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A physical fitness profile of korean national women's ice hockey players differences between forward and defense

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Abstract

The purpose of this study was to compare physique, body composition and physical fitness 41 national ice hockey players team between forwards and defenders of the results were summarized as follow there were no statistically significant differences in all items of physique and body composition between forwards and defenders. Significiant muscular strength, cardiorespiratory endurance (maximum oxygen uptake and 20m shuttle run) ($p<.05$, $p<.05$). maximum strength, power and anaerobic power, muscle mass, body fat which are insufficient compared to foreign players. In conclusion, the national women's ice hockey team can improve athletic performance by increasing muscular strength, muscular power, anaerobic power and muscle mass and reducing body fat. Muscular strength and cardiorespiratory endurance are important factors to distinguish between forwards and defenders when selecting and finding players.

Key words: Ice hockey, position, physique, body composition, physical fitness

Introduction

Ice hockey is a representative winter sport in the United States and Canada in North America and Finland and Sweden in North Europe are known as powerful ice hockey nations. Asia has lately been trying to improve its performance through Asian League of three Asian nations. The Korean national men's ice hockey team won Bronze Medal at the 6th and 7th Asian Winter Games, was promoted to World Championship Division I by winning championship in the World Championship Division II, and won group B of Division I. On the one hand, the Korean national women's ice hockey team was founded in 1998 and put under inferior condition where no professional team was formed for 15 years. Women's ice hockey league was hosted in 2013, and the national women's team showed remarkable growth by getting promoted to group A of Division II. In addition, after securing an automatic qualification for the Pyeongchang 2018 Olympic Winter Games, the team is placing utmost efforts such as appointment of a foreign manager with an intent to show favorable outcome at the Olympic Games.

In all sports, successful athletic performance is affected by various factors (Vescovi, Murray & Vanheest, 2006). Different skills and tactics are required to exhibit solid performance in ice hockey (Ha & Kim, 2013), in addition to excellent physique, body composition, and physical fitness.

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Physique and body composition are important factors determining athletic performance in ice hockey. Height is an important factor because it extends length of stick and determines range of offense and defense (Park, Choi & Park, 1990). Body weight and body fat have great impact on athletic performance in ice hockey because they are significantly correlated with speed and acceleration (Gilenstam, Thorsen & Henriksson-Larsen, 2011).

In addition, since switching of offense and defense is very fast and players are required to maintain maximal physical fitness until the game ends (Koo, 1994; Lee, 2007). It is important to maintain high level of physical fitness throughout the game. Elements of physical fitness known as important in ice hockey include muscular strength, power, anaerobic power and aerobic power (Montgomery, 1988). Maximum speed (power) of about 10 seconds and agility (muscular strength and quickness) are required for quick offense and defense that can overwhelm the opponents in an ice hockey game. Anaerobic power (lactic acid resistance and lactic acid production) is required to show maximal exercise for about 45 seconds after entering game and until switch time. Also, aerobic power is required to be able to reenter the game after recovering fatigue for about 4-5 minutes. Such physical fitness attributes like muscular strength, power, anaerobic power and aerobic power are extremely important factors related to athletic performance in ice hockey.

Ransdell, Murray & Gao (2013) compared physique, body composition and physical fitness of elite women's ice hockey teams from 13 nations participating in high-performance camp hosted by the International Ice Hockey Federation (IIHF) by dividing them according to global ranking into upper, middle and lower groups. They reported that players of the upper group have better body composition and physical fitness such as power and aerobic power compared to the lower group. In addition, Roczniok et al. (2016) compared 20 selected players and 20 non-selected players among 42 players who participated in the team player selection of Top Division League in Poland. They reported that the selected players showed significantly higher height and physical fitness attributes like anaerobic power, aerobic power and lower body fat compared to the non-selected players.

