

Effects of Finnish and Canadian training models on on-ice and off-ice speed performance in U9 ice hockey players

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Abstract

Speed development is a key component of performance enhancement in youth ice hockey training systems. **PURPOSE:** The aim of this study was to compare the effects of Finnish and Canadian training models on the development of speed abilities in U9 ice hockey players. **METHODS:** Twenty-two players were evenly assigned to two performance-balanced groups that completed either the Finnish training model (n = 11) or the Canadian training model (n = 11) focused on speed development. Training effectiveness was evaluated using recommended skating tests of the Slovak Ice Hockey Federation performed on ice (36 m forward and backward, 3 × 6 m, Y test, two lengths) and off-ice running tests (30 m, 3 × 6 m, standing long jump, 200 m, Y test). Baseline and post-intervention assessments were performed. Owing to the characteristics of the data distribution, non-parametric tests of statistical significance (W, U) and effect size (r) were applied. **RESULTS:** At baseline, both groups demonstrated comparable levels of motor performance across all variables (p > .05). Following the intervention, significant improvements were observed in both groups in all on-ice skating speed tests (p < .01), reflecting the effectiveness of the applied on-ice training stimuli. Improvements were also recorded in several off-ice tests (p < .01). However, no positive changes were found in selected off-ice running tests. In the Finnish model group, performance in the 30 m and 200 m runs remained unchanged (p > .05), whereas in the Canadian model group, performance in the 200 m run significantly declined (p < .01). When comparing the magnitude of changes between groups, significantly greater improvements were observed in favor of the Canadian model across most variables (p < .01). **CONCLUSION:** Both training models proved to be effective in enhancing specific on-ice speed performance in U9 ice hockey players. However, when comparing the magnitude of performance changes, significantly greater improvements were observed in the Canadian model.

Key words: ice hockey, Finnish model, Canadian model, speed, comparison, U9

Introduction

Ice hockey is currently defined as a high-intensity intermittent activity in which skating speed, explosiveness, and the ability to rapidly change direction play a dominant role (Nightingale et al., 2016). The game is characterized by repeated short bursts of maximal or near-maximal effort interspersed with brief recovery periods, placing high demands on both anaerobic and neuromuscular capacities. In modern hockey, the requirements for speed-related abilities continue to increase due to faster gameplay, reduced time for decision-making, and higher tactical complexity, which forces practitioners to reconsider traditional training methods already in the early stages of athlete development (Vigh-Larsen & Mohr, 2024). The development of speed in the initiation category (U9) represents a critical phase, as this period is characterized by heightened sensitivity of the nervous system to speed-related stimuli and rapid development of neural pathways responsible for coordination and movement efficiency (Behm et al., 2008).

The development of skating speed in children is not solely a matter of lower limb strength but is primarily determined by neuromuscular coordination, movement efficiency, and the technical execution of skating strides (Brožáni et al., 2024; Kara et al., 2022). Efficient skating requires precise timing, balance, and coordination between muscle groups, which are best developed during early childhood. According to Bukač (2005), ice hockey skating represents a non-natural movement pattern that requires specific physiological and motor adaptation. In younger school age, which Hirtz (2007) refers to as the “golden age of motor development,” the plasticity of the central nervous system is at its highest. This allows for the effective acquisition of fundamental movement patterns, coordination skills, and frequency-based components of speed, which form the foundation for later performance development.

The Slovak hockey tradition, represented by authors such as Tvrdón (2010) and Tóth (2012), emphasizes that speed development in the U9 category should be conducted primarily through playful and engaging forms of activity, with an emphasis on short-duration maximal efforts and variability of movement tasks. Such an approach not only enhances motivation but also supports the development of creativity and adaptability in young players. Tóth (2012) further suggests that insufficient exposure to speed stimuli during this sensitive period may lead to long-term deficits in athletic performance, which is consistent with recent findings highlighting the importance of early neuromuscular development (Söker et al., 2025).

On a global scale, different methodological approaches to youth development can be identified. The Canadian model has traditionally emphasized high-intensity training and early specialization, focusing on strength-oriented skating drills, acceleration, and linear speed development (Lafontaine, 2013). This approach aims to maximize performance outcomes through structured and repeated execution of specific movement patterns. In contrast, the Finnish model, as described by Hakkarainen et al. (2014), places strong emphasis on versatility, long-term athlete development, and multi-sport participation. It promotes the development of agility, coordination, and decision-making through small-sided games and variable training environments. According to Finnish experts, this multidirectional and game-based approach enhances the adaptability and resilience of players in dynamic and unpredictable game situations (Alpini et al., 2008).

