Title: Association between physical performance tests and external load during scrimmages in highly trained youth ice hockey players

Abstract

Purpose: To investigate the relationship between physical performance tests and on-ice external load from simulated games (scrimmages) in ice hockey. **Methods:** 14 players completed a physical performance test battery consisting of 30-m sprint test – run and 30-m sprint test - skate (including 10-m split times and max speed), countermovement jump (CMJ), standing long jump, bench-press, pullups and trap bar deadlift, and participated in four scrimmages. External load variables from scrimmages included total distance, peak speed, slow- (<11.0 km/h), moderate- (11.0-16.9 km/h), high- (17.0-23.9 km/h) and sprint (>24.0 km/h) speed skating distance, number of sprints, PlayerLoad™ and number of high intensity events (HIEs; >2.5 m/s), accelerations, decelerations and change of directions (CODs). Bayesian pairwise correlation analyses were performed to assess the relationship between physical performance tests and external load performance variables. **Results:** The results showed strong evidence (Bayes Factor >10) for associations between pullups and HIEs (τ=0.61), and between max speed skate and peak speed (τ=0.55). There was moderate evidence (Bayes Factor >3 to <10) for six associations; both max speed skate (τ=0.44) and CMJ (τ=0.44) with sprint speed skating distance, CMJ with number of sprints (τ=0.46), pullups with CODs (τ=0.50), trap bar with peak speed (τ=0.45), and body mass with total distance (τ=0.49). **Conclusion:** This study found physical performance tests to be associated with some of the external load variables from scrimmages. Nevertheless, the majority of correlations did not display meaningful associations, possibly influenced by the selection of physical performance tests.

Keywords: Local Positioning Systems, Athlete monitoring, Simulated games, Match performance, Strength training

INTRODUCTION

Physical off-ice testing for ice hockey players has been completed for decades, with the North American National Hockey League (NHL) being a large-scale pioneer of their implementation of the NHL Combine test battery, annually conducting large scale testing of worldwide youngsters potentially eligible for the NHL in the future.[1] Physical performance tests aim to reflect the most relevant physical capabilities underlying ice hockey performance,[2-4] and the results can be useful to monitor longitudinal development, in injury follow-up, and are implemented to set thresholds for fitness requirements in positional, team and/or competitive playing levels.[3,5-8] Enhanced physical capabilities can be beneficial for players' game-related performance, as an increased fitness-level can contribute to players' likelihood of success in explosive efforts such as during puck battle, body checks and breaking free from the opposition to score a goal.[8] In addition, superior fitness contributes to reduced physical and mental exhaustion, affecting players decision making, technical/tactical skills, injury risk etc.[3,9] While there is an inconsistency in the specific physical performance tests applied both on- and off-ice, the majority of tests intent to measure physical abilities such as aerobic and anaerobic power, speed, agility, and upper- and lower body strength.[1-3,8]

How well these physical performance assessments represent game-playing performance is, however, debatable.[8] Measures of on-ice game performance seem to vary and have for example, been limited to pre-defined skating- and puck handling courses.[6,10] Additionally, there is considerable test-retest variability in all physical and game-related performance measurements, which will confound the investigation of potential relationships between specific parameters.[11] Nevertheless, the search for an association or "predictiveness" of game performance is ongoing. Some have explored the association to the draft selection, however without any clear associations between physical test performance and draft round entry.[1,4,12,13] Furthermore, there are a plethora of factors that determines draft selections, and physical performance is only a minor part of those.[1,2,12] In other studies, trivial to moderate associations have been shown between off- and on-ice tests and game performance markers such as; points, goals, assists, shots, scoring chances, ± differential statistics, playing time, shift time, or games played across a variety of player caliber, sex and playing level.[3,7,14,15] The lack of any clear association can be explained by the nature of physical game performances, involving highly complex tasks with great performance variabilities across players competing at the same level. It is therefore, unlikely that any on- or off-ice physical performance test can be the true representative of the current markers of match performance.[10] Hence, the lack of strong associations is more or less expected.

