A 26 year physiological description of a National Hockey League team

H.A. Quinney, Randy Dewart, Alex Game, Gary Snydmiller, Darren Warburton, and Gordon Bell

Abstract: The primary purpose of this investigation was to examine the physiological profile of a National Hockey League (NHL) team over a period of 26 years. All measurements were made at a similar time of year (pre-season) in 703 male (mean age ± SD = 24 ± 4 y) hockey players. The data were analyzed across years, between positions (defensemen, forwards, and goaltenders), and between what were deemed successful and non-successful years using a combination of points acquired during the season and play-off success. Most anthropometric (height, mass, and BMI) and physiological parameters (absolute and relative $VO_{2\ peak}$, relative peak 5 s power output, abdominal endurance, and combined grip strength) showed a gradual increase over the 26 year period. Defensemen were taller and heavier, had higher absolute $VO_{2\ peak}$, and had greater combined grip strength than forwards and goaltenders. Forwards were younger and had higher values for relative $VO_{2\ peak}$. Goaltenders were shorter, had less body mass, a higher sum of skinfolds, lower $VO_{2\ peak}$, and better flexibility. The overall pre-season fitness profile was not related to team success. In conclusion, this study revealed that the fitness profile for a professional NHL ice-hockey team exhibited increases in player size and anaerobic and aerobic fitness parameters over a 26 year period that differed by position. However, this evolution of physiological profile did not necessarily translate into team success in this particular NHL franchise.

Key words: $VO_{2\ peak}$, anaerobic power, body composition, musculo-skeletal fitness, strength.

Résumé : Le but principal de cette étude est d'analyser l'évolution du profil physiologique d'une équipe de la Ligue nationale de hockey (NHL) au cours des 26 dernières années. Toutes les mesures ont été prises chez 703 joueurs (âge moyen ± écart-type : 24 ± 4 ans) à peu près au même moment de l'année, soit avant le début de la saison. Les comparaisons suivantes sont effectuées : d'une année à l'autre, d'un poste à l'autre (défenseurs, attaquants, gardiens de buts), des bonnes et des moins bonnes années selon le nombre de points accumulés durant la saison et le niveau de succès observé durant les séries éliminatoires. En 26 ans, on observe une amélioration graduelle de la plupart des valeurs des variables anthropométriques (masse, taille, IMC) et physiologiques (VO_2 de pointe absolu et relatif, puissance relative de pointe produite en 5 s, endurance abdominale et force de préhension combinée). Comparativement aux attaquants et aux gardiens de buts, les défenseurs étaient plus grands et plus pesants et présentaient un meilleur VO_2 de pointe absolu et une plus grande force de préhension combinée. Par contre, les attaquants étaient plus jeunes et présentaient un meilleur VO_2 de pointe relatif. Les gardiens de but étaient moins grands, moins pesants et présentaient un plus haut total des épaisseurs de pli cutané, un plus faible VO_2 de pointe et une meilleure flexibilité. Le profil physiologique global établi avant le début de la saison n'est pas relié au succès de l'équipe. En conclusion, la condition physique de l'équipe des joueurs de hockey professionnel, définie par le gabarit des joueurs et les variables de performance aérobie et anaérobie, s'est améliorée au fil des ans de façon différente selon les postes occupés sur la glace. L'amélioration du profil physiologique ne s'est pas révélée en lien néanmoins avec le succès de cette équipe de la NHL.

Mots-clés : VO_2 de pointe, puissance anaérobie, composition corporelle, condition physique musculosquelettique, force musculaire.

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H. Quinney, R. Dewart, A. Game, and G. Bell.[1] Faculty of Physical Education and Recreation, University of Alberta, Edmonton, AB T6G 2H9, Canada.
G. Snydmiller. Augustana Faculty, University of Alberta, Camrose, AB T4V 2R3, Canada.
D. Warburton. School of Human Kinetics, University of British Columbia, Vancouver, BC V6T 1Z4, Canada.

[1]Corresponding author (e-mail: gordon.bell@ualberta.ca).

Introduction

The sport of ice hockey has been reported as physiologically demanding, particularly at the professional level (Cox et al. 1995; Green et al. 1979; Montgomery 2006). Ice hockey is characterized by intermittent, high-intensity bouts of skating requiring rapid acceleration and changes in velocity and direction; the potential for high-impact body contact; and the execution of a variety of skilled maneuvers (Cox et al. 1995; Flik et al. 2005; Green et al. 1979; Molsa et al. 2003). Each on-ice shift usually lasts between 30 and 85 s,

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interspersed with 2 to 5 min of recovery between shifts (Cox et al. 1995; Green et al. 1979; Montgomery 1988) depending on the player's position, style or strategy of game, and coaching decisions. The intensity of exercise is high and heart rates of approximately 90% of maximum have been reported for players during competition (Cox et al. 1995; Green et al. 1976; Paterson 1979). The various positions of ice hockey also necessitate different physiological characteristics (Green 1979; Vescovi et al. 2006), potentially leading to a bias towards certain physical attributes according to position and differential training regimens to prepare for these positions (Cox et al. 1995). In addition, ice-hockey players present with a particular body composition, a high level of anaerobic fitness, enhanced musculo-skeletal properties, and a well developed cardio-respiratory system. These attributes are important for effective skating, puck handling, physical contact between players, and the rigorous practice and game schedules associated with this sport (Cox et al. 1995; Green 1979; Montgomery 1988; Montgomery 2006; Shephard 1981).

