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Physical and Performance Differences Among Forwards, Defensemen, and Goalies in Elite Women's Ice Hockey

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Abstract. Geithner, C.A., A.M. Lee, and M.R. Bracko. Physical and performance differences among forwards, defensemen, and goalies in elite women's ice hockey. *J. Strength Cond. Res. 20(3): 500–505. 2006.*—Positional differences have been examined in women's basketball, field hockey, netball, and volleyball, but not in elite women's ice hockey. Our purpose was to describe and compare physical, fitness, and skating performance characteristics of forwards (F), defensemen (D), and goalies (G). Subjects were 112 University of Alberta women players (21.4 ± 2.9 years of age). A full anthropometric battery was conducted on each player. Heath-Carter anthropometric somatotypes were calculated. Percent body fat (%fat) was estimated from both general and population-specific equations. Subjects performed off-ice fitness tests (vertical jump, 40-yd dash, Leger test for predicting $\dot{V}O_2max$) and on-ice fitness (Modified 3-Repeat Sprint Skate Test—MRSS, blood lactate after sprint test) and skating performance tests (6.10-m acceleration test, Cornering S-Turn Agility Test). Descriptive statistics and multivariate analyses of variance were run using SPSS (Version 10.0) for the MacIntosh, with a significance level set a priori at $p < 0.05$. Significant positional differences were found for bicristal breadths (D > G, F > G); relaxed arm circumference (D > F, G > F); supraspinale and biceps skinfolds (G > D, G > F); and endomorphy (G > F). Significant differences among positions were also found for the MRSS (G > D > F) and agility tests (G > D, G > F). D tended to have the most robust build overall. F were leaner than D and G, and their smaller relaxed arm circumference measurements most likely reflect less subcutaneous fat on the upper arm. F had greater anaerobic power than D, followed by G, and they tended to have greater aerobic capacity. F and D were more agile than G. Performance demands appear to be position specific. F need to be the most versatile and fit because of a greater amount and variety of work performed both during practices and games; their required degrees of versatility and fitness are followed by those required of D and G.

Key Words. positional differences, fitness, skating performance

Introduction

Significant differences have been identified in physical and performance characteristics among player positions in women's field hockey (4, 18, 22, 24, 26–29, 34–36), netball (15), basketball (1, 3, 32), and volleyball (14). These differences are shown in Table 1.

Of the sports just mentioned, field hockey is the most similar to ice hockey with regard to the sport as a whole, player positions, and the demands of those positions. Wilsmore (36) concluded that somatotype is an important factor in differentiating between player positions in field hockey, particularly at elite levels. Somatotyping is a common method of quantifying physique as a composite score representing the contributions of 3 components: endomorphy (relative fatness), mesomorphy (relative muscularity and robustness of build), and ectomorphy (relative linearity) (10). Wilsmore (36) observed that all field hockey players tend toward mesomorphy; however, halves and backs tend toward greater mesomorphy and endomorphy and lower ectomorphy than forwards (F). Similarly, Bale and McNaught-Davis (4) found field hockey F and halves to be more mesomorphic, less endomorphic, and lighter in weight than backs and goalies (G). Johnston and Watson (18) concluded that F require a more muscular physique because of greater positional demands for speed, power, and strength in attacking play. Some researchers have suggested that body weight and body composition (%fat) are associated with the amount of running players do related to their position (29, 36)

Findings from several studies indicate that field hockey players who are more involved in attacks on goal are lighter, leaner, and more fit than defensive players, who tend to run less and utilize short-duration movements (4, 29, 36). Tanner (33) stated that the explanation of physical differences between highly successful Olympic athletes competing in different events must lie in task-specific mechanical and physiological requirements. Selection for sport based on skill requirements is also present in elite youth sport (20). Field hockey F have been found to have a higher vertical velocity (26, 34) and a higher $\dot{V}O_2max$ (26) than halves and backs. Greater anaerobic capacity has been reported for halves than for F, backs, and G (26). In contrast, 2 studies (28, 35) showed no significant positional differences among women field hockey players in physical characteristics or fitness and performance, except that G were significantly heavier and had a higher percentage of body fat than did players in other positions (35).