The comparison of these two methodologies provides valuable insight into how different training stimuli influence both sport-specific and general motor performance. While skating-specific training directly targets on-ice performance, off-ice training contributes to the development of general physical qualities such as strength, speed, and coordination, which can transfer to skating performance (Rice et al., 2024). Previous studies (Savinkov, 2015; Blanár et al., 2020) suggest that a balanced combination of off-ice training focused on explosive strength and a high volume of specific skating practice yields the most stable and long-term performance improvements. However, as emphasized by Balyi and Hamilton (2004) and Söker et al. (2025), it is essential to distinguish between chronological and biological age in youth training to avoid excessive training loads, premature specialization, and potential negative consequences such as burnout or injury.

In the context of Slovak ice hockey, a key challenge remains the identification of an optimal balance between general physical preparation and specific skating training. The methodology of the Slovak Ice Hockey Federation (SZLH, 2020) aims to integrate modern elements of international training systems while maintaining a structured approach to long-term athlete development. Standardized testing plays a crucial role in this process, as it enables objective monitoring of performance changes and evaluation of training effectiveness across different developmental stages.

The present study responds to the need for a direct comparison of different methodological approaches within the Slovak context. Despite the widespread use of both Finnish and Canadian training principles, there is a lack of empirical evidence comparing their effectiveness in young athletes. Therefore, the aim of this study was to analyse whether and to what extent the Finnish and Canadian training models influence speed development in U9 players. By examining both on-ice and off-ice performance changes, this study seeks to provide practical recommendations for optimizing training programs and improving long-term athlete development in youth ice hockey.

Methods

Study Design

This study employed a quasi-experimental pretest–posttest design aimed at comparing the effects of two training models focused on speed development in youth ice hockey players. Participants were evenly matched based on initial performance level and assigned in pairs to either the Finnish training model ($n = 11$) or the Canadian training model ($n = 11$), ensuring comparable baseline characteristics between groups. The design was considered quasi-experimental due to the absence of full randomization, as group allocation was based on performance matching rather than purely random assignment.

Both interventions were implemented under comparable training conditions and followed the same overall training structure. The primary independent variable was the type of training model, while dependent variables included on-ice and off-ice performance outcomes.

All participants completed the same standardized testing battery before and after the intervention period. This design allowed for the assessment of both within-group changes over time and between-group differences in training response. Although randomization was not applied, internal validity was strengthened through performance-based matching, standardized testing procedures, and consistent training conditions across both groups.

The structure and periodization of the Finnish and Canadian training models are described in detail in the Procedures section and Supplementary Material.

Participants

The sample consisted of 22 male U9 ice hockey players from the club HK Lokomotíva Nové Zámky. Players were divided into two performance-balanced groups (matched pairs) to ensure comparable baseline characteristics between the intervention groups. In the Finnish training group, the average body height was 135.0 cm and body mass 30.6 kg, while in the Canadian group, the average body height was 135.7 cm and body mass

34.1 kg. These results indicate comparable anthropometric characteristics between groups, with slightly higher body mass observed in the Canadian group. Regarding laterality, the Finnish group included predominantly left-handed players (8 left, 3 right), whereas the Canadian group showed a more balanced distribution (6 left, 5 right).

None of the participants reported any current orthopedic or neurological disorders that could affect performance or safety. All participants were fully informed about the study procedures, potential risks, and anticipated benefits. They voluntarily agreed to participate and provided written informed consent prior to data collection, in accordance with the ethical standards outlined in the Declaration of Helsinki.

Procedures

The Finnish and Canadian training models were implemented over an 8-week period, with three training sessions per week (Monday, Wednesday, and Friday), each lasting 60 minutes. The Finnish model followed a structured, drill-based approach emphasizing skating technique, edge control, and high repetition of movement patterns through powerskating exercises, relays, and coordination tasks, progressing from low to high intensity. Training sessions included two main exercise blocks with two variants each, followed by small-sided games (3 vs. 3) and a feedback phase. Exercise bouts were short (≤ 12 s) with controlled rest intervals (~ 20 s), focusing on technical precision and neuromuscular coordination.