Despite the comprehensive search for relevant physical performance tests that relate to markers of game performance, it is surprising to observe the lack of studies including any on-ice external load measures from gameplay situations. Comparison between physical fitness and external load from official game situations is, however, shown in sports such as soccer.[16] In contrast to outdoor field sports, the limited availability of locomotive characterization research in ice hockey may partly explain this observed research gap.[17] Accordingly, the association between physical performance tests and external load performance from indoor gameplay situations remains to be determined. Notably, recent developments and application of Local Positioning Systems (LPS) and other player tracking technologies have made external load monitoring available in indoor conditions and has indeed provided insight to both official- and scrimmage situations (simulated gameplay replication) in ice hockey.[18-20] Implementation of such technology is suggested to provide helpful information in narrowing this research gap by its potential to accurately quantify specific game demands.[8,17] Based on these previous research recommendations and the obvious gap in the literature, this study aims to explore the association between physical performance tests and external load from on-ice play situations by the application of LPS. Specifically, the purpose of this study is to assess physical fitness of highly trained male youth players and explore the association with on-ice external load from scrimmages.

METHODS

SUBJECTS

Highly trained youth players from a professional ice hockey club, competing at a national level, were invited to participate. To be included in the study, the players were required to complete a physical performance test battery. Furthermore, and to minimize game-to-game variability and single player efforts, players had to participate in all four scrimmages with a LPS-unit to be included in the analysis. 14 players (age: 17.8 ± 1.1 yrs, height: 179.5 ± 6.5 cm, body mass: 71.2 ± 6.0 kg, n=4 defensive, n=10 forwards) completed all measurements and are included in this study. Nineteen players were initially recruited to participate in the present study, but one of these players was excluded for not completing all physical performance tests (injury), while four players were excluded for not participating in all four scrimmages (promotion to senior team: n=1, injury: n=3). Additional players not included in the study were participating in the scrimmages to ensure enough players for each team. Written informed consent was obtained from all players before the study commenced. The study was performed according to the Helsinki declaration of 1975 and was approved by the local ethical committee at the University of Agder, Kristiansand, Norway.

DESIGN

In the present study, assessment of on- and off-ice physical test performance was conducted over two separate test days and four scrimmages were played to assess external load performance. The study was completed over a three-week period during the first half of the regular season.

Physical performance testing

The physical performance tests included counter movement jump (CMJ), 30-m linear running and skating sprint test, standing long jump, pullups (max repetition number with body mass), and 1RM bench-press and trap bar (hexagonal barbell deadlifts) deadlift, performed over two separate days. The test battery was chosen to include physical performance abilities important for ice-hockey and selected based on previous studies involving high-level athletes.[2,3] The specific tests were included as they were a part of the team's regular physical assessment test battery and all players were familiar with the tests. CMJ and sprint assessment were completed on day one, with CMJ and 30-m sprint test - run performed in the morning, and 30-m sprint test – skate performed 6 ± 1 hours later. Strength test, performed on a separate day, were completed in the following order: standing long jump, bench-press, pullups and trap bar deadlift. All participants underwent a typical warmup procedure before the physical performance tests, included jogging, jumps, running/skating drills, sprints with increasing intensity and dynamic stretching.

CMJ

CMJs were performed with hands on the hips, and the depth of the squatting motion was self-selected. The athletes performed 3-5 jumps with a 2-3 min passive rest between each attempt. The CMJs were measured using a force plate (Musclelab; Ergotest AS, Porsgrunn, Norway) and calculated from its accompanying software. The mean jump height (cm) of the two best attempts was included in post-test analysis.

30-m sprint test - run

Sprint test – run were performed wearing light clothing on an indoor athletic synthetic track running surface. Participants performed 2-4 maximal sprints during the test with 4 min passive rest between each attempt. Wireless timing gates were used to measure time at each 10-m interval (Musclelab, Ergotest innovation AS, Langesund, Norway). The timing was initiated when the foot triggered the first sensor, placed 50 cm in front of the start line and 40 cm above the ground. The remaining sensors at 10-, 20- and 30-m were placed 120 cm above the ground. The trial with the best 30-m time was included in post-test analysis and max speed was calculated from the 10-m split-times.

30-m sprint test - skate

Sprint test – skate were performed in full match-kit, including stick. During the test, participants performed 2-4 maximal sprints with 4 min passive rest between each attempt. The same wireless timing gates and setup were used for the sprint test - run and sprint test - skate. Players started from a stationary sideways position holding the stick in front of the photocells, making sure the sensors weren't obstructed by anything other than the body. The timing was initiated when the foot triggered the first sensor, placed 50 cm in front of the start line and 40 cm above the ground. The players were instructed to keep the stick in contact with the ice to avoid prematurely breaking the photocells [5]. The trial with the best 30-m time was included in post-test analysis and max speed was calculated from the 10-m split-times.

