on 16 females aged 20–29 years showed a significant difference in the X axis, but no significant difference in the Y axis in the left Romberg test, and a significant difference in both the X and Y axes in the right Romberg test. In addition, a study by Cho [41] reported that applying six weeks of a core program on 17 subjects aged 40–49 years who were diagnosed with chronic back pain showed significant differences in both the X and Y axes in both right and left Romberg test. Accordingly, it is believed that such findings proved that core exercises can contribute to improving balance ability during functional movement and while maintaining postural alignment [42].

Despite the differences depending exercise type and duration of intervention between the present and previous studies, the results indicated that applying stretching and core muscle exercises can help improve flexibility and balance ability. Such results demonstrated that the findings in the present study were consistent with results reported in previous studies and proved that six weeks of stretching and core muscle exercises has effects on improving flexibility and balance ability. In the comparative analysis on the amount of change in flexibility and balance ability after applying stretching and core muscle exercise, the results showed that stretching exercises were more effective in improving flexibility, while there were no differences between stretching and core muscle exercises for improving balance ability.

Problems caused by muscle damage and muscle weakness result in various problems such as decreased ability to perform daily life and falls. Accordingly, the purpose of this study was to investigate the effect of therapeutic exercises based on approach methods, and it is important to provide a basis for selecting therapeutic exercise. The study was also significant that the findings from the experiment using stretching and core muscle exercises can be used as reference data for exercise programs designed to improve flexibility and balance ability. However, despite the fact that the present study applied stretching and core muscle exercises through therapeutic exercise interventions, there were limitations in that the their everyday life of the subject throughout the study period could not be controlled completely; It is difficult to generalize the findings since the study population included only college students from one specific region.

CONCLUSION

In the comparative analysis of the amount of changes in the matter of flexibility after applying stretching and core muscle exercises, stretching exercises were found to be the more effective intervention to improve flexibility, whereas there were no differences between stretching and core muscle exercises for improving balance ability. Based on the study findings, it is believed that setting the duration of intervention is important when applying exercise programs to improve balance ability. Therefore, it is also believed that future follow-up studies are needed to explain the effects of exercise programs based on different duration of intervention.

REFERENCES

1. An M. The effect of postural correction on pelvis balance and cervical range of motion. Unpublished master's thesis, Daegu University 2004.
2. Kim K, Han, JT, Yu, JY. Effect of hamstring stretching methods on improvement of lumbar

flexibility in adults. Exercise Science. 2008; 17(2): 243-50.
3. Halbertsma JP, Coeken LM. Stretching exercise: effect on passive extensibility and stiffness in short hamstrings of healthy subjects. Arch Phys Med Rehab. 1994; 75(9): 976-81.
4. Knight CA, Rutledge CR, Cox ME, et al. Effect of superficial heat, deep heat, and active exercise warn-up on the extensibility of the plantar flexors. Phys Ther. 2001; 81(6): 1206-14.
5. Kubo K, Kanehisa H, Fukunaga T. Effect of stretching training on the viscoelastic properties of human tendon structures in vivo. J Appl Physiol. 2002; 92(2): 595-601.
6. Faulkner JA, Larkin LM, Claflin DR, et al. Age-related changes in the structure and function of skeletal muscles. Clin Exp Pharmacol Physiol. 2007; 34(11): 1091-6.
7. Ogura Y, Miyahara Y, Naito H, et al. Duration of static stretching influences muscle force production in hamstring muscles. J Strength Cond Res. 2007; 21(3): 788-92.
8. Chang CH, Jeong DH, Park RJ. A Review of conception and developmental process of stretching in sports physical therapy. The Journal of Korean Society of Physical Therapy. 2002; 14(4): 423-40.
9. Kim BY, Eom WS. The Effects of lumbar stretching on the degree of scoliosis and flexibility in elementary school students. The Journal of Korea Elementary Education. 2012; 23(4): 157-66.
10. Choi SY, Kang YS, Eun Y. The effect of an exercise program on quality of life, depression and physical performance for the senior citizen center elderly. Journal of the korea Data analysis Society. 2008; 10(1): 133-47.
11. Kim SH, So WY, Kim JY. Effect of 8-week core stabilization training on skill-related physical fitness and functional movement screen (FMS) test scores in college soccer players. Korean Journal of Sports Science. 2016; 25(1): 1473-1483.
12. Galli M, Rigoldi C, Mainardi L, et al. Postural control in patients with down syndrome. Disability and Rehabilitation. 2008; 30(17): 1274-8.
13. Kim MC, Ahn CS, Kim YS. The effect of exercise program for falls prevention on balance and quality of life in the elderly women. Journal of The Korean Society of Physical Medicine. 2010; 5(2): 245-54.
14. Klaus H, Brenda R, Kirstin R, et al. Exercise training for rehabilitation and secondary prevention of falls in geriatric patients with a history of injurious falls. J Am Geriatr Soc. 2001; 49(1): 10-20.
15. Nadler SF, Malanga GA, Bartoli LA, et al. Hip muscle imbalance and low back pain in athletes: influence of core strengthening. Med Sci Sports Exerc. 2002; 34(1): 9-16.
16. Lee OK, Jang KS, Cho IH. The effects of core exercise program on shoulder function, spinal aliment and balance ability in collegiate shooting players for 6 weeks. Sports Science, 2014; 31(2): 306-13.
17. Kim KJ, Chung JW. Effects of 10-week core rehabilitation training on flexibility, isokinetic muscular strength, driver shot performance, and pain in elite golfers with Lower back pain. Exercise Science. 2009; 18(1): 115-24.
18. Malliou P, Gioftsidou A, Pafis G, et al. Proprioceptive training (balance exercises) reduces lower exteimity injuries in young soccer players. Journal of Back and Musculoskeletal Rehabilitation. 2004; 17(3): 101-4.
19. Gioftsidou A, Ispirlidis I, Malliou P, et al. Injuries in soccer during the championship between adult and young players. Journal of Human Movement Studies. 2004; 46(5): 397-406.
20. Puentedураa EJ, Huijbregtsb PA, Celestea S, et al. Immediate effects of quantified hamstring stretching: Hold-relax proprioceptive neuromuscular facilitation versus static stretching. Physical Therapy in Sport. 2011; 12(3): 122-6.
21. Kim GC, Lee JH, Kwon SM. Effects of hamstring flexibility and dynamic stability of lower lumbar according to stretching and massage techniques. Journal of The Korean Society of Physical Medicine. 2013; 8(4): 609-17.
22. Yi SJ, Cho MS. Flexibility of trunk foreword bending by stretching exercise. J. Korean Soc. Hygenc Sciences. 2004; 10(2): 221-6.
23. Kim SW. The effect of core balance exercise on balance and leap ability of high school students. Unpublished master's thesis. Kong ju National University. 2017.
24. Jeng TW, Lee HW, Lee JW. Effects of the lumbar stabilization exercise on balance ability, flexibility and golf skill in senior`s male golfer. Korean Journal of Sports Science. 2014; 23(3): 1397-407.
25. Park SM. The effect of core program on balance ability in the elderly. Unpublished master's thesis, Chosun University 2011.
26. Kim K, Han JT, Lee HJ. The effects of swiss ball exercise on scoliosis and flexibility in young adults. Journal of Korea Sport Research, 2007; 18(4): 253-61.
27. Norkin CC, White DJ. Measurement of Joint Motion : A Guide to Goniometry, 5th Ed. F.A.Davis Company, Philadelphia. 2017: 260-261.

