

Effects of Pilates core stability exercises on the balance abilities of archers

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This study aimed to provide fundamental data contributing to archery performance improvement and stabilization of shooting posture in archers by examining the influence of Pilates core stability (PCS) exercises on dynamic and static balance. The study was conducted from December 2015 to March 2016 on high school archers who were registered as archers in the Korea Archery Association with 5 or more years of archery experience. Twenty voluntary subjects (exercise group $n=10$; control group $n=10$) with an understanding toward the aims of this study were selected and their body composition, static and dynamic balance abilities, before and after the PCS program, were measured. As for the static balance ability, there were no significant differences between pre- and postvalues in the exercise group after completing the PCS program. Similarly, these results were also represented in the con-

trol group. In the aspect of comparisons between postvalues in both groups, there were significant improvements in only the exercise group. As for the dynamic balance ability, there were significant differences between pre- and postvalues in the exercise group, except for up-right and left postures, whereas, there were no changes or decreases between pre- and postvalues in the control group after completing the PCS program. Meanwhile, in the aspect of comparisons between postvalues in both groups, there were significant improvements in up, and up right, and down right part and overall dynamic scores of the exercise groups.

Keywords: Pilates core stability exercise, Archers, Dynamic balance, Static balance

INTRODUCTION

Archery requires the consistency and stability of movement. In order to shoot the arrow correctly to the target, archers need control of right distribution of strength, balanced pose and change of breathing and so on. The mismatch of these factors can influence in athletic performances directly (Launikitis and Viegas, 2009). The stability of the respiratory function works also as an important variable in game results. This keeps the stillness of the body and maintains the stable heart beat and breathing during the game. It works really important more than the factors of mental, vital dynamics and exercise physiology according to the level of tension (Vikne et al., 2007).

Archery game, due to the exercise pattern that uses only one side of the body (unilateral) or keeping asymmetric pose consistently, can cause injury or fallen athletic performances. And it

would not be wrong to say the moment that archers start keeping the posture of carrying a bow the imbalance starts. It has been reported that most of the archer have severe imbalance posture (Dalleau et al., 2012). The imbalance of body, with the fall of balance ability it can affect largely to the athletic performance. And with the quality of the event that has to act repetitively with the same movement, physical imbalance increases the possibility of damage occurrence (Kim and Park, 2000).

Recently a lot of exercising methods are developed for the stabilization of the physical core, and not only for athletes but also from women to seniors the core stabilizing exercises are known as a very effective exercise method for strengthening muscles and flexibility and improving balance ability (Borden and Elias, 1991; Brown et al., 1995; Howley and Don Franks, 1986). The spinal, abdominal and pelvic muscles which lets the legs and arms move mobility and act functional, are called core muscles. And these

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muscles are the core place that demonstrates stability and motility of the body and it vitalizes first when legs and arms move and keep the center whenever the body moves especially it increases the balance ability by straighten the muscles around the pelvic area (Decker et al., 1999). It also has a role of properly keeping the musculoskeletal structure and protect important muscles and bones (Patterson et al., 2001). Moreover, it is a purpose of core stabilizing program such as Pilates to stretch repeatedly and strengthen such core muscles and maximizing mobility and stability of the spine (Rydeard et al., 2006).

Like this, even though the stability of the core muscle for physical balance and the importance of the respiration while shooting an arrow and balancing ability, in the archery training scene under the awareness that the stillness factor applies more than an active movement which physique or strength is the priority factor, biomechanical study has been performed intensively which is based on physiological study (Kim, 1996; Rose, 2010) and a desirable shooting posture starts from stabled posture (Bergandi, 1985; Cohen et al., 1993). Therefore, we have started this study because this study was considered that there can be a meaning to have an in-depth study of Pilates core stability (PCS) exercise physiologically effecting static and dynamic balance abilities of archers, and also it was considered meaningful to research of whether it can help or not to stabilize the posture and improving athletic performances while archers shooting.

MATERIALS AND METHODS

Subjects

This research was processed from December 2015 to March 2016 with the objects of high school archers from Daejeon city. And we selected the archers who are registered as an athlete in the Korean Archery Association and whom has more 5 years of sports career. We have selected 20 subjects (exercise group $n = 10$; control group $n = 10$) who have understand the purpose of this study and intends to participate voluntarily. The physical characteristic of subjects is in Table 1.

Table 1. Demographic data of archers

Group	Age (yr)	Height (cm)	Weight (kg)	BMI (kg/m ²)	Body fat (%)	Career (yr)
Exercise	17.30±1.06	175.60±2.12	79.67±5.22	24.20±1.94	19.67±1.29	6.55±1.32
Control	17.00±0.67	170.70±4.85	73.23±6.96	25.04±2.05	20.24±1.64	6.77±1.42

Values are presented as mean ± standard deviation.
BMI, body mass index.