Standing long jump

For the long jump, subjects started from a standing position with both feet parallel behind a start line and jumped as far as possible in the horizontal direction. Arm swing was allowed. The jump length was measured to the nearest 0.01 m from the start line to the rear heel, using a tape measure. To qualify as a successful attempt, the subjects had to take off with two feet and maintain balance for at least two seconds upon landing. Three attempts were performed, where the best trial was included in the post-test analysis.

Bench-press

One-repetition maximum (1RM) bench-press test was measured using a free weight Olympic bar and weights. The participants were instructed to hold the bar at a position slightly greater than shoulder width. The subject then lowered the bar to the chest and pushed the bar until full arm extension. The gluteal muscles had to be in contact with the bench throughout the entire lift. Participants performed 3-4 warm-up sets with increasing loads (50-90% of 1RM), based on previous performance. Two to four attempts were then performed to determine 1RM. Upon successfully completing the repetition, weight was subjectively increased by 2.5-10 kg. For subjects that were not able to complete the lift, weight was reduced by 2.5-5 kg.

Pullups

Subjects used an overhand grip (palms facing away from the body) and started from a dead hang (arms fully extended and locked). From this position, a pullup was performed until the chin had cleared the top of the bar. The body was then lowered until the arms where fully extended or locked out. No excessive body motion was allowed. Each subject completed one trial, and the maximum number of valid repetitions was recorded.

Trap bar deadlift

Trap bar deadlift was performed using a standard hex bar with a weight of 32 kg. Participants performed 3-4 warm-up sets with increasing load (50-90% of 1RM), based on previous performance. Two to four attempts were then performed to determine the 1RM. Upon successfully completing the repetition, weight was increased subjectively by 2.5-10 kg. If they could not complete the lift, the weight was reduced by 2.5-5 kg. Participants had to stand fully erect with knees and hips locked, for the lift to be considered successful.

Measurements of external load

Scrimmages and sprint test – skate were performed in the same arena, housing a North American sized ice-rink (60.96 m x 25.90 m). A LPS (Catapult Clearsky T6, Catapult Sports, Australia) with twenty anchor nodes was mounted ~20 meters above the ice-surface. The system was spatially calibrated using a tachymeter (Leica Builder 509 Total Station; Leica Geosystems AG Switzerland), as recommended by the manufacturer. Each player was equipped with an LPS-unit (Catapult Clearsky T6, Catapult Sports, Australia: firmware version 5.6). The LPS-unit was located between the scapulae in a specialized sewn vest supplied by the manufacturer. The data collection was monitored in real time using Catapult OpenField Software (version 1.17.2). Interchanges were manually tracked using the software to ensure that only on-ice time and data were included in the analyses.

To ensure comparable playing time and avoid single player efforts, the scrimmages were standardized by modifying official game regulations, as described in Byrkjedal et al.[20] Briefly, scrimmages were played in accordance with full-game regulations with 3 x 20 min continuous play periods, with 18 min of recovery between periods. Entire line shifts were performed for both teams every 1-min by a whistle signal from the coach, resulting in 1:2 work to rest ratio and ~20 min of ice time per player. No penalties were given and if an offside or icing-situation occurred, the defensive team would gain possession of the puck. When a goal was scored, the play was immediately restarted by the goalkeeper taking out the puck from the net.

30 players were allocated by the team coaches into two separate teams to give a balanced opposition for the scrimmages. Each team consisted of 15 players making three line-ups, where the 1st and 2nd line of each team wore a LPS-unit due to a restricted number of LPS devices. The four scrimmages were arranged within a two-week period and played at the same time of day (± 2.5 hours) with the players allocated to the same teams each time. To ensure maximal efforts, the players were verbally coached during every scrimmage and were given a tactical and motivational-talk between periods, as in official game situations and score tabs was kept between the teams (total and line vs line). Furthermore, as regular league games were postponed due to a covid-outbreak in other regions, the scrimmages were the main competitive arena for the players in this period. The players were aware that if they performed well during the scrimmages, they could be promoted to the elite team.