In contrast, the Canadian model was based on a game-oriented approach utilizing 1 vs. 1 situations and small area games designed to simulate match conditions. Training emphasized decision-making, competitiveness, and reactive speed under pressure. The weekly progression involved gradually increasing task constraints (e.g., mandatory passes, use of a joker player, positional starts), thereby enhancing both cognitive and physical demands. Sessions began with movement-based games and progressed to competitive drills and game situations, maintaining high intensity with relatively longer recovery intervals.

Both models followed an identical session structure (warm-up, main part, game, feedback), but differed fundamentally in training philosophy: the Finnish model prioritized technical execution and repetition, whereas the Canadian model emphasized variability, game realism, and adaptability. A detailed description of the training protocols is provided in the Supplementary Material.

The effectiveness of both training interventions was evaluated using standardized testing procedures. All participants completed identical testing protocols before (pretest) and after (posttest) the intervention period under standardized conditions, including the same environment, equipment, and testing order to ensure comparability of results.

On-ice assessments followed the recommended diagnostic protocols of the Slovak Ice Hockey Federation (2020) and included five skating-specific tests. Forward skating over 36 m (s) assessed linear skating speed, while backward skating over 36 m (s) evaluated backward locomotion efficiency and coordination. The 3×6 m agility test (s) measured the ability to accelerate, decelerate, and rapidly change direction in short skating segments. The Y-shaped agility test (s) assessed reactive agility and directional changes in response to movement patterns. The two-length skating test (s), performed across two full rink lengths, evaluated skating speed endurance and the ability to maintain high-intensity skating over a longer distance.

Off-ice assessments included complementary running and strength tests aimed at evaluating general motor abilities. The 30 m sprint (s) measured acceleration and maximal running speed, while the 3×6 m agility run (s) assessed change-of-direction speed under running conditions. The 200 m run (s) was used as an indicator of speed endurance. A Y-shaped agility test (s) was also performed off-ice to assess reactive agility in a non-skating environment. Explosive lower-body power was evaluated using the standing broad jump (SBJ, cm), which reflects horizontal force production capacity.

All time-based variables were recorded in seconds (s), while the standing broad jump was measured in centimeters (cm). Timing of skating and running tests was performed using electronic timing gates positioned at the start and finish lines to ensure high measurement accuracy. In cases where timing gates were not available, manual timing using a handheld stopwatch was applied by experienced testers, and the best of two trials was recorded. For the standing broad jump, distance was measured using a measuring tape from the take-off line to the nearest point of contact on landing. Each participant performed two attempts in all tests, with the better result used for further analysis. Standardized verbal instructions and sufficient rest intervals between trials were provided to minimize fatigue and ensure maximal performance.

These tests are widely used in youth ice hockey to assess skating performance, agility, and explosive strength and form part of standardized diagnostic batteries in hockey performance evaluation (Farlinger et al., 2007; Bournival et al., 2023).

Data Analyses

Descriptive statistics mean and standard deviation $M(SD)$ were calculated for all variables at pretest and posttest. Baseline differences between the Finnish and Canadian groups were assessed using the Mann–Whitney U test. Within-group changes from pretest to posttest were evaluated using the Wilcoxon signed-rank test. To compare the effectiveness of the two training models, individual change scores ($\Delta = \text{Post} - \text{Pre}$) were calculated and compared between groups using the Mann–Whitney U test. Relative percentage changes were additionally computed as a supplementary analysis. Effect sizes were expressed as rank-biserial correlation and interpreted as small (0.1), medium (0.3), and large (0.5). Statistical significance was set at $p < .05$ and $p < .01$ (Cohen, 1988).

Results

Both groups demonstrated consistent improvements across all evaluated on-ice skating tests. Wilcoxon test statistics showed a narrow range of values ($W \approx 2.84\text{--}2.95$) across all variables, indicating a uniform pattern of change within both the Finnish and Canadian groups. These results were statistically significant for all tests ($p < .01$), including forward (36 m) and backward (36 m) skating, agility (3×6 m), the Y-shaped agility test, and the two-length skating test, suggesting a systematic enhancement of skating performance following the intervention.

Between-group comparisons revealed comparable results across all variables. Mann–Whitney U values ranged from 41.00 to 59.00, indicating similar distributions between the Finnish and Canadian groups at both measurement points. These differences were not statistically significant (all $p > .05$), confirming the absence of meaningful performance differences between the groups.

