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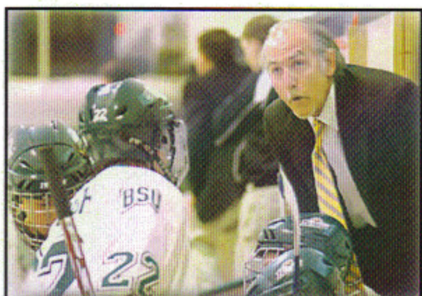

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THE GENERAL MANAGER'S TOOLBOX: A MODEL FOR PREDICTING SUCCESSFUL NHL PLAYERS

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Central Scouting Service (CSS), a division of the National Hockey League's Department of Hockey Operations, collects data on the best prospects prior to the annual entry draft. Results of physical fitness and anthropometric testing, along with reports by scouts and a summary of the athlete's performance statistics, are compiled in a dossier that is provided to each team approximately two weeks before the draft. The data contained in the dossier, complemented by information independently acquired by the particular team, are reviewed by experts—typically the team's general manager (GM) and his senior associates—to formulate a judgment regarding the athlete's potential to play in the National Hockey League (NHL). Decisions formulated from a large quantity of information that rely solely on expert judgment are, however, fraught with a high risk of error due primarily to capacity limitations of the human intellect (Simon, 2000). This intellectual limitation, termed "bounded rationality" (page 25) by Herbert Simon, the Nobel laureate who pioneered the scientific field devoted to understanding the process and accuracy of decisionmaking, cannot be improved by merely utilizing more experienced experts.

Certain aspects of the information obtained on the athlete are also more important than others for predicting future success. However, subjective decisionmaking is not able to precisely take into account these differences in salience. Accordingly, the overall evaluation may either overemphasize less important aspects of the information contained in the athlete's dossier or underemphasize more critical aspects of the information. In addition, subjective decisionmaking cannot discern the extent on-ice performance record reflects the athlete's ability independent of the quality of the competition. For example, an outstanding athlete may score the same number of goals against strong competition as an average athlete scores against weak competition. Consequently, the performance record needs to be weighted to take into account the quality of the competition. Moreover, variability across multiple evaluations of the athlete conducted by a particular scout as well as consistent discrepancies between scouts hampers accurate appraisal of the athlete. Lastly, it should be noted that experts are frequently overconfident regarding their decisionmaking competence (Bazeman, 2002; Belsky & Gilovich, 1999). This potential bias by the GM additionally predisposes to either over- or under-estimation of the athlete's true potential. These challenges to accurate decisionmaking are amplified by the fact that the pool of athletes is large at the time a priority list is provisionally developed, and on the day of the draft, the list is updated and revised in reaction to the choices made by other teams. Formidable obstacles thus challenge decisionmaking accuracy.

Considering the complexity of the task, it is highly unlikely that an error-free method can be developed for identifying the best prospects. Accordingly, employing several complementary procedures for selection of prospects may be the most optimum strategy. One procedure that is increasingly becoming more prominent in sports involves using actuarial prediction methods. Inexpensive powerful desktop computers, easy to use database management systems that can handle a large amount of data, and multivariate statistical techniques are jointed to perform statistical predictions in many types of settings (Ayres, 2007), including sports (Berri, Schmidt & Brook, 2006; Lewis, 2004). In sports, statistical analysis, combined with informative graphing techniques, enables the GM to quickly evaluate each athlete's strengths and weaknesses and objectively compare all athletes prior to the draft. Furthermore, high speed computational analyses assists decisionmaking during the day of the draft while teams are making their selections. However, it is currently not known whether actuarial statistical methods can apply the information collected by CSS prior to the draft to identify athletes who are most likely to transition to the NHL. Hence, this study was directed at determining the accuracy of a composite index (consisting of the results of physical fitness testing, scout evaluations, and junior hockey performance record) for predicting whether athletes who are drafted will transition to the NHL.