SCRIMMAGE VARIABLES

Total distance, distance in speed skating zones, peak speed (m/s), PlayerLoad™, accelerations (ACCs), decelerations (DECs) and change of direction (CODs) were extracted from the OpenField software. Speed skating zones thresholds were chosen in accordance with previous research[18,19], divided into slow- (<11.0 km/h), moderate- (11.0-16.9 km/h), high- (17.0-23.9 km/h) and sprinting (>24.0 km/h) speed skating. PlayerLoad™, high-intensity events (HIEs), ACCs, DECs and CODs were applied as previously reported by Luteberget and Spencer.[21] Briefly, PlayerLoad™ is calculated by summarizing all accelerations and is expressed as the square root of the sum of the squared instantaneous rate of change in acceleration in each of the 3 vectors (x, y and z axes), divided by 100 and scored as arbitrary units (au). ACCs, DECs and CODs is a summary of identified movements in the respective direction with an intensity >2.5 m/s. The sum of ACCs, DECs and CODs were displayed as HIEs. The data were edited post-match to remove time between periods and time on the bench (i.e., only time on ice was included in the analysis). Results from test day one and scrimmage data were extracted from the respective manufactures software and organized in Microsoft Excel (version 16.59 Microsoft Corp. Redmond, WA, USA) together with the results from test day two.

STATISTICS

Descriptive results were calculated using Microsoft Excel and are presented as mean ± SD. The main analyses were conducted in JASP (Jeffreys's Amazing Statistics Program) version 0.16.1. A non-parametric Bayesian correlation analysis was performed to investigate the relationship between the physical performance test variables and the external load variables from scrimmages. The Kendall's Tau correlations in combination with Bayes Factors (BF) were calculated for each comparison.[22] The BF is one method to quantify the likelihood of an alternative hypothesis (H1) compared to the null-hypothesis (H0), and is expressed as BF_{10}.[23] For example, a BF_{10} of 3 should be interpreted as the H1 (e.g., an effect) is 3 times as likely compared to H0 (no effect). For a more comprehensive description of the advantages applying this analysis over more traditional correlation analysis, see Ivarsson et al.[24]; Wagenmakers et al.[25] For each pairwise comparison, a BF was calculated. In line with previous research, the interpretation of BF_{10} were: >100=Extreme strong evidence for H1, 30-100=Very strong evidence for H1, 10-30=Strong evidence for H1, 3-10=Moderate evidence for H1, 1-3=Anecdotal evidence for H1, 1=No evidence. 0.33-1=Anecdotal evidence for H0, 0.10-0.33=Moderate evidence for H0, 0.033-0.1=Strong evidence for H0, 0.01-0.033=Very strong evidence for H0, <0.01=Extreme evidence for H0.[26]

RESULTS

The results from the physical performance tests can be found in Table 1, with a summary of the included variables from the scrimmages presented in Table 2. During scrimmages, players performed 20.0 ± 0.0 shifts and had a total game time of 21:00 ± 00:06 min per match.

A matrix Table of Kendall's Tau correlations are reported in Table 3. Only the pairwise comparison correlations between physical performance tests and external load parameters are reported. Body mass, max speed skate, CMJ, pullups and trap bar deadlift were the only physical performance measures with a BF_{10} >3 for the association with external load variables from scrimmages. Body mass had a moderate correlation to total distance. Max speed skate had a strong correlation with peak speed and a moderate correlation with sprint speed skating. CMJ had a moderate correlation with sprint speed skating and the number of sprints performed. Pullups had a large correlation with HIEs and a moderate correlation with CODs. Finally, a moderate correlation was seen between trap bar deadlift and peak speed. Correlations scatterplots including 95% confidence intervals are shown in Figure 1. No correlations with BF_{10}>3 were shown to the physical performance tests variables 10-m and 30-m max speed run and -skate measures, long jump or bench-press. For the external load variables, no correlations with BF_{10}>3 were shown to the slow-, moderate- and high speed skating distance zones, PlayerLoad™, ACCs or DECs. Relative strength was assessed for the 1RM bench-press and trap bar results by dividing max weight lifted on the player's body mass. No difference was seen between relative and absolute measures for these variables and relative data is therefore not included.