Studies on positional differences in physical characteristics or performance among men's ice hockey players are limited (2, 16). In a preseason study of 48 elite amateur Canadian men's ice hockey players (Major Junior A and University team players), Houston and Green (16) found that defensemen (D) were significantly taller, heavier, and had a greater body surface area than F or G. No significant difference were found in any other measures, including %fat predicted from skinfolds, $\dot{V}O_2max$ (absolute and relative), and several other pulmonary function tests, anaerobic alactic power output, and anaerobic lactate capacity (blood lactate). Agre et al. (2) found significant differences by position among 27 male National Hockey League professional hockey players for body weight (F > G, D > G, $p < 0.05$) and hip and groin

TABLE 1. Summary of findings from other studies on positional differences in women's team sports.*

Sport and variable	Differences among positions ($p < 0.05$)
Field hockey	
Weight	G > B > H, F (29)
	G > B, H, F (35)
Skinfolds	G > B > H, F (triceps & subscapular) (29)
	G > B, H > F (biceps) (29)
% Fat	G > B > H > F (29)
	G > B, H, F (35)
Endomorphy	B > F, H† (36)
Mesomorphy	B, H > F‡
Ectomorphy	F, H > B (36)
Basketball	
Weight	C > F > Gu (1, 32)
Height	C > Gu (3)
Sitting height	C > F > Gu (3, 32)
	Gu > F (1)
Leg/lower-limb length	C > Gu, F > Gu (3)
Arm/upper-limb length	C > F (1)
Biacromial breadth	C > Gu (3)
Arm circumference—relaxed	C > Gu, F > Gu (3)
Arm circumference—flexed	Gu > F (1)
Waist circumference	Gu > F (1), C > F (3)
Lean body mass	G > F (1)
Mesomorphy	C > Gu, F (1)
Anaerobic power	C, F > Gu (3)
($kg \cdot m^{-1} \cdot s^{-1}$)	C > Gu (3)
Netball	
Mesomorphy	Midfield players > goal-attack players, goal defense players (15)
Ectomorphy	Goal defense players > midfield players, Goal attack players (15)
Volleyball	
Weight	C, Sp > Se (14)
Height	C, Sp, opposites > Se (14)
Biepicondylar breadth	C, Sp, opposities > Se (14)
Bicondylar breadth	Sp > C (14)
Arm circumference—relaxed	Sp > C (14)
Subscapular skinfold	Sp > C (14)
Mesomorphy	Se, Sp > C (14)
Ectomorphy	C > Se (14)

* G = goalies; B = backs; H = halves; F = forwards; C = centers; Gu = guards; Sp = spikers; Se = setters.

† All player levels combined.

‡ First grade (highest level) players only.

flexibility (G > F, G > D, $p < 0.05$). No significant differences among positions were found in $\dot{V}O_2$max, %fat by underwater weighing, absolute strength, and relative strength (strength-to-body weight).

Despite numerous studies on female athletes in team sports (1, 3, 14, 27–29, 31, 35, 36) and an increase in participation in women's ice hockey with its 1998 Olympic debut, there are relatively few published research studies on women's ice hockey (5–7, 9, 12, 31). Thus, relatively little objective information is available on physical and performance characteristics of women's ice hockey players (5, 7, 9, 12), and no studies have been published regarding whether or not and how physical and performance characteristics differ by player position in women's ice hockey. Thus, the purpose of this study was to describe and compare the physical and performance characteristics of F, D, and G in elite women's ice hockey. The following alternative hypotheses were posed (with the expectation of significant differences among positions based on the literature, primarily for women's field hockey): (a) F are lighter in weight and leaner (i.e., lower %fat and lower endomorphy) than D and G; and (b) F have better on- and off-ice fitness and skating performance than D and G, and, more specifically, F have higher anaerobic power (i.e., lower time on the Modified Repeat Sprint Skate Test [MRSS]) and aerobic capacity (i.e., higher predicted $\dot{V}O_2$max from the Leger Test) and are faster (i.e., lower times on 40-yd dash and 6.10-m acceleration tests) and more agile (i.e., lower time on Cornering S-Turn test) than D and G.