With respect to physical fitness, intense demands on musculoskeletal and energy systems require the athlete to have superior physical capacity in order to sustain competitiveness and avoid injuries during eight months of intense competition. Inasmuch as resistance of the skates to the ice covaries with body mass, athletes who have large body mass expend more energy at a given skating velocity (Montgomery, 1982). Body mass is thus crucial to performance. Moreover, suboptimum physical conditioning results in fatigue earlier in the game which, in turn, diminishes mental efficiency. Since critical events at the elite level in hockey transpire in the order of milliseconds, and with high frequency, a slight decline in physiological and mental capacity in one player can, therefore, determine the outcome of the game. Notably, $V0_2$ max and lactate production are statistically significant predictors of scoring chances in Division 1 hockey players (Green et al., 2006). Hence, it is essential to include physical fitness measurements as one component of a composite index used for predicting whether the athlete has the potential to play in the NHL.

The athlete's hockey performance record, summarized in the dossier prepared by CSS, is another important predictor of playing in the NHL. Because the performance record is largely contingent on the quality of the competition, interpretation of this information is, however, not straightforward. The hockey record index used to predict the athlete's likelihood of transitioning to the NHL must thus be weighted to take into account the competitiveness of the league.

Lastly, the athlete's dossier contains evaluations conducted by experienced scouts employed by CSS. The observation that European players systematically receive higher ratings than North American players indicates that these evaluations need to be interpreted cautiously. However, performing a mathematical correction reduces risk of incorrect interpretation of the athlete's potential

This study derived a composite index based on physical fitness results, hockey performance record, and scout ratings. It was determined whether this index, termed the *Sports Performance Index for Hockey* (SPI-H) accurately identifies athletes who will be on an NHL team roster five years after the NHL entry draft; thereby providing the GM with quantitative information to complement his expertise to select the best prospects.

METHOD

Sample

The dossiers prepared by Central Scouting Service (CSS) between 1992—2001, were categorized into two groups: Group 1 consisted of athletes (N = 2154) who were on an NHL team roster in the fifth year after the entry draft whereas Group 2 (N =3648) was comprised of athletes who were not playing in the NHL in the fifth year after the entry draft. The criterion of playing in the NHL in the fifth year after the entry draft excludes athletes who either had only a brief tryout or a short term career. Significantly, this outcome captures the period when the athlete is at, or approaching, peak performance.

This interval spanning 1992-2001 coincides with the time CSS initiated a standard system for evaluating the performance of athletes during competition. In addition, a standard protocol to assess physical fitness was instituted at the combine. The last draft year studied was 2001 because it enables assessing the 5-year outcome of all athletes while taking into account cancellation of the 2004-2005 season.

Predictor Variables

Physical Fitness Test Results. This evaluation was conducted at the annual combine sponsored by the NHL. Two of the authors administered the protocol assisted by their graduate kinesiology students. The evaluation was conducted approximately two weeks before the draft. The athletes were sequenced through a series of stations located in a large room. A physical fitness index was derived by submitting the test results to exploratory factor analysis (EFA). This procedure takes into account the strong correlations between scores on the various tests to extract their common variance. At the outset, 21 variables, listed in Table 1, were organized into four categories which were confirmed to comprise distinct factors consisting of 1) upper body strength, 2) lower body power, 3) body composition, and 4) energy

Table 1
Physical Fitness Protocol

Variables	Factor Loading
Factor 1: Upper Body Strength	
Right Hand Grip (lb)	.81
Left Hand Grip (lb)	.81
Bench Press	.76
Push Ups	.23
Pull Strength	.79
Upper Body Development	.59
Factor 2: Lower Body Strength	
Long Jump	.90
Vertical Jump	.89
Curl Ups	.31
Lower Body Development	.10
Factor 3: Body Composition	
Percent Fat	.93
Sum of Skinfolds	.93
Height	.74
Weight	.85
Sit and Reach	.03
Factor 4: Energy Systems	
Anaerobic Peak Power (Watts/kg of body mass)	.53
Anaerobic Mean Power (Watts/kg of body mass)	.57
V02 Max (ml of O2/kg of body mass/min)	.73
Anaerobic Final Workload	.79
Aerobic Peak MR	.79
Aerobic Duration Test	-.05

Table 2
NHL Central Scouting Service Ratings

Variable	Factor Loading
Skating	.74
Competitiveness	.80
Checking/Use of Body	.77
Puck Skill/Control	.80
Physical Play	.71
Hockey Sense	.81
Final CSS Rank	-.74
Estimation of Overall Potential	.85
Game Reports Filed on the Athlete	.18

Table 3
Hockey Performance

Variable	Factor Loading
Year Before Entry Draft	
Points	.99
Assists	.94
Goals	.94
Games Played	-.15
Year of Entry Draft	
Points	.99
Assists	.97
Goals	.97
Games Played	-.23

systems. The scores on these four factors were then submitted to a final EFA to generate an overall factor, named the *physical fitness index*. The factor loadings were .77 (upper body strength), .22 (lower body power), .78 (body composition), and, .73 (energy systems). The overall factor explained 45% of the variance.