(Insert Table 1, 2 and 3 here)
(Insert Figure 1 here)

DISCUSSION

The aim of the current study was to explore the potential associations between physical performance tests and external load variables from ice hockey scrimmages. We found eight meaningful associations across our data including 12 performance test variables and 12 external load variables. Whereas previous studies only compared physical performance to objective game statistics or pre-defined courses during on-ice tests, this is, to the best of the authors knowledge, the first study to explore the relationship between physical fitness and external load performance from scrimmages in ice hockey.

The difficulties with measurements of sport specific sprinting abilities and the complexity of physical game performance complicate the comparisons between game related physical performance and general physical tests. The current study applies external load data from a tracking system as a new marker of game performance, not previously used in the literature when comparing game performance and physical fitness.[8] Generally, sprinting ability is considered highly important within ice-hockey.[17,27] Nevertheless, the relationship between standardized sprinting measurements and game-related sprint skating performance has been unclear.[8] While previous studies have shown associations between off- and on-ice sprinting times,[28] on-ice sprints have generally been suggested as a more valid method to predict sprinting abilities in ice hockey.[17,29] This hypothesis is supported by our findings where max speed skate was associated with sprint speed skating distance and peak speed during scrimmages. Furthermore, a positive association was also seen between CMJ and both sprint speed skating distance and the number of sprints performed. However, we did not observe evidence for any other sprint related performance tests, supporting the limited associations observed between physical performance test and external load as markers of physical game performance.

When assessing the external load performance measures from the inertial measurement data, only pullups showed any evidence for the displayed association, with strong correlations to HIEs and CODs. Leg extensor strength is central for acceleration of the body during sprints or with change of directions in a variety of sports[9] whereas upper body pulling muscles, such as those used during pullups, are less involved in ice hockey performance. Logically, we were therefore expecting inertial measurement data to show some association towards lower body extensor strength, such as trap bar deadlifts. The observed associations could be explained by strength relative to body mass. However, we did not observe any meaningful relationships when trap bar deadlift strength was expressed relative to body mass (data not reported). Notably, body mass tended to be positively correlated to many of the included external load performance variables, which may explain why there were no associations between external load variables and relative strength in trap bar deadlift. Furthermore, technique and the experience may vary more among these youth players which can impact test scores. Thus, while the number of pullups might be related to HIEs and CODs in our study and across our limited number of participants this could potentially be the result of some underlaying factors that we were unable to detect. However, pullups is most likely not a good marker of game performance in other samples of elite senior players. For example, a reversed relationship was shown between upper body maximal strength and playing time and game points when assessing long term career performance.[2] This does not necessarily conclude that players with reduced upper body strength are more likely to have longitudinal success in NHL. On the contrary, players typically reach the top of their careers 7-10 years after the combine testing where the reason for increased performance is more likely due to matureness, technical skill improvements, players game intelligence etc. This highlights the need for more research into the association between physical fitness and game performance at specific points within the same timeframe, and not several years after fitness assessment.[2]

Apart from the association between trap bar deadlift and peak speed, no evidence is shown between bench-press, trap bar deadlift and long jump, and the external load variables from scrimmages. Trap bar deadlift biomechanics have somewhat lower moments at the lumbar spine, hip, and ankle, and higher moments at the knee than conventional straight bar deadlifts,[30] reminiscent to conventional back squat. Our findings are comparable to the findings of Haugen et al.,[3] where trivial to small associations were shown between bench-press and squat strength to the game related statistics included in their study. In addition, longitudinal follow-up of combine test results did not find any predictive ability of standing long jump or bench-press to players NHL-performance.[2] Notably, the standing long jump length (~250 cm) is quite uniform between several studies with varying performance level of the athletes, which may partly explain the lack of association for this jump ability measurement.[2,4,6,13,17]

Finally, if simply assessing the correlations, without considering BF, total PlayerLoad™ had the lowest displayed association to the performance tests with $\boldsymbol{\tau}$=<0.11 for all measures, except for pullups. PlayerLoad™ and other whole-body measures of mechanical load are widely used in field sports such a football and rugby and have been found to be strongly correlated to running distance,[31] but no uniform approach has been applied in ice-hockey.[20] Anecdotally, some of the players eliciting the highest PlayerLoad™ scores in this study, were the lowest ranked players in the team (3rd or 4th lineup). Based on these data, one could speculate if a higher PlayerLoad™ is shown in less efficient players during the scrimmages, as visual observations suggest greater upper body movement, compared to better ranked players. However, compared to official matches, the scrimmages were performed with less high intensity actions, such as tackles and hits, which also influences the data and PlayerLoad™ score. Therefore, the specific use of this kind of workload variable in ice hockey and its relationship to physical performance tests should be further explored.