METHODS

Experimental Approach to the Problem

In order to determine the physical characteristics of the players, a full anthropometric battery was conducted preseason on each player from the University of Alberta women's ice hockey team for 5 seasons from 1999 to 2004, excluding 2001. Percent body fat was estimated from skinfolds using both a general equation for women and a population-specific equation for women athletes, and somatotypes were calculated for classifying physique or body build. In order to determine the performance characteristics of the players, on-ice skating performance was assessed preseason for the same years (acceleration and agility), as were on-ice fitness (anaerobic power and blood lactate concentration) and off-ice fitness (vertical jump, 40-yd dash, and the Leger test for predicting $\dot{V}O_2$max). Means and standard deviations were calculated to describe the players as a group and by position (F, D, and G), and analyses of variance (ANOVAs) were run to test for significant positional differences in physical and performance characteristics.

Subjects

Subjects were players for the University of Alberta (Canada) women's ice hockey team (the Pandas) who averaged 12.4 years of playing hockey. The players were measured preseason for 5 seasons: 1999–2004, excluding 2001 (n = 112, age = 21.4 ± 2.9 years). Informed consent was provided by each of the players, and approval for the research was obtained from the Institutional Review Board at Gonzaga University. The University of Alberta women's ice hockey team has won 7 Canada West Conference titles and 4 Canadian Interuniversity Sports (CIS) National Championships, compiling a 148-12-5 record for the years included in this study through the preseason of 2004–05. The CIS National Championship tournament winner is synonymous with the best women's university hockey team in Canada, and the University of Alberta women's ice hockey team has gone to the CIS National Championship tournament for 7 of the past 7 years. In addition, at the end of the most recent season of play (2004–05), the team had attained a 110-game winning streak in conference and play-off play. Thus, based on the outstanding performance record of the University of Alberta women's ice hockey team and a classification of elite-level athletes as those who are competitive at the national or international level, the players who participated in this study were considered elite athletes.

Subjects performed off-ice and off-season training according to their own programs and time constraints. During the 5 off-seasons prior to the preseasons included in this study, 5 players performed a dedicated, periodized strength and conditioning program. These players performed weight training, jump training and cardiovascular endurance, and power training. The majority of the players trained, primarily to improve their cardiovascular endurance, by riding bikes, running, or by playing outdoor soccer. Nevertheless, the University of Alberta women's ice hockey players were able to maintain their on-ice and off-ice fitness and body composition during the off-season, as evaluated by postseason to preseason differences (7, 12).

Procedures

A full anthropometric battery, which included body weight, height, 4 skeletal lengths and 4 skeletal breadths, 2 trunk and 4 limb circumferences, and 9 skinfolds (SKF), was taken on each player in the players' locker room. All measurements were taken by an experienced anthropometrist (C.A. Geithner), following the standardized procedures of Lohman et al. (19). Intraobserver measurement reliability exceeded 95% (intraclass correlation coefficients ranged from 0.9606 for skinfolds to 0.9956 for height). The digital scale used for measuring body weight (Taylor Lithium Electronic Scale; Taylor Precision Products Ltd., Las Cruces, NM) and the Harpenden SKF calipers (John Bull British Indicators Ltd., London, UK) were calibrated prior to measuring each player. Several measures were derived (calculated from the anthropometric variables measured directly on each player), including body mass index ($kg \cdot m^{-2}$), estimated leg length (height − sitting height), waist-to-hip ratio, and androgyny (relative masculinity or femininity of physique calculated as [3 × biacromial breadth] − bicristal breadth). Percent body fat was estimated from a general equation for body density from SKF (17) and a population-specific equation for female athletes (37). Siri's equation (29) was used to estimate %fat from body density. Heath-Carter anthropometric somatotypes were calculated (10) yielding player-specific scores for endomorphy (relative fatness or leanness), mesomorphy (relative muscularity and robustness of build), and ectomorphy (relative linearity of build).

