Demographic, physiological, psychological, and on-ice performance indicators predict plus/minus status of recreational ice hockey players across a season

Introduction

Sport game outcomes are often based on random events which makes it challenging to predict game outcomes (Boulier & Stekler, 2003; Lames, 1998). To increase their chances of winning a game, a season or a tournament, ice hockey teams (and analysts) strive to find indicators and parameters predicting success in ice hockey and identifying key players contributing to the team’s success (Lee, Kim, Chaeueun, Pathak, & Moon, 2018). In competitive sports such as professional ice hockey, a good amount of research documents the performance indicators that influence match performance (Hvat-tum, 2019); however, due to limited resources (financial, staff, time), little is known about recreational athletes’ performance indicators and metrics providing useful data about a player’s contribution to the team’s success.

A set of parameters to predict success in professional sports (e.g., National Hockey League [NHL], National Basketball League [NBA]) are performance indicators, including physiological (Starkes, Helsen, & Jack, 2001) and psychological characteristics (Sullivan & Feltz, 2001). Janelle and Hillman (2003) suggest four domains being important to reach expert level: physiological, technical, cognitive (tactical/perceptual) and emotional. These domains which eventually lead to expert performance are all influenced by the psychological skills domain, with experts having superior abilities and skills in the domains relevant for the sport (Janelle & Hillman, 2003).

In a professional ice hockey selection camp, selected players by expert coaches showed better physical and physiological parameters than non-selected players. The best predictors of success in the recruitment process were time to peak power and relative peak power as measured by the 30 s Wingate test, VO2max and 30 m sprint forwards on ice (Roczniok et al., 2015). Field-based assessments seem to deliver more meaningful/predictive data compared to laboratory assessments (Henriksson, Vescovi, Fjellman-Wiklund, & Gilenstam, 2016). Henriksson et al. (2016) identified single-leg standing long-jump as a valid method to gain knowledge about performance characteristics for skating among female ice hockey players.

Psychologically, achievement orientation may influence a player’s on-ice performance. Achievement theory assumes that humans aim to demonstrate high abilities rather than low abilities (Roberts, Treasure, & Conroy, 2007). One’s abilities can be judged high or low referring to one’s own performance (task orientation) or in relation to the performance of others (ego orientation; Nicholls, 1984). These different perceptions are part of Gill and Deeter’s (1988) concept of sport orientation. While win orientation describes the athlete’s orientation to judge his own performance only as success in the case of victory (ego orientation), goal orientation describes the athlete’s orientation to excel his own performance, which means that athletes may also recognize failure as success as long as they improve their own performance (task orientation). Competitiveness is the third part of the orientation, referring to the athlete’s perception of competition as enjoyment and challenge (Elbe, Meier, Wenhold, & Beckmann, 2008). Task orientation has been positively associated with adaptive success factors, desirable behaviors, positive emotions, perceived competence and intrinsic motivation and negatively with...
motivation and maladaptive success factors (Lochbaum et al., 2016). In contrast, ego orientation has been positively associated with maladaptive success factors, undesirable behaviors and amotivation (Lochbaum et al., 2016). In team sports, task orientation is positively, and ego orientation negatively associated with the athletes' cooperation with teammates and coaches (Lameiras, Almeida, & Garcia-Mas, 2014). Competitiveness has been associated with high performance (Hellandsig, 1998), reduced competitive anxiety in young adult athletes (Hellandsig, 1998) and sports motivation in professional women football players (Beaudoin, 1998) and sports motivation in professional hockey players/leagues to date (Macdonald, 2011). The APM incorporates both defensive and offensive aspects and is more accurate than other metrics that are commonly used (e.g., box-score) (Macdonald, 2011). This is in line with previous studies which used plus-minus values to evaluate individual performance across different sports (Macdonald, 2011; Okamoto, 2011; Kharrat, Peña, & McHale, 2019). However, such metrics are generally only applied to elite hockey players/leagues to date (Macdonald, 2011). At the elite level, further adjusted versions of the APM have taken into account the quality of teammates and opposition players when calculating a plus-minus for a given player using regression models (Gramacy, Jensen, & Taddy, 2013; Gramacy, Taddy, & Tian, 2017; Thomas, Ventura, Jensen, & Ma, 2013).

Even though this is a definite improvement and controls for important confounds, this kind of data is neither available nor collected for recreational players at this time. Recreational athletes participate in sport as a pastime, which may or may not be organized in league play. They also have less experience than professional hockey players, do not participate at the international level (Swann, Moran, & Piggott, 2015), and most importantly do not participate for remuneration. Since amateur teams usually do not provide a lot of data, the plus-minus is a simple way to acquire potentially revealing data. The plus-minus for recreational athletes is appropriate for several reasons:

- To motivate the players: players can track their own performance or compare with their teammates' data across a season
- To focus on team and individual goal setting
- To acknowledge both offensive and defensive contributions
- To provide objective values making their on-field actions meaningful

Our goal was to investigate which performance parameters could deliver useful data explaining the plus-minus in recreational ice hockey players. This may motivate players to increase their commitment and participation, become more active during their leisure-time, and inform coaches where to focus to build confidence, cohesion, and cooperation.