LIMITATIONS

There are some limitations that needs to be addressed. Firstly, we did not include external load data from official games. However, our scrimmage design has been shown to be comparable to official games, with the main difference being a higher relative intensity during scrimmages due to the continuous play design.[20] Thus, the association between physical performance tests and external load performance in this study may therefore be relevant to official games. Secondly, only sprint test - skate was used as an on-ice physical performance measure. Further studies should assess the relationship to other on-ice tests. In addition, while we adopted specific tests previously applied in high-level and elite players[2,3], there was a restricted number of tests included, and we did not include any measure of endurance. A more comprehensive test battery could have potentially provided a more thorough overview of physical performance. Finally, we included a limited number of high-level athletes. Small samples are a limitation because it provides restricted information. We have, however, used statistical methods suggested for small sample research. Further studies should, however, include a lager sample to provide more information into the analyses.

PRACTICAL APPLICATIONS

Physical game performance is a complex measure, difficult to decipher by fixed moving patterns, such as those included in traditional physical performance test batteries. The association between physical performance tests and markers of game performance seem to vary, both in relation to objective statistics and external load performance. This is reflected in our results, where evidence (BF_{10} >3) is shown for 8 of 144 associations. Coaches and practitioners should assess the relevance and importance of any physical test and external load measure thoroughly before including in a test- and monitoring regime. In addition, the low association between physical tests and external load measures indicate that they should not be used to monitor an athlete's performance level interchangeably or in isolation, but rather include a variety of relevant performance markers to cover the complex nature of abilities underlying game performance. Lastly, while scrimmages differ from official matches, the standardized design could be favorable when exploring associations to physical performance, as external load in official matches is affected by factors such as level of opposition, differences in playing time, stops, puck-drops and penalties etc, influencing the intensity of the match. Future studies should, however compare the differences to official game data and include players from different competitive levels.

CONCLUSION

While some physical performance test variables were associated with external load variables, the low number of meaningful associations in this study indicate that external load performance cannot be explained by the performance in physical tests alone. Several factors could affect these finding, such as a limited test-battery and limited number of specific on-ice tests. Thus, more research is needed to explore the association between physical performance tests and external load measures, both in training- and match situations.

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Figure 1: Scatterplots between physical performance tests and external load variables for the meaningful associations (BF >3). Including trend line (solid) and 95 % confidence limits (dotted lines). SS: Speed skating, CMJ: Countermovement jump, HIEs: High intensity events, Change of directions.

Table 1: Results from physical performance tests (n=14).

Physical Test	Mean ± SD
Sprint test - run	
10-m (s)	1.66 ± 0.06
30-m (s)	4.19 ± 0.15
Max speed run (m/s)*	8.21 ± 0.33
Sprint test - skate	
10-m (s)	1.77 ± 0.09
30-m (s)	4.29 ± 0.15
Max speed skate (m/s)*	8.41 ± 0.30
CMJ height (cm)	39.5 ± 5.1
Standing long jump (cm)	253.6 ± 13.7
Bench-press 1RM (kg)	86.1 ± 7.6
Pullups (nr)	17.1 ± 5.7
Trap bar deadlift 1RM (kg)	162.1 ± 24.9

*Max speed was calculated using the 20-30m spilt time
Nr: Number.

Table 2: Game data from the included variables during scrimmages (n=14).