A common perception is that professional ice hockey and its schedule has placed increasingly greater physical and psychological demands on its athletes in recent years. As such, it has been hypothesized that ice-hockey players have increased in stature and become progressively faster, stronger, and more aerobically fit to meet these increasing demands of their sport (Cox et al. 1995, Montgomery 1988; Montgomery 2006). To date, there have been several investigations examining the metabolic costs of ice hockey (Carroll et al. 1993; Green 1979; Green 1987; Green et al. 1978) and other studies that have evaluated the physiological profile of elite hockey players (Agre et al. 1988; Green et al. 1976; Houston and Green 1976; Montgomery 1988; Montgomery 2006; Paterson 1979; Smith et al. 1982; Vescovi et al. 2006). However, this latter research has generally focused on single-season appraisals and (or) evaluations conducted over a few consecutive seasons and with players of different levels of competition. The only other study that has reported the long-term longitudinal changes in the physiological characteristics of a professional ice hockey team is a recent publication by Montgomery (2006).

We have the unique opportunity of reporting on physiological parameters collected in the same laboratory under the direction of the same principal investigator of the same professional ice hockey team over a 26 year period. The purpose of this research was to examine the longitudinal changes in physiological characteristics of professional ice-hockey players and any differences that exist in player positions. It was hypothesized that players belonging to a professional ice-hockey team have increased body mass and generally become more physically fit over a 26 year period and that certain physiological parameters would vary by position. Finally, this study had the unique opportunity to investigate whether success was related to pre-season fitness parameters, since several successful years and 5 NHL championship years existed within our data set. It was hypothesized that improved fitness may be associated with success determined by points acquired in regular season games as assigned by the NHL, playoff success, and championships attained.

Materials and methods

Subjects and experimental design

The athletes (n = 703) involved in the sample were active members of a National Hockey League (NHL) team between the 1979 and 2005 seasons and ranged in age from 18 to 38 y (mean ± SD = 24 ± 4 y). Another unique anecdote to this data set was that the 1979 season marked the entry of this team into the NHL. No data were collected during the 1980–1981 season, and the 2004–2005 season was cancelled owing to the NHL lock out. Prior to fitness testing, all athletes completed an informed consent that included an agreement to use their fitness data for research purposes and received a medical examination. Permission was also obtained from the team management to publish these results and ethical clearance was obtained from a University Research Ethics Board. It is important to note that the same appraisers could not be used over the whole 26 year period, but consistency in the assessments was maintained, since all the fitness testing in this time period was conducted under the supervision of the principal investigator. Also, all appraisers were clearly instructed on all protocols prior to the testing period each year and well-trained appraisers were assigned to and (or) supervised each assessment station. However, the involvement of different appraisers over the years would yield some variability in our measurements and this should be considered as a limitation of the present study.

The ice-hockey players examined in this investigation were evaluated to assess their individual fitness levels prior to each season and were required to be active players on the team during the year of evaluation. The data set was coded for individual player, year, position, and a success criterion. To investigate whether a successful season was related to overall fitness levels, the authors used points acquired during the season as determined by the NHL combined with playoff success to classify a season as successful or not. The cut-off for number of points was set at 90, since this represented a time when the present team reached the final playoff series 7 times, winning the championship (Stanley Cup) 5 times. The team earned less than 90 points 14 times in the past 26 years. During these seasons, the team did not make the playoffs 5 times and when the team was in the post season, they only advanced to the third round of the playoffs once. Note that the seasons deemed successful using these criteria were associated with a win percentage of greater than 52% (win percentage = (season points ÷ total possible points) × 100).

Physiological assessments

The order for completion of the fitness assessments was as follows: body composition, anaerobic power, musculoskeletal fitness (trunk forward flexion, grip strength, abdominal endurance), and cardio-respiratory fitness.