Ice hockey teams that exhibit excellent athletic performance have higher level of physique, body composition and physical fitness, and it is necessary to improve physique and physical fitness of players to improve athletic performance. Athletic performance of the national team can be improved by examining physique, body composition and physical fitness of the national women's ice hockey team and training the team to the same level as high-ranking foreign teams. Such data can be utilized as basic data for finding, training and prescription of players. However, there is complete lack of studies that examined physique, body composition and physical fitness of the Korean national women's ice hockey team.

In addition, a study reported that physique, body composition and physical fitness properties differ among different positions of the same sport (Kim, 2007). In an ice hockey game, forwards participate in about 35% (game 1: rest 8) of game time and defenders participate in about 50% (game 1: rest 3.5) of game time. In comparison to defenders, forwards are required to have faster skating speed and greater recovery time, as well as wider range and direction change during offense. On the contrary, defenders perform exercise at relatively same activity and intensity, less substitution and longer time of recovery (Paterson, 1979; Twist & Rhodes, 1993a). As such, there are differences in exercise intensity, exercise time and resting time between forwards and defenders in ice hockey. Therefore, training programs appropriate for different positions can be established and applied by comparing physique and physical fitness attributes of different positions, which can improve athletic performance and be used as data during player selection.

According to previous studies, there were differences in physique, body composition and physical fitness (muscular strength, power, aerobic ability, etc.) between forwards and defenders of male ice hockey players (Ha & Kim, 2013; Burr et al., 2008; Vescovi et al., 2006). However, some of these studies showed different results. Since women's ice

hockey is different (body checking) from men's ice hockey, physique, body composition and physical fitness attributes of each position can differ from male players. There is lack of studies that examined physical fitness attributes of each position of female ice hockey players, and the results of such small number of studies do not agree (Geithner, Lee & Bracko, 2006; Randsdell et al., 2013). Additional studies are required.

The purpose of this study is to compare physique, body composition and physical fitness attributes between forwards and defenders. The results can be compared with global players to establish and apply a scientific training program that can improve athletic performance of the Korea national women ice hockey, and they can be used as basic data to implement a scientific approach to training programs for different positions and to find players.

Methods

Participants

This study was conducted on 41 Korean national women's ice hockey players in 2015 and 2016. And there were 18 overlapping players who were included in both 2015 and 2016 (n=20 in 2015, n=21 in 2016). Physical attributes of the participants are as presented in <Table 1>.

Table 1. *Characteristics of the Subjects*

Variable	All (n=41)	Forwards (n=24)	Defenders (n=11)
Height (cm)	160.4±4.06	160.5±3.48	160.6±4.33
Weight (kg)	59.9±5.03	58.6±3.80	59.6±4.67
Body fat (%)	24.0±4.22	22.8±2.58	22.9±3.30
BMI (kg/m2)	23.3±1.86	22.7±1.14	23.1±2.07

Methodology

Physique and body composition

Height was measured nearest 0.1cm using an anthropometer, and body weight, BMI and body fat were measured for body composition using Inbody 720 (Biospace, Korea). After first measuring body weight and height, players were told to stand on foot plate electrodes, grab electrodes on both hands, open their arms to about 30° and away from their body, and stand still during measurement.

Measurement of physical fitness

Muscular strength

Back muscle strength was measured using back muscle dynamometer (TKK-1270, Takei, Japan) by making the subjects stand with knees and arms open while grabbing the handle, straightening the waist and then bending the waist forward by about 30 degrees to exert maximal force in perpendicular direction. This procedure was repeated twice and higher value was recorded. Grip was measured using grip dynamometer (TKK-1270, Takei, Japan) by making the subjects exert maximal force after adjusting the adjustment screw so that the second joint of the index finger is almost at a right angle. Left and right sides were alternately measured twice, and higher value was recorded.

Leg strength was measured using isokinetic muscle strength measuring device (Humac Norm, CSMI, USA). Leg strength was measured at angular speed of 60°/sec and trunk strength was measured at angular speed of 30°/sec. After adjustment of posture, players were given sufficient explanation on the measurement method before repeating warm-up exercise several times and measuring. Leg strength was measured first, and trunk strength was measured after taking enough rest. After repeating flexion and extension of the two parts three times at maximum force, peak torque (%BW) of flexion and extension was calculated.