Game variable	Mean ± SD
Total distance (m)	5072.0 ± 458.9
Peak speed (m/s)	8.45 ± 0.41
Slow Speed Skating (m)	607.3 ± 149.3
Moderate Speed Skating (m)	1744.8 ± 225.9
High Speed Skating (m)	2240.0 ± 565.5
Sprint Speed Skating (m)	470.3 ± 266.0
Number of sprints	19.9 ± 7.6
Total PlayerLoad™ (au)	145.6 ± 27.4
High Intensity Events (nr)	269.3 ± 56.3
Accelerations (nr)	9.0 ± 3.2
Decelerations (nr)	44.2 ± 13.7
Change of Directions (nr)	216.1 ± 49.5

Nr: Number, au: arbitrary units. Mean ± SD was calculated from the players' average score after the four scrimmages

Table 3: Kendall's Tau correlation matrix

		Sprint test - run			Sprint test - skate							
	Body mass	**10-m**	**30-m**	**Max speed run**	**10-m**	**30-m**	**Max speed skate**	**CMJ**	**Long-jump**	**Bench-press**	**Pullups**	**Trap bar**
TD	0.49*	-0.01	-0.17	0.18	-0.09	-0.21	0.29	0.42	0.14	0.37	0.34	0.27
Peak Speed	0.22	-0.28	-0.39	0.27	-0.13	-0.34	0.55**	0.42	0.36	0.16	0.10	0.45*
SlowSS	-0.30	0.01	0.17	-0.13	0.18	0.21	-0.29	-0.29	-0.10	-0.25	-0.17	-0.23
ModSS	-0.35	0.12	0.19	-0.24	0.11	0.28	-0.35	-0.40	-0.17	-0.25	-0.21	-0.27
HighSS	0.42	0.03	-0.12	0.09	-0.09	-0.17	0.24	0.33	0.06	0.32	0.30	0.18
SprSS	0.28	-0.21	-0.32	0.29	-0.16	-0.36	0.44*	0.44*	0.30	0.25	0.17	0.34
Nr of sprints	0.43	-0.04	-0.16	0.10	-0.21	-0.29	0.28	0.46*	0.13	0.22	0.34	0.15
Total PL	0.29	0.11	0.00	-0.08	-0.06	-0.09	0.03	0.06	-0.09	-0.10	0.38	0.10
HIEs	0.37	0.39	0.36	-0.20	0.29	0.14	-0.16	0.02	-0.17	-0.07	0.61**	-0.14
ACCs	0.27	0.22	0.33	-0.28	-0.06	-0.02	-0.17	0.03	-0.13	-0.37	0.29	-0.15
DECs	0.12	0.21	0.28	-0.40	-0.04	0.14	-0.20	-0.07	-0.25	-0.18	0.32	-0.11
CODs	0.30	0.30	0.23	-0.07	0.20	-0.03	-0.02	0.07	-0.08	0.02	0.50*	-0.02

-1.0 0.0 1.0

Kendall's Tau correlations are displayed by graded color backgrounds. *Moderate evidence for H1 (BF_{10} >3), **Strong evidence for H1 (BF_{10} >10).

CMJ: Counter movement jump height (cm), pullups (max repetitions), bench-press (1RM), trap bar: Deadlift in a trap bar, TD: Total distance, SS: Speed skating, PL: PlayerLoad^{TM} (au), HIEs: High intensity events, ACCs: Accelerations, DECs: Decelerations, CODs, Change of directions.