Body composition

Height (cm) was measured with an anthropometric tape to the nearest 0.2 cm without shoes and with each subject standing erect against a wall. A set scale was placed on the head while the subject stood as upright as possible. Body mass (kg) was measured to the nearest 0.1 kg without shoes and in shorts, socks, and with or without a t-shirt on a beam

balance scale (Health-o-meter, Bridgeview, Ill.). Body mass index (BMI) was calculated using the following formula: body mass (in kg) ÷ height^2 (in m). There were 4 common skinfold sites taken each year over the 26 years of data collection that were common to all players. These 4 sites were used to calculate a sum of skinfolds to represent body fat content of each player. Percent body fat was not calculated, since no prediction formula for professional hockey players has been validated using these 4 skinfold sites. The mean of 2 measurements within 0.4 mm of each other were added together for each skinfold site to create the sum. The 4 anatomically landmarked sites were the mid tricep, subscapular, iliac crest, and mid medial calf. All measurements were made on the right side of the body using skinfold calipers.

Musculoskeletal fitness

Trunk forward flexion was assessed with a sit and reach test using a Wells–Dillon flexometer. Two trials were allowed and the highest score to the nearest 0.5 cm was recorded. Combined grip strength of the right and left hand was assessed using a hand dynamometer. A sum was calculated in kilograms from the best score of 2 trials recorded for each hand. Abdominal muscle endurance was assessed using a modified curl-up protocol that controlled tempo at a rate of 25 curl-ups in 60 s using a standardized protocol as previously reported by our laboratory (Quinney et al. 1984). Subjects were stopped if a maximum of 100 curl-ups was achieved. Note that the assessment of trunk flexibility and abdominal endurance did not begin until 1982.

Anaerobic power

From 1979 to 1994, all subjects performed a 30 s Wingate anaerobic power test using a resistance of 0.095 kg·kg body mass^{-1} on a Monark cycle ergometer. From 1995 to 2005, the anaerobic power test was identical in set up, resistance setting, and starting instructions as the Wingate protocol, except that it was modified so that the players were required to perform 4 repeats of 5 s maximal effort sprints with 10 s of active recovery in a 60 s period. This modification was made to the traditional Wingate testing protocol in an attempt to be more sport specific and more closely simulate the intermittent, high-intensity skating patterns of actual game performance. Research in our laboratory has shown that the peak 5 s power output (PO) for hockey players was not different using these two different protocols. Thus, only the peak 5 s PO was used for comparison between years for our whole data set (26 years) to represent peak 5 s anaerobic power and was expressed in watts per kilogram (W·kg^{-1}).

Cardio-respiratory fitness

From 1979 to 1983, maximal aerobic power was predicted from a submaximal PWC_{170} protocol on a Monark cycle ergometer as described by Sjostrand (1947). These scores were eliminated from our data set because starting in 1984 to the end of the data collection, a metabolic measurement system was used to directly assess peak oxygen consumption ($VO_{2\ peak}$). The exercise testing protocol was conducted on a Monark cycle ergometer that increased power output in ~37 W increments until volitional exhaustion. $VO_{2\ peak}$ was defined as the highest VO_2 attained during the test. Heart rate was measured with either an electrocardiograph (Cambridge, Model VS4) or a heart rate monitor (Polar Electro, Finland).

Statistical analyses

Descriptive statistics were used to describe the various physiological parameters reported in the results. Trend analysis was used to represent any change in the fitness parameters over the 26 year period. To do this, trend lines for each fitness parameter over time were generated and the coefficient of determination (R^2) values are reported for each trend line. Note that some of the players in the data set were with the team for more than 1 year, but were retained in the data set for each season they were with the team. The seasons were also grouped according to successful or non-successful years and position (goal, forward, defense). Analysis of variance was used to evaluate differences between successful year criteria and the different positions and a Newman–Kuels multiple-comparison procedure was used to further investigate any significant F-ratio using Statistica 7.1 (Statsoft, Inc, Tulsa, Okla.). Only active players on the roster for each year were included in the analyses. The α level was set a priori at $p < 0.05$ for all analyses.

Results

Longitudinal changes in fitness

The trend in the mean age of the NHL players within a season fluctuated over the 26 year period (see Fig. 1) with an overall mean age of 24.5 y. Body mass, height, and BMI showed an increase over the 26 year period (Figs. 2, 3, and 4). Sum of skinfolds showed no consistent change over the period of the study (Fig. 5). The trend for absolute $VO_{2\ peak}$ showed an increase over the 26 years with the largest increases observed during the 1989–1993 period and then remained relatively constant since that time point (Fig. 6). Although relative $VO_{2\ peak}$ showed increases between the years of 1989 and 1993, the overall trend showed no increase over the 26 year period, which is likely due to the increase in body mass during this same period of time (Fig. 7). Relative peak 5 s anaerobic PO exhibited an increase over the 26 year period (Fig. 8). Muscular endurance of the abdominals (curl-ups; Fig. 9) and combined grip strength (Fig. 10) showed only a small increasing trend, whereas trunk flexibility (sit and reach) remained relatively unchanged over the 26 year period (Fig. 11).