Overall, the findings indicate that both training models were similarly effective in improving on-ice motor performance. Although minor numerical differences were observed, these did not reach statistical significance, (tab. 1).

Table 1. On-ice motor performance (mean $\pm$ SD) before and after intervention

Test	Time	Finnish M (SD)	Canadian M (SD)	p (between groups)
36 m forward	Pre	7.08 (0.70)	7.14 (0.85)	n.s.
	Post	6.95 (0.65)**	6.87 (0.83)**	n.s.
36 m backward	Pre	10.09 (0.52)	9.96 (0.54)	n.s.
	Post	9.90 (0.56)**	9.65 (0.54)**	n.s.
3×6 m	Pre	7.10 (0.39)	7.90 (0.44)	n.s.
	Post	7.00 (0.35)**	6.84 (0.45)**	n.s.
Y test	Pre	12.37 (0.50)	12.55 (0.61)	n.s.
	Post	12.18 (0.47)**	11.98 (0.53)**	n.s.
2 lengths	Pre	19.79 (1.31)	20.70 (1.76)	n.s.
	Post	19.52 (1.18)**	19.18 (1.62)**	n.s.

Notes: ** $p < .01$ within-group change (Wilcoxon test), n.s. = non-significant difference between groups (Mann–Whitney U test).

Off-ice performance changes showed a more variable pattern across the assessed tests. In the 30 m sprint, Wilcoxon test statistics indicated no meaningful change in the Finnish group ($W = 1.12$; $p > .05$), whereas a stronger shift was observed in the Canadian group ($W \approx 2.95$), corresponding to a statistically significant improvement ($p < .01$).

Despite this, between-group comparisons revealed no significant differences, with Mann–Whitney U values ranging from approximately 46.50 to 51.50 ($p > .05$).

In the 3×6 m agility test, both groups demonstrated consistent changes, with Wilcoxon values ranging from approximately 2.13 to 2.94, indicating improvements in agility performance. These changes were statistically significant in both groups ($p < .01$), while between-group comparisons remained non-significant ($U \approx 53.00\text{--}57.00$; $p > .05$).

In contrast, the 200 m run showed a decline in performance in both groups. Wilcoxon statistics indicated no significant change in the Finnish group ($W = 0.27$; $p > .05$), whereas a substantial change was observed in the Canadian group ($W \approx 2.93$), corresponding to a significant worsening of performance ($p < .01$). However, between-group differences remained non-significant ($U \approx 35.00\text{--}51.00$; $p > .05$).

For the Y-shaped agility test, both groups showed consistent improvements, with Wilcoxon values around 2.94 and statistically significant changes ($p < .01$).

Similarly, in the standing broad jump (SBJ), both groups demonstrated improvements supported by Wilcoxon values ranging from approximately 2.45 to 2.94 ($p < .01$), indicating enhanced explosive strength. In both variables, between-group comparisons showed no significant differences (all $p > .05$).

Overall, Wilcoxon test statistics revealed a less uniform pattern of adaptation compared to on-ice performance, with meaningful improvements observed in most variables, except for the 200 m run. Mann–Whitney U values consistently indicated comparable outcomes between the Finnish and Canadian groups.

Although slightly more pronounced changes were observed in the Canadian model in selected variables, these differences did not reach statistical significance (tab. 2).

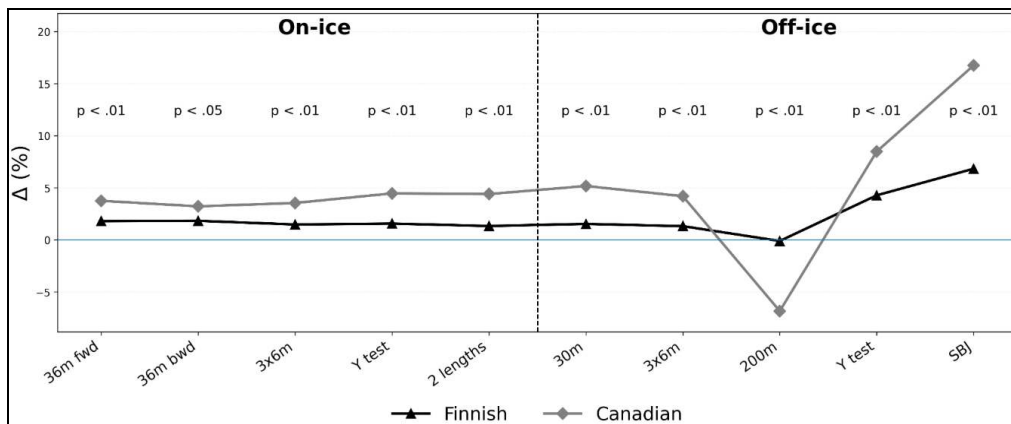
Table 2. Off-ice motor performance (mean $\pm$ SD) before and after intervention