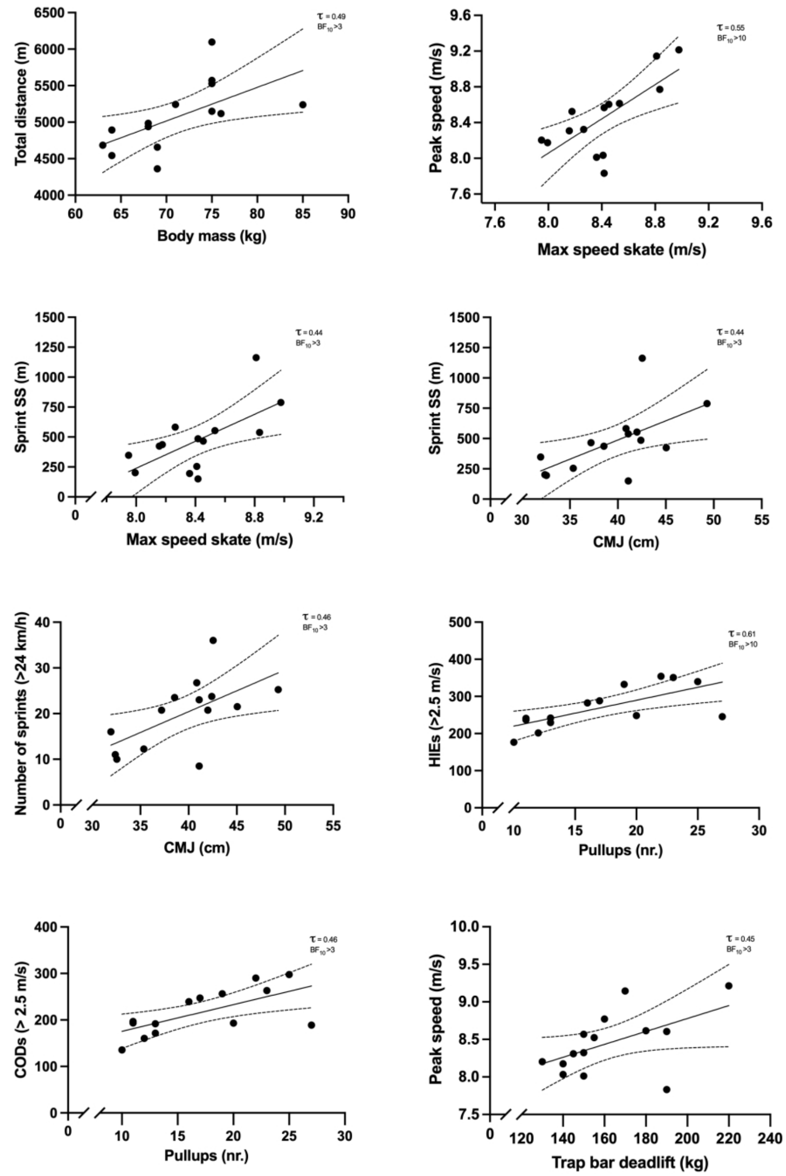
Table 3: Kendall's Tau correlation matrix, black and white version

		Sprint test - run			Sprint test - skate							
	Body mass	10-m	30-m	Max speed run	10-m	30-m	Max speed skate	CMJ	Long-jump	Bench-press	Pullups	Trap bar
TD	0,49*	-0,01	-0,17	0,18	-0,09	-0,21	0,29	0,42	0,14	0,37	0,34	0,27
Peak Speed	0,22	-0,28	-0,39	0,27	-0,13	-0,34	0,55**	0,42	0,36	0,16	0,10	0,45*
SlowSS	-0,30	0,01	0,17	-0,13	0,18	0,21	-0,29	-0,29	-0,10	-0,25	-0,17	-0,23
ModSS	-0,35	0,12	0,19	-0,24	0,11	0,28	-0,35	-0,40	-0,17	-0,25	-0,21	-0,27
HighSS	0,42	0,03	-0,12	0,09	-0,09	-0,17	0,24	0,33	0,06	0,32	0,30	0,18
SprSS	0,28	-0,21	-0,32	0,29	-0,16	-0,36	0,44*	0,44*	0,30	0,25	0,17	0,34
Nr of sprints	0,43	-0,04	-0,16	0,10	-0,21	-0,29	0,28	0,46*	0,13	0,22	0,34	0,15
Total PL	0,29	0,11	0,00	-0,08	-0,06	-0,09	0,03	0,06	-0,09	-0,10	0,38	0,10
HIEs	0,37	0,39	0,36	-0,20	0,29	0,14	-0,16	0,02	-0,17	-0,07	0,61**	-0,14
ACCs	0,27	0,22	0,33	-0,28	-0,06	-0,02	-0,17	0,03	-0,13	-0,37	0,29	-0,15
DECs	0,12	0,21	0,28	-0,40	-0,04	0,14	-0,20	-0,07	-0,25	-0,18	0,32	-0,11
CODs	0,30	0,30	0,23	-0,07	0,20	-0,03	-0,02	0,07	-0,08	0,02	0,50*	-0,02

-1,0 0,0 1,0

Kendall's Tau correlations are displayed by graded color backgrounds. *Moderate evidence for H1 (BF_{10} >3), **Strong evidence for H1 (BF_{10} >10).

CMJ: Counter movement jump height (cm), pullups (max repetitions), bench-press (1RM), trap bar: Deadlift in a trap bar, TD: Total distance, SS: Speed skating, PL: PlayerLoad^{TM} (au), HIEs: High intensity events, ACCs: Accelerations, DECs: Decelerations, CODs, Change of directions.



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