Positional differences

Table 1 indicates that forwards were younger than defense and goaltenders ($p < 0.05$). Defensemen were heavier and taller than the forwards and goaltenders and the forwards were taller and heavier than the goaltenders ($p < 0.05$). Goaltenders had a lower BMI than defensemen, a higher sum of skinfolds, and a lower absolute $VO_{2\ peak}$ compared with both the defense and forward positions ($p < 0.05$). There was a significant difference between all 3 positions for relative $VO_{2\ peak}$, with the forwards having the highest score and the goalies the lowest ($p < 0.05$). Goalies had a lower combined grip strength and a higher trunk flexibility compared with the defense and forward positions ($p < 0.05$).

Fig. 1. Mean age (y) for an NHL team from 1979 to 2005.

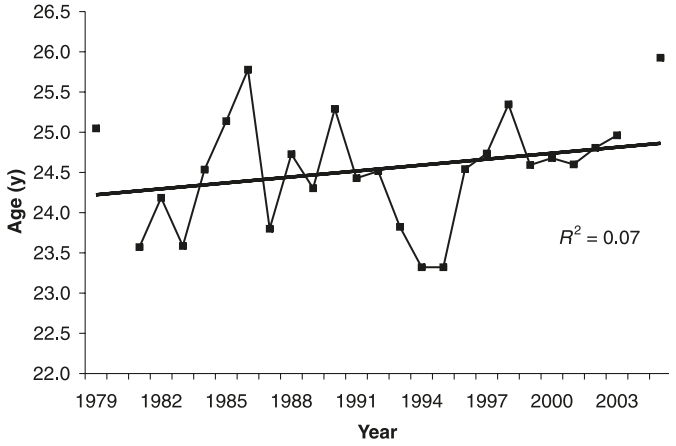


Fig. 2. Mean body mass (kg) for an NHL team from 1979 to 2005.

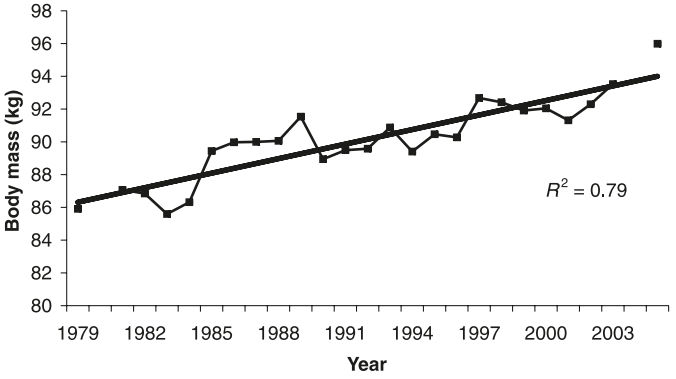


Fig. 3. Mean height (cm) for an NHL team from 1979 to 2005.

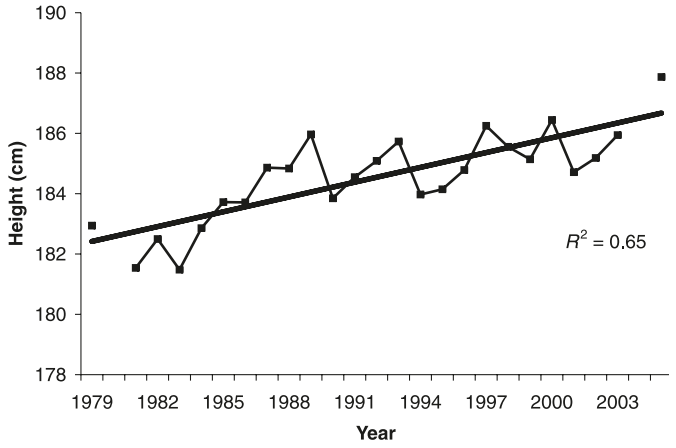


Fig. 4. Mean BMI (kg·m^{-2}) for an NHL team from 1979 to 2005.