Muscle endurance for sit-up, number of sit-ups done in a minute was recorded by bending knees to right angle and counting the number of times in which two elbows touch the knees and return to starting position.

Power

For Sargent jump, highest distance was recorded using Sargent jump meter (TKK-1220, Takei, Japan) after the

subjects jumped in place. Standing long jump measured distance jumped from a take-off board. Both Sargent jump and standing long jump were done twice to record higher values.

Anaerobic power

Peak power (w/kg), mean power (w/kg) and power drop rate (%) were measured by 30-second Wingate test using bicycle ergometer (Monark 824E, Sweden). Warm-up exercise was done by lightly pedaling for less than 3 minutes on the bicycle ergometer. The bicycle ergometer exercise was done with full strength for 30 seconds when the subjects were given a 'start' signal.

Cardiorespiratory endurance

Maximum oxygen uptake was measured by maximum exercise load test using respiratory gas analyzer (Quinton, USA). KISS protocol developed by Korea Institute of Sport Science was used as the measurement protocol. Starting on a 6% slope at speed of 80m/min, speed was increased by 20m/min at every 2 minutes and measurement was done until all subjects were out. Maximum oxygen uptake was determined by maximum value of oxygen uptake.

20m shuttle run was measured by running 20m distance according to sound source. Running ended upon second time at which the subjects failed to reach the destination before the signal sound, and the number of repetitions was recorded.

Pulmonary function was measured using Chestgraph HI-101(Chest M.I Inc, Japan) by making the subjects stand up, take a deep breath with the mouth piece on the mouth, and fully breathe air out of the lungs. Measurement was repeated twice, and higher value was recorded.

Flexibility

Sitting trunk flexion was measured using sitting trunk flexion meter (Welltek, Korea) by making the subjects sit with legs straight and bend the upper body forward as much as possible without bending the knees.

Trunk extension was measured using trunk extension meter (TKK-1860, Takei, Japan). During measurement, an assistant grabbed both ankles of the subjects and the subjects put both hands on their waist while lying face down, lift the upper body as much as possible, and maintaining lifted posture for 1 second or longer with the chin lifted. Linear distance from the chin to the floor was measured. Both sitting trunk flexion and trunk extension were measured twice, and higher values were recorded in cm.

Statistics

For data analysis of the study results, SPSS 21.0 was used to calculate mean and standard deviation of all measurement items. Independent t-test was performed to find the differences in body composition, basic physical fitness and professional physical fitness between forwards and defenders. Statistical significance level was $p<0.05$ for all analyses.

Results

Physique and body composition attributes

The results of examining physique and body composition attributes of the Korean national women's ice hockey players and comparing physique and body composition between forwards and defenders are as presented in <Table 1>.

Mean height of the national team was 160.4 ± 4.06cm, mean body weight was 59.9 ± 5.03kg, and mean body fat was 24.0 ± 4.22%. There was no significant difference in height, body weight and body fat between forwards and defenders.

Physical fitness attributes

Muscular strength

The results of examining physical fitness attributes of the Korean national women's ice hockey players and comparing muscular strength factor between forwards and

defenders are as presented in <Table 2>.

Mean leg strength of right flexion was 119.8 ± 18.28%BW, and it was significantly higher ($p<0.05$) in forwards (M=126.1%) than defenders (M=112.3%BW).

Mean leg strength of right extension of the national team was 246.8 ± 31.40%, and it was significantly higher ($p<0.05$) in forwards (M=258.5% BW) than defenders (M= 234.2% BW). Mean leg strength of left flexion and left extension was 118.6 ± 18.56% BW and 237.85 ± 28.19%, respectively. There was no significant difference between forwards and defenders.