On-ice skating performance tests included a 6.10-m acceleration test (seconds) (23, 24; reliability coefficient calculated by Bracko and George [9]: $r = 0.80, p < 0.001$) and the Cornering S-Turn Agility Test (seconds) (10; reliability coefficient calculated by Bracko and George [9]: $r = 0.64, p < 0.02$). On-ice fitness was measured using the MRSS (a proxy for anaerobic power; seconds), as illustrated in Bracko and George (9), and blood lactate concentration ($mmol \cdot L^{-1}$) was assessed with a Lactate Pro Portable Lactate Analyzer (FaCT Canada, Quesnel, British Columbia, Canada) and taken immediately after the MRSS (21). On-ice testing was completed each year at the University of Alberta on a standard-sized hockey rink (200 × 85 ft). On-ice skating test times (acceleration, agility, and MRSS) were recorded with a Brower Speed Trap II (Brower Timing Systems, Draper, UT) photoelectric timing system that was calibrated before each testing session. Blood lactate concentrations were evaluated with a Lactate Pro Portable Lactate Analyzer, which was calibrated before each test session, and after every 25 samples or analyses. The Lactate Pro Portable Lactate Analyzer has been previously shown to provide reliable measurements of blood lactate concentration (20). Off-ice fitness tests included the vertical jump (cm), 40-yd dash (seconds), and Leger test for predicting $\dot{V}O_2max$ ($ml \cdot kg^{-1} \cdot min^{-1}$). Off-ice testing was completed each year in the University of Alberta field house. Both on-ice and off-ice testing sessions were conducted each year by the same investigator (M.R. Bracko). The same equipment was used in all of the testing sessions for anthropometry, on- and off-ice fitness, and skating performance.

Statistical Analyses

Statistical analyses were run using SPSS for MacIntosh version 10.0 (SPSS, Inc., Chicago, IL), including descriptive statistics and 2 multivariate ANOVAs with Tukey's and Bonferroni post hoc tests to check for significant differences among positions in physical and performance characteristics. The significance level was set a priori at $p \leq 0.05$. For this alpha level ($p \leq 0.05$) and a desired power value of 0.80, the sample size required was determined to be 23 subjects (11). There were only 13 G over the 5-year period included in this study; however, there were 33 D and 66 F and an average subgroup size (by position) of 37.3 subjects. Thus, based on the duration of the study and the subgroup sample sizes, statistical power was deemed adequate to identify true significant differences among subgroups by position. Observed power estimates associated with significant differences found by position are reported in the Results section (range = 0.623 to 0.912 for anthropometry and 1.000 for fitness and skating performance tests).

Results

Descriptive statistics for the physical and performance characteristics of the total sample and the subjects by position are shown in Tables 2 and 3, respectively. Significant physical differences ($p < 0.05$) among positions (F, D, and G) were found for bicristal breadth (D > G, F > G; observed power = 0.785), relaxed arm circumference (D > F, G > F; observed power = 0.912), supraspinale SKF and biceps SKF (G > D, G > F; observed power = 0.841 and 0.629, respectively), and endomorphy (G > F; observed power = 0.623) (Table 2). F tended to be the leanest players, while G tended to have the most body fat by SKF, %fat estimates, and endomorphy. D tended to have greater skeletal breadths than F and G, but these differences were only significant for hip width. D also tended to have larger trunk (waist and hip) and lower limb (thigh and calf) circumferences than F and G.

Significant positional differences ($p < 0.05$) were also found for the MRSS (G > D > F) and the Cornering S-Turn Agility Tests (G > D, G > F) (observed power for both tests = 1.000), with G demonstrating significantly less anaerobic power than D, followed by F, and significantly less agility than D and F (Table 3). Although no significant differences were found by position in the off- or on-ice fitness tests, F tended to be the fastest and G the slowest, based on performance times for the 40-yd–dash test, and F and G tended to have higher vertical jumps than D. Also, F tended toward the greatest aerobic capacity, as predicted by the Leger test (positional differences nearly reached significance at $p = 0.054$), as well as the greatest anaerobic capacity, as reflected by the highest post-MRSS blood lactate levels. No significant dif-

TABLE 2. Physical characteristics of ice hockey players for the sample (all) and by position.*