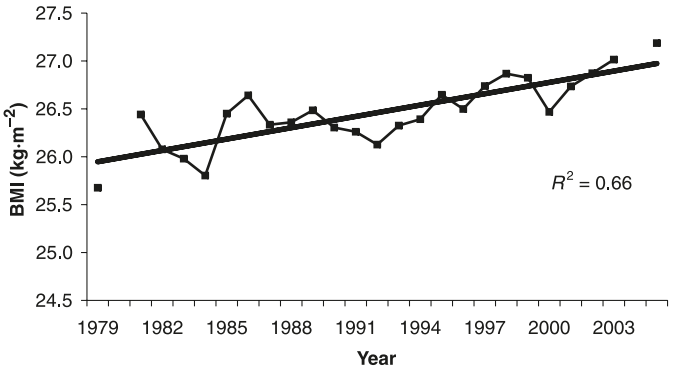
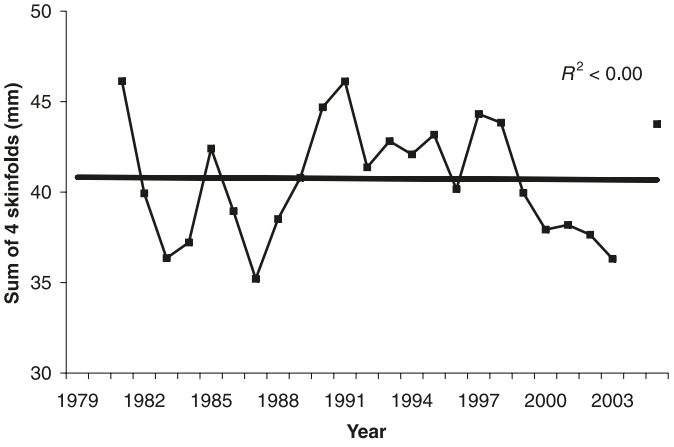


Fig. 5. Mean sum of 4 skinfolds (mm) for an NHL team from 1979 to 2005.



Success

The sum of 4 skinfolds, absolute and relative $VO_{2\ peak}$, and abdominal endurance were lower ($p < 0.05$) for the players associated with the successful teams (Table 2). Combined grip strength was higher among the successful teams ($p < 0.05$). No other differences were observed between the successful and non-successful teams (Table 2).

Discussion

The present investigation had the unique opportunity to provide insight into the physiological changes that have occurred in elite hockey players over a 26 year period. We revealed a series of important findings in this analysis of an NHL team: (*i*) several indices of performance-related physical fitness and body stature have shown increased trends over a 26 -year period, (*ii*) there were several physiological differences among the 3 player positions, and (*iii*) there was a lower sum of skinfolds and higher combined grip strength in players during hockey seasons that were deemed successful versus non-successful.

Longitudinal changes in physiological profile

The present investigation examined the commonly held belief that NHL players have progressively increased in size and improved in fitness over time. In support of previous findings (Cox et al. 1995; Montgomery 1988; Montgomery 2006), we revealed that many indices of performance-related physical fitness and body stature have increased progressively over a 26 year period in one NHL team. The most notable trends were increases in peak 5 s anaerobic power, body mass, height, BMI, absolute $VO_{2\ peak}$, and grip strength. Related to this, the observed anthropometric changes have important functional implications for the individual player. The improved "physique", as indicated by an increase in height, mass, and BMI, whereas sum of skinfolds have showed little change, would support the contention that there has been an increase in lean mass of the players in this study. This increase in lean mass would also assist in generating power and speed and positively influence outcomes of

Fig. 6. Mean absolute $VO_{2\ peak}$ ($L \cdot min^{-1}$) for an NHL team from 1984 to 2005.

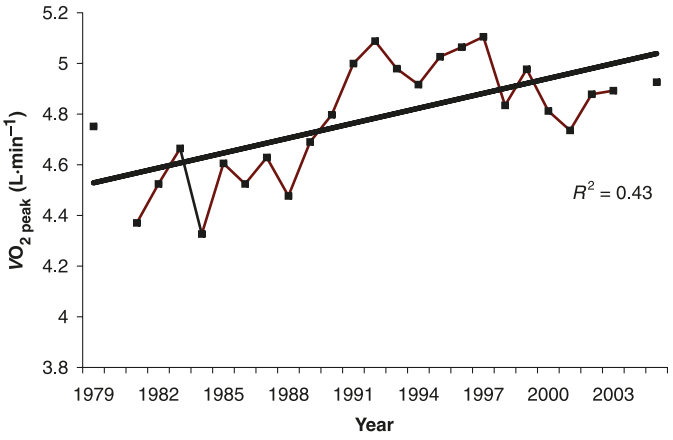


Fig. 7. Mean relative $VO_{2\ peak}$ ($mL \cdot kg^{-1} \cdot min^{-1}$) for an NHL team from 1984 to 2005.

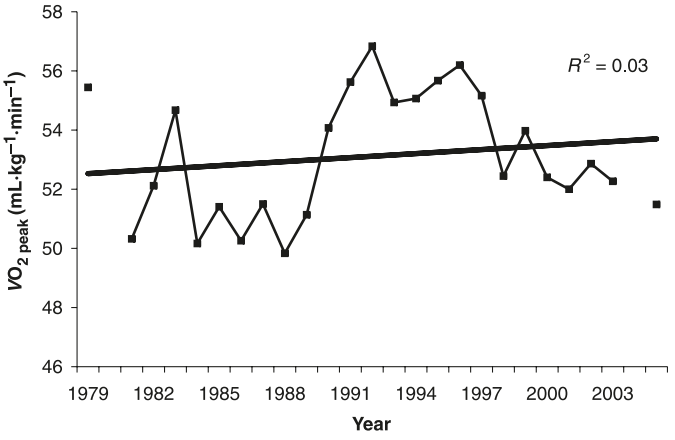


Fig. 8. Mean relative peak 5 s anaerobic PO ($W \cdot kg^{-1}$) for an NHL team from 1979 to 2005.