**Methods**

**Participants**

The participants (n = 20 players, no goaltender; 1 female; mean age = 36.25 ± 12.91 years; height = 178.85 ± 8.64 cm; weight = 81.36 ± 12.89 kg; mean years of ice hockey experience = 5.68 ± 8.93) were from one team playing in the 5th level of the 9 level DPL (the German Players League), the largest recreational league across Germany with about 1100 players. Professional and former professional players are not allowed, there

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**Fig. 1** Diagram of skating tests on an olympic-sized ice hockey rink
are two referees per game, slap shots are allowed, whereas body checks are not allowed and it is a self-organized league. The season for level 5 teams consisted of 8 games within the German state of Baden-Württemberg.

**Procedure**

Approval was obtained from the coach and the project was explained to the players upon which they provided informed consent. Anthropometrical data were collected right before and performance data was collected during a practice session after the 3rd game of the 8 game regular season and plus-minus were recorded after each game. Prior to this practice session every player took part in an online survey including demographics via SurveyMonkey.com. Some indicators were not assessed due to lack of resources (e.g., VO\textsubscript{2}max, and several fitness indicators). An ethical approval was not required as per the local legislation, due to this being an anonymous study containing anonymous data.

**Measures**

**Demographics.** Age, sex, hockey experience, and years on team were included.

**Height and weight.** Height and weight were measured without shoes and in light clothing. For height, the player had his back towards the stadiometer (Seca 216 Accu-Hite, seca gmbh & co. kg., USA) standing tall on flat feet with head in the Frankfort plane with arms at the sides. A minimum of two height measurements were taken. If the values varied by 1 mm or less the average was recorded, if more than 1 mm an additional measurement was taken and the average of the three measurements was recorded. For weight, the player had to stand still with both feet on the scale (portable Health-o-Meter digital scale with a capacity of 170 kg, Sunbeam Products Inc., USA). Two measurements of weight were taken. If the values varied by 0.1 kg or less the mean was recorded, if by more than 0.1 kg an additional measurement was taken and the average of the three measurements recorded.

**Body fat.** To determine the body fat a three site skinfold caliper (Lange Skinfold Caliper, Cambridge Scientific Industries Inc.) measurement was used (ACSM, 2013) measuring chest, back and suprailium for male and triceps, suprailium and thigh for the female was used. Every spot was measured two times and the average was taken. If the deviation of the two measures was more than 1 mm a third measurement executed and the average calculated.

**Sport orientation and cohesion.** The survey included the Sport Orientation Questionnaire (Elbe, Wenhold, and Beckmann, 2008) which is the German translation of the original questionnaire by Gill & Deeter (1988). The reliability and the accuracy of the translation have been confirmed (Elbe et al., 2008). The questionnaire consists of 25 items including three related subscales: level of competitiveness (13 items; current study Cronbach’s alpha (α) = 0.82), goal orientation (6 items; α = 0.72) and win orientation (6 items; α = 0.68). Response options ranged on a 5-point Likert scale from 1 (“Strongly disagree”) to 5 (“Strongly agree”). For each scale, sum scores were used.

The MAKO-02 questionnaire investigates the social and task cohesion (Lau & Stoll, 2002). It consists of 19 items aiming for social cohesion (9 items; α = 0.72) and task cohesion (10 items; α = 0.83). Validity and reliability have been confirmed (Lau & Stoll, 2002). Response options ranged from 1 ("Strongly disagree") to 5 ("Strongly agree"). The score average was calculated for social and task cohesion respectively.

**Muscular strength and endurance.** We measured upper and lower body muscular strength and endurance based on the recommendation from Ransdell and Murray (2011) via the maximum repetitions during a 30 s interval for push-ups (upper body strength) and a separate 30 s interval for squats (lower body strength). One push-up repetition started with weight on hands and toes and straightened arms, went to the elbows being at 90° and ended in the same straightened arm position. One squat
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Table 1  Demographics, physiological, psychological, on-ice performance and plus-minus descriptives