28. Hwang HS, Kim NJ. The effect of core muscle training program on improving balance ability. J Int Acad Phys Ther Res. 2017; 8(2): 1175–81.
29. Kim GC, Lee JH, Kwon SM. Effects of hamstring flexibility and dynamic stability of lower lumbar according to stretching and massage techniques. Journal of The Korean Society of Physical Medicine. 2013; 8(4): 609–17.
30. Lee KK, Kim HD, Back SH. The change of the underwater dolphin kick performance, body composition, and physical fitness after core stability exercise and circuit weight training. Journal of Sport and Leisure Studies. 2009; 37(2): 1281–92.
31. Kim KJ. The effects of core muscle strengthening training on flexibility, strength and driver shot performance in female pro-golfer. Korean Journal of Sport Science. 2009; 20(2): 212~21.
32. Ahn NY, Kim HS, Kim KJ. Effects of balance and flexibility exercise training on functional power of tennis player. International Journal of Coaching Science. 2013; 15(3): 225–32.
33. Nam JH. The effects of 16 weeks of static stretching exercise on the balance and gait ability in elderly women. Unpublished master's thesis, Hannam University. 2007.
34. Lee JC, Choi SO, Bae JJ, et al. Effect of stretching exercise on the proprioceptive and gait ability in elderly women. Journal of Sport and Leisure Studies. 2010; 39(2): 575–86.
35. Park YJ, Lee JS, Seok MG, et al. Effects of 9 weeks core muscle strengthening exercise on 3static balance, gait balance and maximum gait speed for women in twenties. Korean Journal of Sports Science. 2016; 25(5): 1227–39.
36. Yun KS, Jun IS, Kwak HM, et al. The effect of 12-weeks core stability exercise program on physical fitness and soccer techniques in middle school soccer players. International Journal of Coaching Science. 2013; 15(3): 205–13.
37. Choi SH, Lim JH, Cho HY, et al. The effects of trunk stabilization exercise using swiss ball and core stabilization exercise on balance and gait in elderly women. Journal of The Korean Society of Physical Medicine. 2012; 7(1): 49–58.
38. Kim TH. The effect of stretching type on muscular fitness. Unpublished master's thesis, Incheon National University. 2015.
39. Jeong KH. The effects of postisometric stretching on muscle strength, performance, joint position sense, and flexibility. Unpublished master's thesis, Sahmyook University. 2017.
40. Hwang SJ, Cho NJ, Lee JW. Effects of core program exercise on static balance of females in their twenties. The Korean Academy of Clinical Electrophysiology. 2010; 8(1): 31–6.
41. Choi WJ, Park BS, Yoo BK, et al. The Effects of Core Program Exercise on Balance in Patients with Chronic Low Back Pain. Journal of Korean Physical Therapy Science 2018; 25(1): 1–10.
42. Akuthota V, Nadler SF. Core strentthening. Archives of Physical Medicine and Rehabilitation. 2004; 85(1): 86–92.