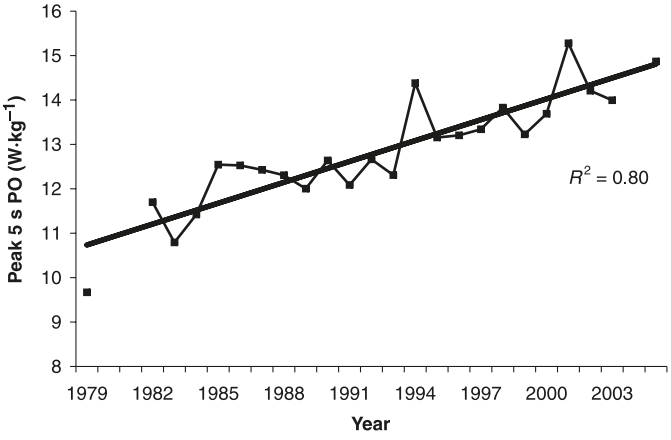


Fig. 9. Mean muscular endurance of the abdominals (cm) for an NHL team from 1982 to 2005.

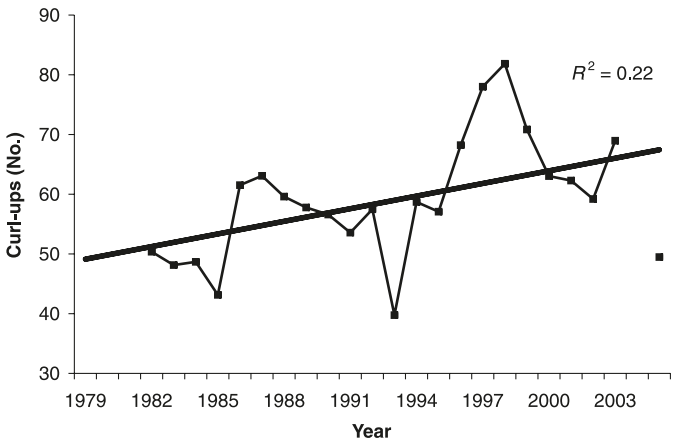


Fig. 10. Mean combined right and left grip strength (kg) for an NHL team from 1979 to 2005.

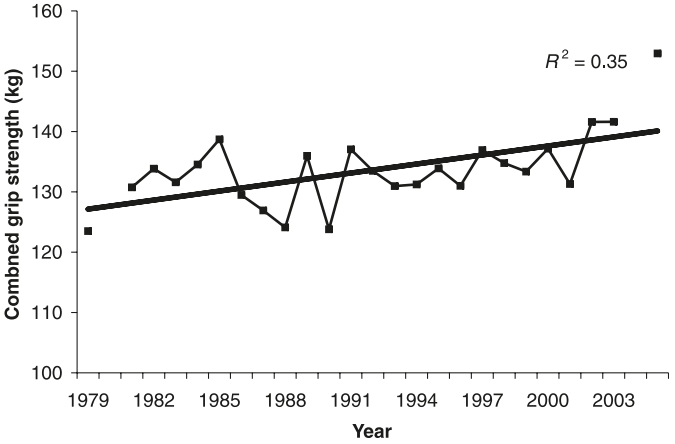
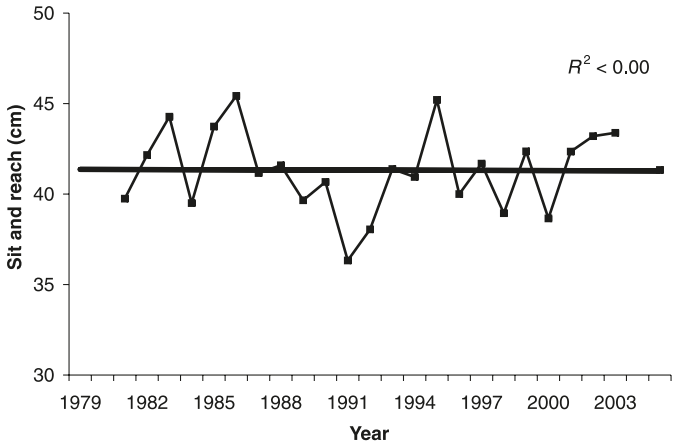


Fig. 11. Mean trunk forward flexibility (cm) for an NHL team from 1982 to 2005.



the physical nature of the game of hockey at the professional level.