Variables	All (n = 112)	F (n = 66)	D (n = 33)	G (n = 13)
Age (y)	21.39 ± 2.94	20.95 ± 2.09	22.41 ± 4.29	21.04 ± 1.84
Weight (kg)	66.42 ± 6.96	65.28 ± 6.19	68.51 ± 6.76	67.05 ± 9.97
Height (cm)	167.96 ± 5.26	167.66 ± 5.32	169.08 ± 4.91	166.67 ± 5.73
BMI ($kg \cdot m^{-2}$)	23.55 ± 2.35	23.23 ± 2.15	23.97 ± 2.57	24.06 ± 2.73
Sitting height (cm)	89.88 ± 2.89	89.89 ± 2.59	90.27 ± 2.82	88.79 ± 4.27
Leg length (height − sitting height)	78.09 ± 3.34	77.77 ± 3.51	78.81 ± 3.37	77.88 ± 1.96
Thigh length (cm)	40.76 ± 2.08	40.53 ± 2.11	41.27 ± 2.20	40.58 ± 1.50
Calf length (cm)	37.24 ± 1.99	37.04 ± 2.22	37.58 ± 1.75	37.42 ± 1.03
Arm length (cm)	72.54 ± 3.32	72.51 ± 3.16	72.58 ± 3.81	72.62 ± 3.13
Biepicondylar breadth (cm)	6.36 ± 0.31	6.35 ± 0.27	6.43 ± 0.36	6.23 ± 0.28
Bicondylar breadth (cm)	9.04 ± 0.41	9.01 ± 0.35	9.12 ± 0.46	8.97 ± 0.53
Biacromial breadth (cm)	38.00 ± 1.58	38.00 ± 1.62	38.39 ± 1.29	37.01 ± 1.73
Bicristal breadth (cm)	28.20 ± 1.45	28.25 ± 1.30	28.57 ± 1.50	27.00 ± 1.52
Androgyny	85.80 ± 4.52	85.75 ± 4.75	86.60 ± 4.06	84.02 ± 4.17
Arm circumference—relaxed (cm)	28.78 ± 2.17	28.18 ± 1.79	29.59 ± 2.64	29.77 ± 1.69
Arm circumference—flexed (cm)	30.24 ± 2.30	29.76 ± 1.87	30.92 ± 2.76	30.96 ± 2.53
Thigh circumference (cm)	58.33 ± 4.87	57.81 ± 4.44	59.07 ± 5.70	59.07 ± 4.74
Calf circumference (cm)	36.15 ± 1.98	35.75 ± 1.74	36.89 ± 2.18	36.33 ± 2.19
Waist circumference (cm)	75.18 ± 4.67	74.99 ± 4.58	75.49 ± 4.32	75.30 ± 6.17
Hip circumference (cm)	100.78 ± 5.29	100.43 ± 5.18	101.50 ± 5.22	100.72 ± 6.21
WHR	0.75 ± 0.03	0.75 ± 0.03	0.74 ± 0.03	0.75 ± 0.04
Triceps SKF (mm)	16.02 ± 4.21	15.37 ± 4.38	16.72 ± 4.09	17.52 ± 3.13
Subscapular SKF (mm)	12.12 ± 4.74	11.26 ± 3.95	13.05 ± 6.09	14.17 ± 3.60
Midaxillary SKF (mm)	9.68 ± 3.57	9.35 ± 3.54	9.54 ± 3.63	11.69 ± 3.18
Suprailiac SKF (mm)	19.83 ± 7.08	19.31 ± 6.78	18.91 ± 7.86	24.82 ± 4.48
Supraspinale SKF (mm)	12.99 ± 5.75	12.30 ± 5.40	12.19 ± 5.36	18.57 ± 5.77
Abdominal SKF (mm)	17.54 ± 6.17	16.85 ± 6.00	17.06 ± 6.34	22.30 ± 4.71
Biceps SKF (mm)	7.37 ± 3.20	7.09 ± 3.42	7.07 ± 2.48	9.55 ± 2.99
Mid-thigh SKF (mm)	24.77 ± 7.81	23.64 ± 8.39	26.62 ± 7.29	25.78 ± 4.95
Medial calf SKF (mm)	15.99 ± 10.56	13.84 ± 3.92	19.97 ± 6.02	16.82 ± 3.99
%Fat (Jackson et al. [17])	25.94 ± 4.57	24.95 ± 4.47	26.94 ± 4.74	28.38 ± 3.21
%Fat (Withers et al. [37])	20.85 ± 4.67	19.67 ± 3.94	22.42 ± 5.86	22.84 ± 2.70
Endomorphy	4.12 ± 1.15	3.91 ± 1.09	4.19 ± 1.20	4.98 ± 0.91
Mesomorphy	4.33 ± 0.96	4.24 ± 0.80	4.47 ± 1.23	4.47 ± 0.98
Ectomorphy	1.92 ± 0.97	2.01 ± 0.92	1.84 ± 1.07	1.67 ± 0.91

* F = forwards; D = defensemen; G = goalies; BMI = body mass index; WHR = waist-to-hip ratio; SKF = skinfolds.