Measurement method

Body composition

The measurement of body composition was processed after arriving in examination place and removing the carried metals and urinated 30 min before measurement and taking 5 min of break in a comforting status. We calculated weight, body mass index, waist/hip ratio, and percentage of body fat using body composition measuring instrument, Inbody 720 (Biospace Co., Seoul, Korea). The way of measuring was making subject take pose by spreading arms and legs a little bit and stepping on a marked position in the machine with bare foot and then holding an electrode handle. And then the machine process the analysis of body composition according to the measurement order (Cha et al., 2014).

Balance ability measurement

Static balance ability test

This measurement was measured using Center of Pressure measuring method from Humac Norm Balance System (Computer Sports Medicine Inc., Boston, MA, USA) and Weight Bearing measuring method. The subject steps up to the balance board and stares at the screen and giving pressure on a central circular above the balance board, in a direction of the flickering beacon light in the center. And it is a method that constantly measures the balance ability without losing balance and shows the value as a result.

Dynamic balance ability test

It measures balance ability through same above machine. Limits of stability recorded by this Balance System. Using the method of measuring balance ability constantly with not losing balance the subject steps on to the balance board and stares at the screen and giving pressure in the central circular above the balance board in the way of the flickering beacon direction which is in a random way. And it shows the value by measuring total 10 ways of movement time and continuous time.

PCS program

The objects from this study have been training followed by the school exercise program and we have process the program using

Table 2. Pilates core stability exercises program for exercise group

Stage	Pilates motions	Training period (min/motion)			Intensity
		1–4 wk	5–8 wk	9–12 wk	
Warm-up	Breathing	10/3	12/3	15/3	Borg's scale 8–10
	Rolling back	10/3	15/3	20/3	
	Coccyx-curl	8/3	10/3	12/3	
	Hundred breathing	100/3	100/4	100/5	
Work-out	Single leg stretch	8/2	10/2	12/2	Borg's scale 11–13
	Straight leg raise	8/3	10/2	12/3	
	Basic bridge	8/2	10/2	12/2	
	Bridging variation	8/2	10/2	12/2	
	Quadruped	8/3	10/3	12/3	
	Clap with seal motion	10/2	10/3	10/5	
	Mermaid twist	8/2	10/2	12/2	
	Swimming	8/2	10/2	12/2	
	Double leg stretch	8/2	10/2	12/2	
	Shoulder bridge	8/2	10/2	12/2	
	Swan dive	8/2	10/2	12/2	
	Leg full front	8/2	10/2	12/2	
Cool-down	Rest position	1/3	1/3	1/3	Borg's scale 8–10
	Cat with arm/leg extension	5/2	5/2	5/2	
	Breathing	10/3	10/3	10/3	

the nonwinter season. Thus the PCS program was not processed separately at a certain time, it was processed additional after normal training.

The PCS exercise which we wanted to apply in this study is composed with Pilates mat exercise program and by following the recommended exercise allowance which is suggested in Thompson et al. (2013), we have processed total 60 min work out with warm-up exercise for 10 min, main exercise for 40 min, warm-down exercise for 10 min. The exercise was applied for 12 weeks with 3 times a week. With increasing the scale and number of mat exercise movements and by applying the principle of incremental motion load which increases the intensity of exercise, we have composed the routine that it does not get out of the previously set maximum exercise intensity. And also when practicing each move, we have focused on safety more than accuracy so we suggested a bit changed movement in parts which is hard to follow. The specific contents are composed as Table 2.

Data processing

This study has calculated the average and standard deviation of every data using IBM SPSS Statistics ver. 20.0 (IBM Co., Armonk, NY, USA). We have figured out the degree of equal variance through Kolmogorov–Smirnov testing, and in all data it did not show normal distribution, so we chose the nonparametric test

and analyzed the difference of between groups and between times. The testing within the group proceeded Wilcoxon Signed Ranks test, and testing between the groups proceeded Mann–Whitney *U*-test. For the attentive level of every data, we set it as $P < 0.05$.

RESULTS

Change of static balance ability

After applying the PCS program the change of static balance ability is shown in Table 3. The exercise group which have worked on PCS program did not show an attentive change for before and after and also in control group there were no attentive results. But the results have shown of just comparing the after value, the static balance ability of left part ($Z = -2.923$; $P < 0.05$) and right part ($Z = 2.923$; $P < 0.05$) of the exercise group were attentively improved.

Change of dynamic balance ability

After applying the PCS program the dynamic balance ability change is shown in Table 4. The exercise group that have worked on PCS program in the before and after change, except the balance ability of the up right part and left part it was attentively improved. But it was shown that in the control group there were no attentive change nor the dynamic balance ability got decreased.

Table 3. The changes of static balance scores in both groups after core exercise program

Part	Exercise group (n=10)			Control group (n=10)			Z ^{b)}
	Pre	Post	Z ^{a)}	Pre	Post	Z ^{a)}	
Up	51.10±1.20	50.80±0.92	1.152	51.00±1.94	50.60±1.43	0.885	0.372
Down	48.90±1.20	49.20±0.92	-1.152	49.00±1.94	49.40±1.43	-0.885	-0.372
Left	51.10±1.66	50.20±0.42	1.868	51.60±2.37	51.70±1.57	-0.198	-2.923**
Right	48.90±1.66	49.80±0.42	-1.868	48.40±2.37	48.30±1.57	0.198	2.923**

Values are presented as mean ± standard deviation.