The changes in musculoskeletal fitness are also of importance due to the high demand of the sport for strength and power. Players who lack muscular strength are less likely to be successful in challenging and overcoming their opponents and may perform some requisite game skills less competently than players with superior musculo-skeletal fitness. Furthermore, muscular endurance of the abdominals is fundamental to the stability of the ice-hockey player and must be considered an important requirement for the successful performance of many of the unique skills that are performed at fast velocities in the sport of hockey (Quinney et al. 1984). Additionally, high levels of abdominal muscular en-

Table 1. Anthropometric and physiological fitness characteristics of different player positions for an NHL team over a 26 year period.

Position	Age (y)	Mass (kg)	Height (cm)	BMI (kg·m^{-2})	Sum of 4 skinfolds (mm)	Absolute $VO_{2\ peak}$ (L·min^{-1})	Relative $VO_{2\ peak}$ (mL·kg^{-1}·min^{-1})	Peak 5 s anaerobic PO (W·kg^{-1})	Curl-ups (No.)	Combined grip strength (kg)	Sit and reach (cm)
Defense (*n* = 180)	25.0±3.7	93.8±5.4^a	187.6±5.4^a	26.7±1.2	41.0±9.3	4.92±0.48	52.5±4.9^a	13.0±1.4	58.4±29.7	136.7±16.2	41.9±15.4
Forward (*n* = 372)	24.2±3.2^b	89.8±7.2^a	184.1±5.0^a	26.5±1.7	38.9±9.8	4.84±0.51	54.0±5.4^a	13.0±1.6	58.9±29.6	134.5±17.8	40.6±6.7
Goalie (*n* = 45)	25.2±3.4	84.0±7.1^a	180.1±5.6^a	25.9±1.5^b	49.8±10.4^c	4.18±0.54^c	49.8±5.5^a	12.8±1.5	61.1±29.6	120.6±17.6^c	46.2±10.1^c

Note: Scores are mean ± standard deviation.

[a]Significantly different between all 3 positions ($p < 0.05$).

[b]Significantly different from defense ($p < 0.05$).

[c]Significantly different from both defense and forwards ($p < 0.05$).

Table 2. Anthropometric and physiological fitness characteristics for an NHL team separated by successful and non-successful seasons over a 26 year period.

	Age (y)	Mass (kg)	Height (cm)	BMI (kg·m^2)	Sum of 4 skinfolds (mm)	Absolute $VO_{2\ peak}$ (L·min^{-1})	Relative $VO_{2\ peak}$ (mL·kg^{-1}·min^{-1})	Peak 5 s anaerobic PO (W·kg^{-1})	Curl-ups (No.)	Combined grip strength (kg)	Sit and reach (cm)
Successful	24.6±3.3	90.2±7.0	184.6±5.5	26.4±1.4	38.8±10.4^a	4.78±0.54^a	52.0±5.5^a	12.9±1.8	55.5±27.5^a	136.2±17.2^a	41.7±7.0
Non-successful	24.5±3.6	90.8±6.9	185.1±5.5	26.5±1.6	41.7±11.3	4.93±0.54	54.3±5.6	13.0±1.5	61.9±30.9	132.3±16.9	41.1±11.8

Note: Scores are mean ± standard deviation.

[a]Significantly different between seasons ($p < 0.05$).

durance may reduce the risk for injury and (or) lower back pain (Albert et al. 2001; Quinney et al. 1984). Interestingly, despite improvements in other markers of musculo-skeletal fitness, there were minimal changes in flexibility of trunk forward flexion during the 26 year period despite the widespread promotion of the health-related benefits of flexibility training for athletes. Reduced flexibility, particularly in the lower back, hip, and hamstring muscle groups, may hinder a hockey player's ability to perform complex skills and predispose them to injury.

An important trend observed as a function of time occurred for peak anaerobic power and is consistent with the metabolic requirements of ice hockey and the anecdotal evidence that hockey at the NHL level has become faster (Cox et al. 1995; Green 1979; Montgomery 1988; Montgomery 2006). For example, several investigators have shown that ice hockey involves intermittent high-intensity exercise at near maximal heart rates and at a high percentage of peak oxygen consumption (Green et al. 1976; Green et al. 1978). Accordingly, numerous investigators have evaluated the anaerobic fitness of amateur and elite ice hockey players (as reviewed by Montgomery 1988). This research (conducted in the early to mid 1980s) revealed peak anaerobic power outputs of 10–12 W·kg^{-1}, which was consistent with the early years of the NHL team in the present study. In the later years of the present investigation, the mean values for peak anaerobic power exceeded 13 W·kg^{-1}. These marked changes in anaerobic fitness likely reflect the leaner, stronger player and the implementation of more advanced training programs that specifically address the sport-specific demands of ice hockey (Montgomery 2006). Certainly, part of being a successful player in professional ice hockey requires the player to perform high-intensity skating and, at times, rapidly change their speed and direction. All of these attributes require a high level of anaerobic fitness.