TABLE 3. Performance characteristics of ice hockey players for the sample (all) and by position.*

Variables	All	F	D	G
Vertical jump (cm)	43.10 ± 4.91	43.97 ± 4.22	40.94 ± 5.01	43.96 ± 6.64
40-yd dash (s)	5.78 ± 0.29	5.74 ± 0.28	5.84 ± 0.29	5.85 ± 0.36
Cornering S-Turn Agility Test (s)	10.14 ± 0.96	9.77 ± 0.32	9.96 ± 0.33	12.68 ± 0.42
6.10-m acceleration (s)	1.47 ± 0.13	1.46 ± 0.13	1.45 ± 0.12	1.58 ± 0.07
Modified Repeat Sprint Skate Test (s)	49.57 ± 4.01	47.90 ± 2.08	49.16 ± 1.92	59.22 ± 1.72
Blood lactate concentration ($mmol \cdot L^{-1}$)	13.37 ± 1.65	13.44 ± 1.54	13.22 ± 2.12	13.34 ± 0.93
Predicted $\dot{V}O_2max$ ($ml \cdot kg^{-1} \cdot min^{-1}$) (Leger test)	44.62 ± 5.31	45.96 ± 4.94	43.32 ± 5.04	41.09 ± 5.85

* F = forwards; D = defensemen; G = goalies.

ferences were found among positions on the 6.10-m acceleration test; however, D and F tended to perform better than G. Of the 2 alternative hypotheses posed regarding positional differences, both were rejected on the following bases. The first hypothesis (F are lighter in weight and leaner [i.e., lower %fat and lower endomorphy] than D and G) was only supported in that F were significantly leaner than D and G by endomorphy and 2 SKF. F and D did not differ in weight or %fat; however, they tended to be lighter and leaner than G, on average. The second hypothesis (F have better on- and off-ice fitness and skating performance than D and G; more specifically, F have higher anaerobic power and aerobic capacity and are faster and more agile than D and F) was only supported in part by significant differences in on-ice anaerobic capacity (MRSS) and agility tests, with F having greater anaerobic capacity than D, followed by G, and F and D being more agile than G. F tended to have higher anaerobic capacity than D and F, based on slightly higher blood lactate concentrations and higher aerobic capacity, as demonstrated by performance on the Leger Test; however, F were not faster than D or G by 40-yd–dash or acceleration times.

DISCUSSION

The results of the present study are different than those of Agre et al. (2) and Houston and Green (16) for male ice hockey players, in that significant differences were not found for body size (weight, height) but rather were found for measures of physique (bicristal breadths and endomorphy), body composition (supraspinale and biceps

SKF), anaerobic power (MRSS), and skating performance (agility). Perhaps male ice hockey players are more homogeneous in physique than female players. In addition, the significant differences for weight (2, 16) and height (16) among different positions in men's ice hockey might be explained by the inclusion of body checking and a more physical game overall, compared to women's ice hockey. The significant differences in performance tests in the female players but not in male players may reflect a greater dependence on skill and finesse in women's ice hockey, compared to men's hockey. Comparisons of positional differences in women's ice hockey to those found in field hockey are most interesting because of the higher degree of similarity between these 2 sports than are observed between ice hockey and other sports previously studied. Wilsmore (36) observed that all field hockey players tend toward mesomorphy, and the physiques of ice hockey players in the present study were more mesomorphic than endomorphic or ectomorphic. Findings were also consistent between ice hockey and field hockey for F tending to be the leanest player group and G the fattest by SKF, %fat estimates, and endomorphy (4, 29, 35). Although ice hockey players in the present study were not significantly different by position in ectomorphy or mesomorphy, F had the highest mean score for ectomorphy, followed by D and then G, and D and G had higher means for mesomorphy than F. These findings are consistent with Wilsmore's (36) findings for field hockey players (F and halves had higher ectomorphy than backs, and backs and halves had greater mesomorphy than F). In contrast, Bale and McNaught-Davis (4) found F and halves to be more mesomorphic than backs and G, and Johnston and Watson (18) concluded that F require a more muscular or mesomorphic physique related to greater positional demands for speed, power, and strength in attacking play. Differences among studies of field hockey players may reflect sample differences (sample size, age, nationality, etc.) or differences in style of play.