| Variable          | Mean ± SD |
|-------------------|-----------|
| Age               | 36.25 ± 12.91 |
| Experience (years)| 5.68 ± 8.93  |
| On team (years)   | 2.05 ± 1.13  |
| Body fat (%)      | 18.43 ± 5.75 |
| BMI (kg/m²)       | 25.31 ± 2.74 |
| Goal orientation  | 25.6 ± 3.05  |
| Win orientation   | 21.45 ± 2.87 |
| Comp orientation  | 20.85 ± 6.67 |
| Social cohesion   | 7.79 ± 0.70  |
| Task cohesion     | 5.34 ± 0.87  |
| Push-ups (n/30 s) | 28.53 ± 8.46 |
| Squats (n/30 s)   | 28.33 ± 4.17 |
| S-Curve (s)       | 9.90 ± 0.48  |
| Acceleration (s)  | 1.24 ± 0.06  |
| Speed (s)         | 3.93 ± 0.22  |
| Shot accuracy (/20)| 5.17 ± 2.28  |
| Shot speed (km/h) | 66.77 ± 14.85 |
| Plus/Minus        | 0.05 ± 3.02  |

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Table 2

Shooting accuracy and speed. 1) To monitor the accuracy there was a shooter tooter (72° Shooter Base Accushot) which had holes in each of the four corners (bottom left/right, top left/right). They had 5 shots at each corner and the goals scored were summed. 2) To measure shooting speed, we took the fastest out of three shots into the goal (without a target) with a speed measurement instrument set to km/h (SpeedCheck, Outer Limits Sports; frequency set to 10.525 GHz).

Plus/minus. To be included in the analysis, each player had to play at least 2 games. This is to decrease the chance of an outlying performance and a player needs to participate in at least 2 games in order to be able to participate in the playoffs. After each game each player was asked for their plus/minus in the dressing room before he/she departed and this was validated with the coach’s game notes.

Discussion

This is one of the first studies to investigate psychological, muscular strength and endurance, and on-ice performance indicators related to outcome in recreational/amateur ice hockey players. The muscular strength and endurance variables were most strongly positively associated with the plus-minus statistic. Somewhat surprisingly, none of the skating variables were meaningfully related to plus-minus.

That muscular strength and endurance variables are most strongly related to the outcome replicates results of elite male (Peyer, Pivarnik, Eisenmann, & Vorkapich, 2011) and female ice hockey players (Henriksson et al., 2016). Ice hockey requires strength in many facets (e.g. skating, accelerating and decelerating, balancing, stickhandling, defending the puck from opponents, and attempting to obtain the puck from opponents). That muscular strength and endurance was the strongest variable may be due to the skill level (recreational athletes) where some of the other specific on-ice skills like skating or shooting accuracy are not as developed as in elite athletes. Therefore, a recreational player may be well guided to ensure maintaining strength and possibly related fitness at
| Variable                  | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | 16   | 17   | 18   |
|--------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 1. Age                   | 1    | 0.41 | 0.01 | 0.72*| 0.43 | 0.12 | 0.03 | -0.24| 0.36 | 0.31 | -0.31| 0.09 | 0.58 | 0.60*| 0.67**|0.03 | 0.24 | 0.12 |
| 2. Experience            | -    | 1    | -0.12| 0.61*| -0.18| -0.19| -0.31| -0.39| 0.31 | 0.37 | -0.67**| -0.23 | 0.22 | 0.52*| 0.63**| -0.23 | 0.01 | -0.05 |
| 3. Years on team         | -    | -    | 1    | 0.18 | 0.10 | -0.08| 0.13 | 0.22 | 0.44 | 0.30 | -0.09 | 0.21 | 0.16 | -0.03| 0.27 | 0.29 | 0.04 | 0.23 |
| 4. Body fat              | -    | -    | -    | 1    | 0.46 | -0.16| 0.10 | -0.40| 0.69**| 0.52*| -0.63**| -0.05 | 0.65*| 0.54*| 0.77**| 0.05 | -0.10 | -0.20 |
| 5. Body Mass Index       | -    | -    | -    | -    | 1    | 0.06 | 0.28 | -0.03| 0.21 | 0.21 | -0.02 | -0.07| 0.36 | 0.35 | 0.24 | 0.10 | 0.12 | -0.28 |
| 6. Goal orientation      | -    | -    | -    | -    | -    | 1    | 0.35 | 0.50*| 0.11 | 0.00 | 0.26 | 0.37 | -0.45| -0.11| -0.21| 0.44 | -0.08 | 0.11 |
| 7. Win orientation       | -    | -    | -    | -    | -    | -    | 1    | -0.08| -0.53*| 0.58*| 0.41 | -0.53*| -0.70**| -0.66**| 0.62**| 0.06 | 0.28 |
| 8. Competitiveness       | -    | -    | -    | -    | -    | -    | -    | 1    | 0.47*| -0.36| 0.21 | 0.35 | 0.22 | 0.50*| 0.45 | -0.21 | 0.06 |
| 9. Social cohesion       | -    | -    | -    | -    | -    | -    | -    | -    | 1    | -0.61*| -0.20| 0.41 | 0.59*| 0.67**| -0.05| -0.51*| -0.24 |
| 10. Task cohesion        | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | 0.51*| -0.37| -0.51*| -0.70**| 0.22| 0.10 | 0.52*|
| 11. Squats               | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | 0.12 | -0.33| -0.19 | 0.19 | -0.08| 0.37 |
| 12. S–Curve              | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | 1    | 0.49*| 0.74*| -0.34| 0.13 | 0.02 |
| 13. Acceleration         | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | 0.79**| -0.26| -0.01| -0.17 |
| 14. Speed                | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | -0.28| 0.01 | -0.18 |
| 15. Shot accuracy        | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | -0.36| 0.04 |
| 16. Shot speed           | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    | 0.33 |
| 17. Plus-Minus           | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | -    | 1    |