Mean back strength of the national team was 97.7 ± 12.35kg and mean left and right grips were 34.5 ± 4.16kg and 34.5 ± 4.16kg, respectively. There was no significant difference in back strength and grip between forwards and defenders.

Mean trunk strength of flexion and extension was 244.2 ± 45.57% and 339.6 ± 80.44%, respectively. Mean sit-up count was 48.7 ± 9.13 times. There was no significant difference in both trunk strength and sit-up between forwards and defenders.

Table2. *Physical fitness profiles of elite female hockey players, with comparisons between playing positions*

	Variable	All (n=44)	Forwards (n=24)	Defenders (n=11)	t-value	p-value
Strength	Right knee flexion 60°/sec (%BW)	119.8 ± 18.28	126.1 ± 15.87	112.3 ± 21.61	2.123	.041*
	Right knee extension 60°/sec (%BW)	246.8 ± 31.40	258.5 ± 26.22	234.2 ± 33.92	2.324	.026*
	Left knee flexion 60°/sec (%BW)	118.6 ± 18.56	123.6 ± 12.13	117.4 ± 18.87	1.173	.249
	Left knee extension 60°/sec (%BW)	237.85 ± 28.19	245.0 ± 25.16	230.4 ± 30.52	1.494	.145
	Back strength (kg)	97.7 ± 12.35	99.9 ± 13.73	94.4 ± 9.48	1.210	.235
	Grip strength (left, kg)	35.4 ± 4.59	35..6 ± 4.79	36.5 ± 4.56	-.535	.596
	Grip strength (right, kg)	34.5 ± 4.16	34.1 ± 3.85	35.8 ± 5.15	-1.087	.285
	Trunk flexion (%BW)	244.2 ± 45.57	241.7 ± 47.52	255.3 ± 20.17	-.908	.371
	Trunk extension (%BW)	339.6 ± 80.44	346.0 ± 88.48	344.6 ± 65.28	.048	.962
	Sit-up (60sec)	48.7 ± 9.13	50.4 ± 9.15	46.8 ± 6.73	1.151	.258
Power	Vertical jump (cm)	44.4 ± 4.61	44.88 ± 3.57	46.1 ± 3.36	-.953	.348
	Long jump (cm)	197.8 ± 11.6	199.7 ± 6.98	202.5 ± 12.4	-.719	485
	Peak power (W/kg)	9.52 ± .734	9.66 ± .699	9.58 ± .774	.307	.761
	Mean power (W/kg)	6.55 ± .529	6.73 ± .378	6.63 ± .506	.662	.513
	Fatigue index (%)	58.0 ± 6.08	57.3 ± 7.13	59.2 ± 4.38	-.784	.439
Aerobic capacity	VO2max[$] (ml/kg/min)	50.79 ± 4.20	52.80 ± 2.78	48.21 ± 4.78	2.517	.024*
	20m shuttle run (rep)	64.2 ± 12.9	69.8 ± 9.86	62.6 ± 7.24	2.137	.040*
	FVC (cc)	3170.2 ± 394.9	3210.8 ± 421.5	3093.6 ± 411.9	.769	.447
	FEV1 (cc)	2937.8 ± 331.4	2957.1 ± 357.0	2917.3 ± 343.2	.310	.759
Flexibility	Trunk forward flexion (cm)	26.8 ± 6.00	25.2 ± 7.08	28.4 ± 2.62	-1.467	.152
	Trunk backward extension (cm)	54.7 ± 8.88	53.4 ± 9.84	54.2 ± 5.34	-.266	.792

$ Maximum oxygen uptake: Average value of national team in 2015 (overall n=20, forwards n=12, defenders n=5), *p<.05

Power

The results of examining physical fitness attributes of the Korean national women's ice hockey players and comparing power factor between forwards and defenders are as presented in <Table 2>.

Mean Sargent jump of the national team was 44.4 ± 4.61cm and mean standing long jump was 197.8 ± 11.6cm. There was no significant difference in Sargent jump between forwards and defenders.