Test	Time	Finnish M (SD)	Canadian M (SD)	p (between groups)
30 m sprint	Pre	5.10 (0.25)	5.25 (0.39)	n.s.
	Post	5.02 (0.18)	4.98 (0.38)**	n.s.
3 $\times$ 6 m	Pre	6.83 (0.79)	6.95 (0.62)	n.s.
	Post	6.73 (0.70)**	6.65 (0.57)**	n.s.
200 m	Pre	51.53 (6.97)	54.83 (10.44)	n.s.
	Post	51.64 (7.53)	58.55 (10.93)**	n.s.
Y test	Pre	11.68 (1.12)	11.63 (1.53)	n.s.
	Post	11.18 (1.60)**	10.65 (1.51)**	n.s.
Standing broad jump (SBJ)	Pre	144.45 (16.24)	137.64 (23.13)	n.s.
	Post	154.00 (17.33)**	160.00 (24.80)**	n.s.

Notes: ** $p < .01$ within-group change (Wilcoxon test) ; non-significant changes are not indicated, n.s. = non-significant difference between groups (Mann–Whitney U test).

Analysis of raw differences revealed a consistent pattern of greater changes in the Canadian model compared to the Finnish model across most variables. In on-ice tests, both models showed improvements (negative differences indicating faster times), with larger changes observed in the Canadian group (e.g., -0.27 s vs. -0.13 s in 36 m forward; -0.32 s vs. -0.18 s in 36 m backward). A similar trend was evident in agility (3 $\times$ 6 m) and Y test, as well as in the two-length skating test. In off-ice variables, the Canadian model again demonstrated larger changes, particularly in the 30 m sprint and agility test. However, in the 200 m run, both groups showed a decline in performance, with a markedly greater deterioration in the Canadian group ($+3.71$ s vs. $+0.11$ s). In contrast, the standing broad jump showed substantially greater improvement in the Canadian model ($+22.36$ cm vs. $+9.55$ cm), indicating a stronger development of explosive power. These differences were further supported by effect size estimates Rank-biserial correlation, which ranged ($r \approx 0.63$ – 0.97) as a very large effect.

These trends were consistently reflected in the percentage-based changes presented in Figure 1, which were calculated to allow a clearer comparison across variables with different units. The graphical representation closely mirrored the raw data, with the Canadian model showing greater relative improvements in most tests, particularly in off-ice variables such as the Y test and standing broad jump. Conversely, the decline in the 200 m run was more pronounced in the Canadian group. The use of percentage changes enabled a more intuitive visualization of the magnitude and direction of changes between the Finnish and Canadian models, highlighting differences that are less apparent in absolute values.

**Figure 1.** Percentage changes in motor performance variables across Finnish and Canadian training models

Discussion

The aim of the present study was to compare the effects of two training models on the development of speed-related abilities in U9 ice hockey players and to provide practical insight into early-stage training optimization. The main finding is that both the Finnish and Canadian training models led to significant improvements in skating performance. This supports the concept of high neural and motor system plasticity during early school age, often referred to as the “golden age of motor development” (Hirtz, 2007; Behm et al., 2008).

These findings are consistent with recent evidence highlighting meaningful relationships between off-ice and on-ice performance in youth hockey players. Sprint performance (30 m) and lower-body power (e.g.,

standing broad jump) have been identified as important predictors of skating speed and acceleration (Rice et al., 2024). In line with this, improvements in off-ice sprint and jumping performance in the present study were accompanied by improvements in skating performance, particularly within the Canadian model.

The observed improvements across all on-ice tests ($p < .001$) in both groups align with theoretical assumptions emphasizing the importance of specific, game-like training in early hockey development (Bukač, 2005; Tvrdón, 2010). The Canadian model showed slightly greater improvements in the two-length skating test, which may be explained by the higher intensity and volume of competitive, game-based drills typical of North American training systems (Lafontaine, 2013). These drills likely stimulate repeated maximal efforts and enhance skating speed under game-like conditions.