Scout Ratings. Central Scouting Services (CSS) rates athletes according to a set of standard criteria. The ratings contained in the most recent evaluation were submitted to EFA to extract their common variance. Because a systematic difference in ratings was detected between scouts who evaluated North American and European players, this difference was mathematically taken into account in the analysis. The derived factor accounted for 53% of overall variance. As can be seen in Table 2, with the exception of number of game reports filed, each variable strongly loads on this factor, termed the *Scout Index (SI)*.

Hockey Performance Record. Performance record during the prior two seasons, consisting of the variables shown in Table 3, was submitted to EFA. Variables having a loading of .30 or higher were retained. This factor, termed the *Historical Performance Index* (HPI), accounted for 69% of the total variance in year 1 and 73% in year 2. Because an athlete's performance is strongly related to quality of the opposition, the index was adjusted mathematically to take into account differences between leagues.

Development of the Overall Index for Predicting Playing in the NHL

The numerous variables pertaining to physical fitness, scout ratings, and hockey performance were reduced to three indexes as described above. Next, the three indexes were studied to determine how strongly they predicted playing in the NHL in the fifth year after the draft. As the result of this analysis, each index was weighted to take into account its salience for predicting playing in the NHL. Hence, the fitness index, hockey performance index and scout index were assigned coefficients of .08 and .16 and .76 (total = 1.0). The weighted scores were summed to yield the composite index for each athlete, termed the *Sports Performance Index* for hockey (SPI-H).

Outcome Variables

Three outcomes were evaluated: 1) presence/absence of the athlete on an NHL team in the fifth year after the entry draft, 2) number of games played in the NHL since the draft; and, 3) number of times the athlete was designated a star in the game. This latter score consists of the number of times in year 5 after the draft the athlete was awarded the first, second or third star.

Statistical Analysis

Logistic regression was conducted to determine the accuracy of the SPI-H for predicting whether an athlete was on an NHL team in the fifth year after the entry draft. Receiver operating curve (ROC) analysis was performed next to derive cut-off scores for individual prediction. Lastly, product moment correlations were computed to document the association between the SPI-H and number of games played in the five-year period after the draft and the star quality scores. The analyses were conducted using SAS software.

RESULTS

The SPI-H significantly predicted whether the athlete is on a team roster five years after the draft (OR =3.83; 95% CI: 3.34—4.40; $p < .001$). The results of the ROC analysis indicate that accuracy of predicting whether an athlete will play or not play in the NHL was 78.3%. Accuracy of predicting whether an athlete will play in the NHL who actually did play was 80% (true positives). Accuracy of predicting whether an athlete will not play who actually did not play was 60% (true negatives). These results, documenting respectively sensitivity and specificity, illustrate that the SPI-H complements expert judgment in the decision-making process. An athlete who scored 1.5 and 2.0 standard deviations above the mean on the SPI-H had a probability of 70% and 82% of being on a team roster five years after the entry draft.

The SPI-H also significantly predicted number of games played during the 5-year period after the draft ($r = .47$; $p < .001$). Furthermore, the SPI-H predicted the number of times the athlete was named a star. The correlations between the SPI-H and number of times the athlete was awarded the 1st, 2nd and 3rd star were respectively .34, .34, and .30. These correlations all exceed the .001 level of significance.

Discussion

The results reported herein demonstrate that information gathered and compiled annually by Central Scouting Services of the NHL prior to entry draft has a high level of accuracy for detecting athletes who have the best prospects of playing in the NHL. In effect, prediction accuracy exceeding 78% substantiates the utility of quantitative methodologies to buttress subjective decision-making conducted by experts. Notably, prediction accuracy would have been even higher if unforeseen intervening events since the draft, such as career ending injury or a personal reason to discontinue a hockey career, were taken into account. These events are, however, not recorded in the database. Nevertheless, prediction accuracy approaches 80% despite the absence of a subset of true positives; that is, players who were predicted and subsequently played in the NHL but did not continue to the fifth year after the draft. In other words, an athlete who played for four years has a very high probability of playing a fifth year if not for an injury or other unforeseen factor. The fact that a subset of the population dropped out by the fifth year, indicates that accuracy would have been higher if they had been retained in the league.