Peak power of the national team was 9.52 ± 0.734W/kg, mean power was 6.55 ± 0.529W/kg, and power drop rate was 58.0 ± 6.08%. There was no significant difference in peak power, mean power and power drop rate between forwards and defenders.

Cardiorespiratory endurance

The results of examining physical fitness attributes of the Korean national women's ice hockey players and comparing cardiorespiratory factor between forwards and defenders are as presented in <Table 2>.

Mean maximum oxygen uptake of the national team was 50.79 ± 4.20 ml/kg/min, and it was significantly higher ($p<0.05$) in forwards (M=52.80 ml/kg/min) than defenders (M=48.21ml/kg/min).

Mean 20m shuttle run of the national team was 64.2 ± 12.9 times, and it was significantly higher ($p<0.05$) in forwards (M=69 times) than defenders (M=62.6 times).

Mean vital capacity of the national team was 3,170.2 ± 394.9cc, and mean one-second capacity was 2,937.8 ± 331.4cc. There was no significant difference in vital capacity and one-second capacity between forwards(3210.8 ± 421.5) and defenders(3093.6 ± 411.9).

Flexibility

Flexibility factor between forwards and defenders are as presented in <Table 2>.

Mean sitting trunk flexion of the national team was 26.8 ± 6.00 and trunk extension was 54.7±8.88cm. There was no significant difference in both sitting trunk flexion (25.2 ± 7.08 vs 28.4 ± 2.62) and trunk extension (53.4 ± 9.84 vs 54.2 ± 5.34) between forwards and defenders.

Discussion

The purpose of this study was to examine physical fitness levels of the Korean national women's ice hockey players in 2015 and 2016, find out physical fitness factors of different positions, and present basic data for scientific training method and player selection that can improve athletic performance of the national team. Physique, body composition and physical fitness were measured on 41 players. They were divided into forwards (n=24) and defenders (n=11) to analyze physique, body composition and physical fitness factors of each position.

Physique and body composition attributes

In ice hockey, height is an important factor that determines range of offense and defense, and height difference can decide performance (Park et al., 1990). There was no significant difference in height between forwards and defenders of the Korean national women's ice hockey players. Geithner et al. (2006) compared height of forwards and defenders of college women's ice hockey teams for five years and reported that height of defenders is larger than forwards (167.66±5.32 for forwards, 169.08±4.91 for defenders). A domestic study also reported that height of defenders is larger than forwards (Ha & Kim, 2013). Height of forwards is smaller because forwards in ice hockey are required to have speed, agility, power and muscular strength during offense. In addition, mean height of the national team was 160.4±4.06cm, about 9cm smaller than the national women's team of the United States, 8cm smaller than regional champion team of Sweden and college teams of Canada, and 4cm smaller than NCAA Division III teams <Table 3>. Height needs to be considered during player selection to improve athletic performance of Korean national players.

According to different positions, body weight and body fat decrease as greater speed, agility, radius of activity, aerobic ability and anaerobic ability are required (Geithner et al., 2006). Body weight of forwards was slightly higher than defenders, but the difference was not significant. In

addition, there was no significant difference in body fat between forwards and defenders. A study of Randsdell et al. (2013) reported that there is no significant difference in body weight and body fat between forwards and defenders. However, a study of Burr et al. (2008) on men reported that defenders have significantly high body weight and body fat compared to forwards. Unlike men, body checking is not allowed in women's ice hockey and heavy body weight and high body fat of defenders do not affect athletic performance. In addition, whereas mean body weight of the Korean national team was 1kg lower than the U.S national team, body fat was about 8% higher <Table 3>. In addition, body weight of the national team was about 3kg higher than top world class level, and body fat was about 7% higher (Ransdell et al., 2013). Peterson et al. (2015) compared male ice hockey players of Division I and Division III and reported that height and body weight of Division I players are significantly higher than Division III players but body fat is significantly lower. To improve athletic performance of Korean national players, it would be necessary to implement physical fitness training that can increase muscle mass and reduce body fat.