In contrast, the Finnish model demonstrated a more balanced adaptation profile, particularly in agility-related tasks. This finding is consistent with the Finnish training philosophy, which emphasizes multidirectional speed, coordination, and movement variability from an early age (Hakkarainen et al., 2014). Such an approach may contribute to more stable and adaptable movement patterns, which are essential in dynamic game situations. More pronounced differences between the models were observed in off-ice performance. The Canadian model led to substantial improvements in explosive lower-body power, as reflected in the standing broad jump, but was also associated with a significant decline in 200 m running performance. This pattern suggests a trade-off between anaerobic power and speed endurance, which has been previously described as a consequence of training programs focused predominantly on high-intensity, short-duration efforts without sufficient aerobic support (Tóth, 2012).

Conversely, the Finnish model showed stable performance in the 200 m run, indicating a more balanced distribution of training load. This is consistent with long-term athlete development (LTAD) principles, which emphasize versatility and gradual progression rather than early specialization (Balyi & Hamilton, 2004). This aspect is particularly relevant given the increasing trend of early specialization in youth hockey, where players accumulate high volumes of sport-specific training already between the ages of 9 and 12 (Garland et al., 2023). While such an approach may accelerate performance gains, it may also increase the risk of imbalanced development.

The present findings are also consistent with previous research demonstrating that sport-specific, on-ice training has a stronger transfer to performance than general off-ice conditioning (Nightingale et al., 2016). However, the relatively greater improvements in explosive strength observed in the Canadian group suggest that off-ice qualities still play an important supporting role in performance development.

At the same time, previous studies indicate that the relationship between on-ice and off-ice performance is not straightforward. Rocznik et al. (2024) showed that in less advanced players, off-ice power is more strongly related to skating performance, whereas in more advanced players, technical proficiency reduces this dependency. This may partially explain why greater improvements in off-ice performance in the Canadian group did not translate into significantly superior on-ice outcomes.

Similarly, Daigle et al. (2022) demonstrated that explosive strength is associated not only with skating performance but also with game-related indicators, further supporting the importance of lower-body power development. However, the complexity of performance transfer is highlighted by Williams and Grau (2020), who reported weak or inconsistent relationships between physical performance and actual game performance. This suggests that performance in team sports is multifactorial and influenced by technical, tactical, and cognitive factors beyond physical capacities alone.

Finally, it is important to note that research specifically focused on the U9 category remains limited, with most studies targeting older youth or adolescent players. Therefore, the present study contributes to a better understanding of early-stage athlete development and provides valuable insights for this underrepresented age group.

Limitations and practical implications

Several limitations of this study should be acknowledged. First, the relatively small sample size may limit the generalizability of the findings and reduce statistical power. Second, the duration of the intervention may not have been sufficient to fully capture long-term adaptations and differences between training models. Third, the quasi-experimental design without full randomization introduces the possibility of selection bias despite performance matching. Additionally, biological maturation was not controlled, which may influence performance development in this age group. Finally, the absence of game performance indicators limits the ability to directly relate physical improvements to match performance.

Despite these limitations, the findings provide important practical implications for coaching practice. The Canadian model appears highly effective for developing explosive strength and maximal skating speed, whereas the Finnish model offers a more balanced approach, particularly in maintaining endurance-related capacities. From a practical perspective, an optimal training strategy should integrate elements of both models, combining structured technical drills with game-based training, incorporating multidirectional agility and coordination exercises, and ensuring balanced development of speed, strength, and endurance. Avoiding early specialization and excessive focus on a single physical component appears crucial for supporting long-term athlete development and minimizing potential negative adaptations.

Conclusion

The present study demonstrated that both the Finnish and Canadian training models are effective approaches for developing speed-related abilities in U9 ice hockey players. A key strength of both models lies in their high specificity, which resulted in significant improvements across all on-ice skating tests ($p < .001$). While the Canadian model showed a tendency toward greater improvements in explosive power and linear speed, the Finnish model appeared more methodologically balanced, particularly in maintaining overall physical preparedness, as evidenced by stable performance in the 200 m run.

These findings confirm that targeted interventions during this sensitive developmental period can substantially accelerate motor development. However, they also highlight the risks associated with unilateral training approaches, which may lead to stagnation or even regression in certain performance domains, as observed in endurance-related measures within the Canadian model.

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