It remains to be determined whether prediction accuracy could be further enhanced by including additional information. For example, beginning in 2007, quantitative measurement of the mental requirements for successful performance in hockey (e.g. suppression of distraction, spatial orientation, decision-making speed etc.) along with an assessment of motivation (e.g. competitiveness, commitment to training), personality (stress resilience), and social behavior (e.g. leadership) were introduced in the annual combine. However, the extent to which prediction accuracy is improved by these processes can be determined only after several years have elapsed. It also needs to be determined whether the SPI-H is useful for identifying athletes who may have specialty skills in hockey such as penalty killing or a proclivity for scoring in the game tie-breaker shootout.

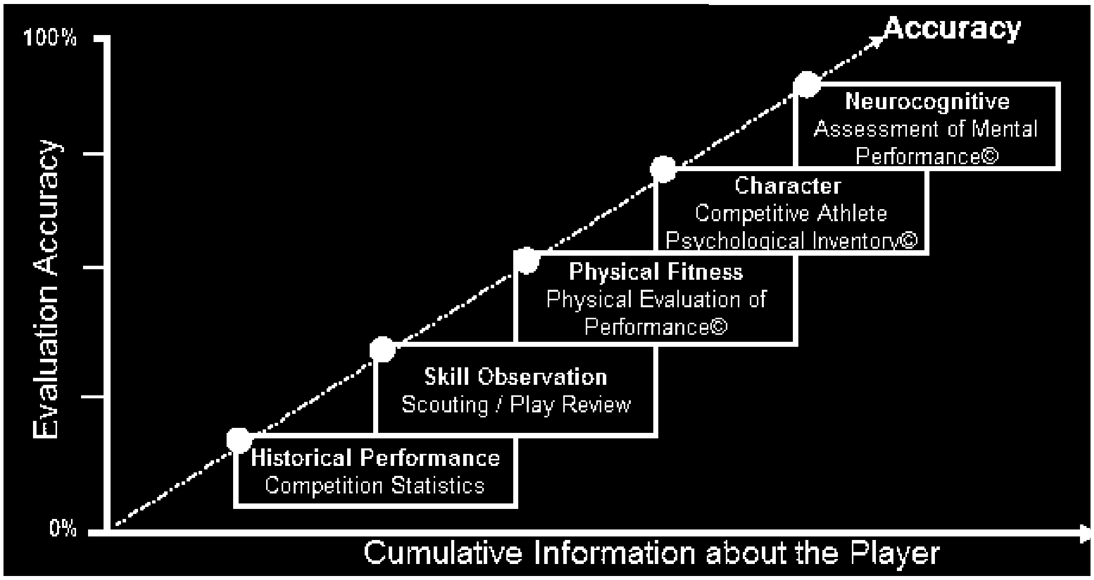

Figure 1. Comprehensive Player Talent Identification Model

As shown in Figure 1, the model guiding the assessment framework is anchored in the assumption that prediction accuracy increases with both the quality and quantity of data pertaining to the components of athleticism that are integral to success in the particular sport. The extent to which the model, shown herein to be useful in hockey, is applicable to other sports needs to be determined.

Conclusion

In summary, the *Sports Performance Index-Hockey* (SPI-H), derived from routinely acquired information, predicts playing in the NHL within five years after the entry draft with over 78% accuracy. This composite index, used in conjunction with qualitative decision-making conducted by experts, potentiates accuracy in selecting athletes who have the best prospects of playing in the NHL. Importantly, quantitative information supplants but does not replace the judgment of experienced experts. Rather, quantitative information allows the GM to quickly gauge the potential of each athlete so as to narrow the focus on a particular subset of the best prospects. Using predictive measurement as a reference for dialog with senior staff, consisting of scouts, fitness professionals, physicians and sport psychologists, the GM's decision-making process is thereby streamlined. Accordingly, accuracy of decisions also increases. Considering the substantial opportunity and fiscal costs that ensue from an erroneous decision, it is concluded that quantitative analysis, joined with expert judgment, is a practical cost-effective strategy for selecting the most promising hockey players in the entry draft.

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