Table 3. *Comparative data for studies with elite female ice hockey players*

Variable		Height (cm)	Weight (kg)	Body fat (%)	Vertical jump (cm)
Korea Women's Ice Hockey team (n=44)		160.4±4.06	59.9±5.03	23.30±1.86	44.40±4.61
US Women's Ice Hockey team[a] (n=44)		169.7±6.9	70.4±7.10	15.80±1.90	50.30±5.70
13 Countries Eliteb	Group 1 (n=30)	-	66.25±6.51	16.61±2.63	51.93±5.67
	Group 2 (n=31)	-	64.53±7.00	19.10±3.30	49.50±6.08
	Group 3 (n=141)	-	61.72±7.79	18.71±3.53	45.79±5.02
Sweden Regional winner[c] (n=11)		168.0±0.04	77.0±10.7	-	-
University of Alberta team[d] (n=112)		168.0±5.26	66.42±6.96	20.85±4.67	43.10±4.91
NCAA Division III[e] (n=11)		164.0±0.06	67.1±10.2	22.60±7.80	35.70±6.00
Canada varsity[f] (n=19)		166.6±6.3	62.3±7.3	-	-
Variable		Long jump (cm)	VO2max(ml/kg/min)	Peak power (W/kg)	Fatigue index (%)
Korea Women's Ice Hockey team (n=44)		197.8±11.6	50.79±4.20	9.52±.734	58.0±6.08
US Women's Ice Hockey team[a] (n=44)		214.8±10.9	-	-	-
13 Countries Eliteb	Group 1 (n=30)	206.3±12.85	47.96±4.61	-	-
	Group 2 (n=31)	206.6±14.70	45.49±3.96	-	-
	Group 3 (n=141)	194.0±14.22	44.79±4.80	-	-
Sweden Regional winner[c] (n=11)		-	-	-	-
University of Alberta team[d] (n=112)		-	44.62±5.31	-	-
NCAA Division III[e] (n=11)		-	-	9.24±1.46	43.08±6.70
Canada varsity[f] (n=19)		-	-	-	-

a: Ransdell & Murray, 2011; b: Ransdell et al., 2013; c: Gilenstam et al., 2011;
d: Geithner, Lee & Bracko, 2006; e: Janot, Beltz & Dalleck., 2015; f: Wilson, Snydmiller, Game, Quinney & Bell, 2010

Table 4. Comparative data for studies with elite female ice hockey players by position

Variable	Height (cm)		Weight (kg)		Body fat (%)	
	Forwards	Defenders	Forwards	Defenders	Forwards	Defenders
Korea Women's Ice Hockey team	160.5±3.48	160.6±4.33	58.60±3.80	59.60±4.67	22.80±2.58	22.90±3.30
13 Countries Elite	-	-	61.91±8.31	64.61±6.92	18.43±3.51	18.7±3.5
University of Alberta team	167.7±5.32	169.08±4.91	65.28±6.19	68.51±6.76	19.67±3.94	22.42±5.86
Variable	Vertical jump (cm)		Long jump (cm)		VO_{2max}(ml/kg/min)	
	Forwards	Defenders	Forwards	Defenders	Forwards	Defenders
Korea Women's Ice Hockey team	44.88±3.57	46.10±3.36	199.70±6.98	202.50±12.4	52.80±2.78	48.21±4.78
13 Countries Elite	47.11±5.55	47.06±5.73	197.79±15.05	197.32±14.58	45.93±4.66	45.05±4.91
University of Alberta team	43.97±4.22	40.94±5.01	-	-	45.96±4.94	43.32±5.04