In contrast to the research on women's field hockey players, in which body weight was found to differ significantly among positions (with G heavier than backs, halves, and F [4, 29, 35]), weight did not differ among the ice hockey F, D, and G. However, ice hockey G and D were significantly more endomorphic than F. The differences in findings regarding weight and endomorphy between studies of field hockey and ice hockey players might be explained, at least in part, by the differences in playing surface (i.e., turf vs. ice). Once movement is in progress, it would seem that field hockey players have to work harder to move their bodies around the field than ice hockey players have to, in order to move their weight over the ice, because of differences in surface friction.

Positional differences among women's ice hockey players are most similar to those for field hockey players and are consistent with the majority of the findings from studies of other women's team sports (basketball, netball, and volleyball). The greater a given position's demands for speed, acceleration, agility, mobility, field, court, or ice coverage, and aerobic and anaerobic power, the greater the capacities for those performance-related measures and the lower the body weight and %fat characteristic of players in that position. Positional demands are also reflected in significant height differences among basketball centers (tallest), forwards, and guards (shortest; 3, 32) and among volleyball centers, spikers and opposites (taller), and setters (shorter; 14). Similarly, greater ectomorphy, or linearity of physique, has been observed in netball goal attack and goal defense players (15), which provides an advantage when rebounding an attempted goal, leaping to catch a pass, and during interception. These positional differences in female athletes in team sports, including women's ice hockey, lend further support to the notion of selection for sport based on physical characteristics, fitness, and skills that confer performance advantages, particularly at elite levels of play, as observed in young (20) through Olympic athletes (33). This research represents 5 preseasons of data over a 6-year period, during which the University of Alberta Pandas won 7 Canada West titles and 4 CIS National Championships, compiling a 148-12-5 record. This study is the first to provide data for positional differences in physical and performance characteristics for women's ice hockey, and this study extends the literature regarding selection for sport related to positional demands. The generalizability of the results is limited to other elite women's ice hockey players. Further research is necessary to extend the results to age-group women's ice hockey players. In conclusion, significant differences in physical, fitness, and skating performance characteristics were found among elite female ice hockey players. D had significantly broader hips than F, followed by G, and D tended to have more robust builds on average. F were significantly leaner than D and G by 2 SKF and means for endomorphy, and their significantly smaller relaxed arm circumference measurements most likely reflect less subcutaneous fat on the upper arm. Positional differences in fitness included significantly greater anaerobic power in F than D, followed by G, and the tendency for F to have the greatest aerobic capacity. Skating performance differed significantly by position in that F and D were more agile than G. F and D tend to be more like each other and different than G in physical, fitness, and skating performance characteristics. Physical and performance characteristics in elite women's ice hockey appear to be position specific, because performance demands vary by position, as is the case in many other team sports. In women's ice hockey, F are required to be the most versatile and fit players because of a greater amount and variety of work (speed, agility, anaerobic and aerobic) performed both during practices and games compared to those required for D and G. Thus, the physical and performance characteristics appear to reflect a selection for position within the sport of women's ice hockey, which is consistent with observations of positional differences in other women's team sports.

PRACTICAL APPLICATIONS

The results of this study indicate 3 practical applications. First, through appropriate preseason testing, a coach can use information about players' physical and performance characteristics to place them in specific positions with greater likelihood of high-level performance and team success. More specifically, hockey players who are leanest and have the greatest agility and anaerobic and aerobic power might be placed as forwards, or perhaps as defensemen; those who tend to be less fit might be better suited to being goalies. Second, with an enhanced understanding of position-specific demands within a sport (e.g., speed, agility, anaerobic and aerobic power, body size, and relative leanness or fatness, etc.), a coach and players can train more effectively to develop the abilities associated with success in a particular position at elite levels of play. Third, subjective criteria are usually the basis for choosing forward line pairings and defense partners in ice hockey. However, knowledge of players' physical and performance characteristics provides a coach with objective information that can be used to help determine which players will work well together on a forward line or in a defensive pairing based on physical characteristics, fitness, and skating ability.

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