Although researchers have clearly established the anaerobic nature of ice hockey, it is also clear that a well developed cardio-respiratory fitness level is also important for professional players (Cox et al. 1995). A reasonably high aerobic fitness level has been suggested as important for the ability to sustain high-intensity, intermittent exercise bouts such as those that occur during training and games through an enhanced recovery ability and resistance to fatigue (Montgomery 1988; Montgomery 2006; Smith et al. 1982; Cox et al. 1995). Furthermore, many premier NHL players exceed 20 min of total time during a game. In the present investigation, there was an increased trend observed for absolute aerobic fitness ($VO_{2\ peak}$) across years. This increase in $VO_{2\ peak}$ was most notable for the absolute value ($VO_{2\ peak}$ in L·min^{-1}) and was probably a reflection of the increased size of the average NHL player, since relative VO_2 showed little change over the 26 year period. However, the positive trend in absolute aerobic fitness was less than that observed for anaerobic power, which underscores the relative importance of anaerobic fitness for professional hockey players.

Positional differences

The present investigation supports previous findings that indicated that the physiological profile of hockey players may vary according to hockey position (Cox et al. 1995;

Houston and Green 1976; Montgomery 1988; Smith et al. 1982; Vescovi et al. 2006). We observed that defensemen were generally larger (greater body mass and height) and had greater musculoskeletal fitness compared with other positions, whereas forwards had greater relative aerobic fitness and lower body fat. Goaltenders tended to be smaller and have reduced physical fitness (with the exception of flexibility) in comparison to the other positions. It is difficult to discern whether or not self-selection to position can partially explain these findings. Previous investigators have observed differential body dimensions (e.g., forearm length, hand length, arm circumference, thigh circumference) between player positions in ice hockey (Chovanova 1972). It is also likely that conditioning methods and the physical demands that these positions require for practice and competition may partly explain the divergent fitness profiles between positions. In support of this, Cox et al. (1995) postulated that differences between players according to position may be attributable to positional biases with respect to conditioning techniques implemented by coaches, trainers, and athletes specifically designed to meet the metabolic requirements of the position.

Successful versus non-successful years

Unique to this investigation, we compared the physiological profile of an NHL team during seasons when the team was considered successful as assessed by the combination of points attained during the season, reaching the post-season playoffs, and winning the championship (Stanley Cup) versus less-competitive years. Also, using these criteria, the successful seasons were associated with a win percentage of greater than 52%. This was done in an attempt to assess the role of overall fitness (physiological profile) on success in the NHL. Few differences were observed between the seasons deemed as successful versus those that were not. Our data showed the players on the successful teams had lower body fat content and greater combined grip strength, but cardio-respiratory fitness and abdominal endurance were more improved on the non-successful teams.

It is important to note that in addition to a positive physiological profile, there is a myriad of other factors that contribute to a team's success, including the individual player attributes and skills that make up the team, leadership, coaching, injuries, league schedule, player development, management, and budget. It is also true that elite NHL players are highly skilled and physically conditioned and, as such, could be considered quite homogeneous in certain characteristics and there may be a "fine line" between what is considered a successful or unsuccessful season in any given year. Our analysis revealed that the many of the pre-season physiological results of this professional ice-hockey team were not related to success of the team, or at least were not markedly different between non-successful years based on our pre-determined success criteria at the start of the season. It is important to point out that the fitness assessments were conducted during the pre-season and these fitness levels may change over the course of a hockey season that lasts several months of seasonal practices and games. Thus, it is likely that fitness does change over the course of a season and that fitness may still have a relationship to success in sport. Further research is required to investigate this relationship.

The other factor to consider is that the improvement in physical fitness was not unique to the team in the present study and at the same time other NHL teams were also engaging in physical training programs and player and team development. Other teams have shown similar changes in physical fitness to that observed in our cohort (Cox et al. 1995; Montgomery 1988). Furthermore, in our players, the level of fitness and physical stature continued to increase after the championship seasons had passed. Thus, our data would indicate that in highly trained players, success of the team is not solely related to physiological profile despite the fact that physical fitness of ice-hockey players must be considered influential in the attainment of success. However, the achievement of team success is clearly multivariate and includes many tangible and intangible factors.

Conclusion

The present investigation revealed that several indices of performance-related physical fitness and body stature have shown an increased trend over a 26 year period in an NHL team. Physiological differences exist among different positions, and the physiological profile during successful and non-successful NHL seasons for the players associated with the team examined in the present study was not markedly different.

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