^{a)}Wilcoxon Signed Ranks test between pre- and postvalues in a group. ^{b)}Mann-Whitney U-test[†] results between postvalues in both groups. **P<0.01.

Table 4. The changes of dynamic balance scores in both groups after core exercise program

Part	Exercise group (n=10)			Control group (n=10)			Z ^{b)}
	Pre	Post	Z ^{a)}	Pre	Post	Z ^{a)}	
U	40.70±8.31	46.90±7.58	-3.637**	40.30±13.47	39.40±8.26	0.494	2.115*
UR	42.60±8.78	46.50±7.37	-1.591	40.60±8.66	39.40±3.03	0.612	2.819*
R	38.50±14.83	50.40±8.41	-2.644*	44.70±16.28	43.60±10.35	0.472	1.612
DR	31.90±7.82	42.20±7.74	-5.859***	26.20±9.45	30.90±5.30	-2.819	3.808**
D	42.00±15.10	48.70±14.21	-4.052**	37.20±12.70	38.40±8.53	-0.591	1.966
DL	29.60±15.53	40.20±11.98	-2.383*	28.70±15.14	32.40±10.10	-1.573	1.574
L	41.50±18.69	49.60±14.24	-2.081	43.20±14.73	43.00±13.06	0.231	1.080
UL	43.30±13.46	52.50±12.73	-2.358*	48.60±15.63	47.40±11.74	0.707	0.931
OVE	38.60±7.40	47.50±9.29	-5.655***	38.30±7.09	39.20±4.54	-0.608	2.539*

Values are presented as mean ± standard deviation.

U, UR, R, DR, D, DL, L, UL, and OVE mean up, up right, right, down right, down, down left, left, up left, and overall, respectively.

^{a)}Wilcoxon Signed Ranks test between pre- and postvalues in a group. ^{b)}Mann-Whitney U-test[†] results between postvalues in both groups. *P<0.05. **P<0.01. ***P<0.001.

On the other hand, the difference between the groups in dynamic balance ability, by the attentive change in up part, and up right part, and down right part, the total score was attentively increased in exercise group compared with control group.

DISCUSSION

Archery is a sports event that improves the athlete performance using series of coordination of supporting ability of the lower body support surface of static stability and the aiming of the upper body and shooting. And also for archery when shooting according to the up and down movement of the bow, there can be a change in center of the body, so the stability has to be increased in body balance, and archers can minimize the shaking of the body and can help improvement in scores through balance training (Norton et al., 1996). Recently in order to keep strengthen muscles and balance from the center of the body, the interests in core muscle strengthening exercise are getting higher (Baek et al., 2008) and in many study results we are also seeing the positive effects. Brill (2002) have reported that after working on PCS exercise the posture stability and static balance ability has been im-

proved, and McGuine and Keene (2006) have reported that with core stabilize exercise in exercise group the ability of physical balance has been noticeably increased compared with control group. And also, there are other studies that have reported that core muscle strengthen exercise for woman pro-golfer improves flexibility, muscle strength and balance ability.

On the other hand, Kim (2008) has reported that balance training according to the Sprinter/Skater pattern for 12 weeks influences the physical balance stability of a high school archer, and this was almost coincided with the study result that the core stabilize exercise in the study is effective for static balance ability and dynamic balance ability for archers. Namely, the results of this study was, for the exercise group who worked on PCS program did not show attentive changes in the change of before and after. But when comparing the after value only, it was shown that the static balance ability of the left and right part of exercise group was attentively improved. On the other hand in the case of dynamic balance ability, the exercise group was attentively improved in ever posture except the balance ability of up right part and left part of in the change of before and after, but in the control group it has shown that either there were no attentive changes or de-

creased. By the attentive change in up, up right, and down right part, the difference between groups, the total score of exercise group was attentively improved compared to control group.

We have realized that the results of this study was similar to the reports that PCS exercise improves physical stability and balance ability (Fuss, 2009; Vaclav and Jiri, 1990), and also it was confirmed that the PCS exercise was a suitable exercise method for improving balance ability due to the physical stability of archers. But in the study of Kim (2008), with the study reports that it was helpful for improving balance ability for archers but it did not give a direct effect in shooting record and the study result of Baek et al. (2010) that physical stabilizing exercise was effective in improving shooting ability of an archer is considered meaningful to find out if either static or dynamic balance training has associated in the athletic performance and shooting record of archers.

Synthesizing the results above, it is considered that the PCS exercise helps to improve balance ability of archer, and it can show a superb athletic performance in archery when harmonized with technical ability through stabilized posture and a balanced movement and the control ability for bows. And in order to do these delicate and stabilized movement, along with training repeatedly it is required to develop suitable training for archers. We have gained the following conclusion in the result of watching the influence which PCS exercise causes in balance ability. First, the static balance ability of left and right part of the exercise group who have worked on PCS program attentively improved. Second, the dynamic balance ability by the attentive change in up, up right, and down right part, the total score has appeared significantly improved only in exercise group.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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