Physical fitness attributes

strength

Muscular strength is divided into absolute muscular strength and relative muscular strength, and both absolute and relative muscular strengths are important in ice hockey. Absolute muscular strength provides strength to move and withstand body contact with other players. Relative muscular strength provides strength for quickness, speed and agility (Twist, 2007; Twist & Rhodes, 1993b). Since body checking is not permitted in women's ice hockey, relative muscular strength for speed and agility is more important (Twist, 2007). Leg strength of right flexion and right extension of the Korean national women's ice hockey team was significantly higher in forwards than defenders. There was no significant difference in left flexion and left extension. A study of Ha & Kim (2013) on male ice hockey players reported that isokinetic leg strength of right flexion and right extension is significantly higher in defenders than forwards. Muscular strength of lower body is needed for sudden stop, quick direction change, and high-speed turn during skating. In women's ice hockey, forwards showed higher relative muscular strength because they are required to show faster skating speed, wider range of activity and quick direction change compared to defenders.

Muscular strength of upper body is needed for accurate handling of puck and maintenance of shooting posture. In addition, core muscular strength greatly helps balance, stabilization, power and delivery of strength from lower limbs to upper limbs during game (Twist, 2007). There was no significant difference in back strength, grip, trunk strength (flexion, extension) and sit-up of the national team between forwards and defenders. However, according to studies of Burr et al. (2008) and Vescovi et al. (2006) conducted on men's ice hockey, both muscular strength and muscular endurance of upper body were significantly higher in defenders than forwards. Whereas defenders need high muscular strength of upper body to push forwards away from the goal post using muscular strengths of upper body and lower body because of ice checking in men's ice hockey, there is no difference between forwards and defenders in women's ice hockey because body checking is not permitted. Although muscle hypertrophy is not the main focus of training in ice hockey, as sufficient muscle mass is important in all aspects and can reduce risk of injuries (Twist & Rhodes, 1993b), training that focuses on increasing muscle mass can be important during off-season (Moller & Bracko, 2004). On the one hand, since excessive muscle can affect skating speed and agility and increase of body weight from increase of muscle can consume greater energy for movement, deceleration and direction change (Bompa & Haff, 2009), muscle mass should only be increased by appropriate amount.

Power

Muscular strength is important in ice hockey, but muscular power is more essential (Moeller & Bracko, 2004; Twist & Rhodes, 1993b). Ability to make fast speed is the most important part of ice hockey game (Twist & Rhodes, 1993b), and power is an important factor of acceleration (Bompa & Haff, 2009). There was no significant difference in power variables like Sargent jump, standing long jump, peak power and mean power between forwards and defenders. Studies of Ransdell et al. (2013) and Vescovi et al. (2006) reported that there is no significant difference in muscular power between forwards and defenders. However, a study of Burr et al. (2008) on male ice hockey players reported that peak power and standing long jump of defenders are significantly higher than forwards. There is no difference in power between forwards and defenders because both forwards and defenders are required to respond to various situations and repeatedly exhibit explosive performance during three 20-minute game periods on ice.

Comparing the Korean national team with global players, Sargent jump of the Korean national team was lower than elite players of the U.S national team and 13 other nations and higher than college teams of Canada and NCAA Division III teams <Table 4>. Standing long jump was lower than top and middle-ranking elite players of the U.S national team and 13 other nations but higher than low-ranking players <Table 4>. Ransdell et al. (2013) reported that players of top-ranking nations showed about 6-12% higher power of lower body compared to players of low-ranking nations. To improve athletic performance of the Korean national team, it would be necessary to increase power of lower body to the same level as high-ranking nations. Exercises such as maximum muscular strength, plyometric, power clean and snatch should be continuously done to improve power of lower body. In addition, the Korean national team was found to have lower power drop rate compared to players of NCAA Division III. Power drop rate is an indicator used to check power endurance, and lower power drop rate indicates higher power endurance. Ice hockey game consistently requires high power, and players need to have enough power endurance to able to respond to various situations and repeatedly exhibit explosive strength during 60 minutes of game time (Twist & Rhodes, 1993b). As power drop rate of the Korean national team was relatively low, lactic acid resistance training that can improve power endurance would be necessary.