Correlation size: small (italic), medium (bold), large (bold italics)

*– p <0.05, **– p <0.01
the amateur level. Related, but perhaps not surprising, are the findings that higher BMI and body fat percent may be related to lower performance outcomes. This has also been found in elite ice hockey players (Montgomery, 1988), although not always significant (Peyer et al., 2011) and may be an indicator of overall fitness. There may be differences in recreational compared to professional ice-hockey players as overall preseason player size and anaerobic and aerobic fitness parameters of a professional NHL ice-hockey team was not related to team success over a 26-year period (Quinney et al., 2008).

The psychological results also replicate those found in elite athletes. Our study indicates that enjoying the challenge of competition is beneficial for recreational athletes as in elite athletes (Hellandsig, 1998). In contrast, win (ego) orientation and task cohesion may be detrimental to performance in our recreational ice hockey players as in elite athletes (Lameiras et al., 2014; Lochbaum et al., 2016). Win orientation and task cohesion may be detrimental if the players redirect focus on specific tasks (e.g., focus on checking or scoring goals) to the detriment of overall game performance. This underlines the importance of adopting a team atmosphere of enjoying competition and decrease focus of win-at-all-costs (ego) orientations across skill levels.

That acceleration, speed, or curve skating was not related to plus/minus rating replicates results with elite National Collegiate Athletic Association division I ice hockey players (Peyer et al., 2011) and may be due to a couple of reasons. The small dispersion of the participants’ performance (the standard deviation is less than 5% of the mean) indicates that the players were very similar in skating ability; thus this factor did not differentiate the players in terms of skill. Statistically, the relatively small dispersion limits the indicators’ ability to explain outcome variability. There may be other not-tested skating skills that should be included such as starting and stopping, backwards skating, or repeated skating performance which may be more related to game performance. Stanula, Rocznik, Gabryś, Szmatał-Gabryś, & Oźimek (2018) did find that a fatigue index calculated from the repeated-skate sprint test was significantly related to the plus/minus rating with elite Polish men’s national ice hockey players participating in the U18 Ice Hockey World Championship.

This study added to the literature in that it included psychological, muscular strength and endurance, and on-ice performance indicators, tracked outcomes across an entire season, and addressed recreational athletes. However, some limitations need to be considered when interpreting our results. Some potentially important indicators were not assessed (e.g., VO₂max, and several fitness indicators) limiting the comprehensiveness of the variables included. The study focused on one team of one skill level in one German recreational league limiting generalizability. Assessing the performance and psychological indicators during the season midpoint does not allow investigating the indicator changes occurring during the season on outcomes. There was no external recorder of the plus-minus statistics; however this is not deemed a serious limitation as the players/line-mates were each other’s validity checks after each game decreasing the chance of anyone’s biased reporting. Finally, the small sample sizes does not allow for subgroup (e.g., position) analyses.

The limitations notwithstanding, this study revealed that some performance and psychological indicators are related to recreational ice hockey players plus-minus ratings over a season. Thus, coaches and players of recreational teams should focus on muscular strength and endurance, shooting speed, body composition, and enjoying the challenge of competition while lowering their win orientation. Future directions include larger sample sizes of different amateur teams across skill levels and leagues to replicate and increase generalizability, including a more comprehensive set of indicators, off-ice fitness indicators, and experimental studies based on these results to improve the meaningfulness of the indicators in order to improve performance in recreational ice hockey players.

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Corresponding address
Prof. Dr. Claudio R. Nigg
Health Science Department, Institute of Sport Science, University of Bern
Bremgartenstraße 145, 3012 Bern, Switzerland
claudio.nigg@ispw.unibe.ch

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Compliance with ethical guidelines
Conflict of interest. C. R. Nigg, A. Gessner, C. Nigg, M. Giurgiu and R. Neumann declare that they have no competing interests.

For this article, an ethical approval was not required as per the local legislation, due to this being an anonymous study containing anonymous data. This study was performed in accordance with the ethical standards indicated in each case.

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