Cardiorespiratory endurance

It is estimated that 31% of energy required in ice hockey is supplied by aerobic system (Moeller & Bracko, 2004). High level of aerobic ability is important because it increases endurance needed for actions continuously repeated for 60 minutes (Twist, 2007; Bracko, 2001). Maximum oxygen uptake and shuttle run, variables of aerobic power, were significantly higher in forwards than defenders ($p<0.05$). Whereas aerobic ability of forwards was higher than defenders in a study of Twist & Rhodes (1993a), aerobic ability of forwards was significantly lower than defenders in studies of Ha & Kim (2013) and Burr et al. (2008). The reason why aerobic ability was higher in forwards than defenders is probably because of repeated speed actions during game, quick recovery during short time of substitution, and consistent agility and speed training.

Comparing maximum oxygen uptake of the Korean team with global players, it was higher than high, middle and low-ranking elite players of 13 nations and higher than college teams of Canada <Table 3>. The Korean national team showed higher level of aerobic ability compared to global players, suggesting that its aerobic ability is well trained. On the one hand, Carey, Pliego & Raymond (2007) proposed that there is minimal aerobic ability required to improve recovery in women's ice hockey, and they reported that higher aerobic ability does not provide additional recovery. In addition, since intensive interval training develops aerobic ability, they suggested that there is no need to include a separate aerobic program in training. As the Korean national team currently has relatively excellent level of aerobic ability, no separate training program is necessary for aerobic ability.

Flexibility

Flexibility is important because of unexpected movement from reaction in sports. Joints must be able to pass all motions to reduce risk of injuries (Twist, 2007). Especially, flexibility of the hip, inguinal region and thighs increases skating speed and efficiency and decreases risk of injuries (Moller & Bracko, 2004; Twist & Rhodes, 1993b). There was no significant difference in flexibility variables like sitting trunk flexion and trunk extension between forwards and defenders. A study of Burr et al. (2008) also reported that there was no significant difference in flexibility between forwards and defenders. Crouching posture maintained throughout game time refers to a state in which hamstring muscles are not completely extended and causes excessive contraction of hamstrings. Since excessive contraction of hamstrings can hinder skating speed and power, flexibility of hamstrings is particularly important (Twist & Rhodes, 1993b). Also, when players cannot fully straighten their hind leg while skating, poor skating speed and skate mechanic can restrict flexibility of other body parts. Players must maintain flexibility through regular stretching (Twist & Rhodes, 1993b). It would be desirable for the Korean national team to maintain current flexibility.

Conclusion

The purpose of this study was to examine physical fitness attributes of 41 Korean national women's ice hockey players in 2015 and 2016 by dividing them into forwards and defenders and to prepare basic data for scientific approach and player selection that can improve athletic performance of the Korean national women's ice hockey team. Physique, body composition and physical fitness of players were measured to analyze differences between positions, and the following conclusion was drawn.

First, there was no significant difference in all items of physique and body composition between forwards and defenders of the national women's ice hockey team.

Second, for muscular strength of forwards and defenders of the national women's ice hockey team, knee strength of right flexion and right extension was significantly higher ($p<0.05$, $p<0.05$) in forwards than defenders.

Third, for cardiorespiratory endurance of forwards and defenders of the national women's ice hockey team, maximum oxygen uptake and 20m shuttle run of forwards were significantly higher ($p<0.05$) than defenders.

Fourth, Korean players need to implement systematic physical fitness training programs to increase muscular strength, muscular power and anaerobic power that are low compared to foreign players, reduce body fat, and increase muscle mass.

In conclusion, it was found that the national women's ice hockey team needs to improve muscular strength, muscular power and anaerobic power, increase muscle mass, and reduce body fat to improve athletic performance of the team. Muscular strength and cardiorespiratory endurance are important factors to distinguish between forwards and defenders when selecting and finding players.

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