ORIGINAL ARTICLE

Enhancing spin mastery in figure skating: A longitudinal case-control study on off-ice spin board training for rotational proficiency in young skaters

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ABSTRACT

Mastering fast and stable spins is a key challenge for young figure skaters. This study tested whether off-ice training using a spin board with gyroscopic feedback could improve spin performance in skaters aged 9 to 14. Over 36 months, we followed 40 skaters from Kazakhstan and Belarus. Half of the group used the spin board in addition to regular on-ice training, while the other half followed traditional training only. Skaters who used the spin board showed better results: faster rotation speeds (1,150 vs. 950 RPM; $p < .001$), earlier spin mastery (10.8 vs. 11.6 years; $p = .04$), and higher success rates in performance tests (78% vs. 62%; $p = .002$). Participants of this study self-reported feeling more confident during training and competition. In particular this paper includes a case study of the skater Mariya Sosnovskaya, who earned a top score of 101.89 points at a national event, demonstrating that the alternative training improved real-world performance. Our findings suggest that spin board training is a safe, practical, and effective way to help young athletes tremendously improve spin skills. Furthermore, it may also support confidence and reduce injury risks, making it a valuable tool for coaches and sports professionals.

Keywords: Performance analysis, Figure skating, Off-ice training, Gyroscopic feedback, Vestibular adaptation, Youth athletes, Rotational velocity.

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INTRODUCTION

According to the International Skating Union (ISU), spins are a critical component of competitive figure skating as they account for up to 20% of technical scores in ISU events (ISU, 2024). Moreover, upright and camel spins are particularly challenging as they demand precise technique as well as sustained rotational speeds ranging from 800 to 1,200 rpm. For skaters aged 9 to 14, these demands place significant stress on their still developing vestibular and proprioceptive systems, often leading to dizziness, balance difficulties, and heightened injury risk (Sands et al., 2012). As such research is needed to provide with novel solutions that can help support these young learners develop the needed skills without overburdening them physically or psychologically.

Despite the foundational nature of on-ice training, it suffers from several constraints such as limited ice time, physically taxing nature of repetitive complex elements, and bodily overuse which increase the frequency of injuries. It has been observed that such impediments related to traditional on-ice skating delay rather than aid skill acquisition and can lower the confidence of athletes during key stages of their growth. However, with recent innovations in off-ice training most of these issues can be addressed successfully.

As is documented in the study, the use of modified spin boards that allow for resistance adjustment and equipped with gyroscopic feedback systems offer a promising solution. These hybrid spin boards enable athletes to rehearse spin mechanics safely and consistently in a controlled environment. As a result, they allow the needed vestibular adaptation and technical refinement without the risks associated with high-impact, on-ice repetitions (Nakamura & Petrov, 2022).

Notwithstanding these benefits the efficacy of these tools and techniques has not been rigorously assessed in young skaters over an extended period. It is to address that deficiency that this study has been carried out so that baseline real-world data is available to inform further research and best practices in the domain of ice skating. This study addresses the existing research gap by presenting the first longitudinal evaluation of a structured spin board training program integrated with regular practice. Instead of completely substituting traditional practice, this study suggests a supplementary approach in order to retain the recognized benefits of traditional training while minimizing the potential for damage. By examining key performance indicators like rotational velocity, spin mastery age, execution success, and psychological confidence and using objective biomechanical measures and subjective athlete reports, this study aims at improving ice staking training significantly. Furthermore, by providing reliable, multi-dimensional evidence, the research makes a strong case for incorporating off-ice spin training into standard pathways for young figure skaters.

METHODS

Study design

This study follows a longitudinal controlled design and was carried out over a 36-month period (2022 to 2025). It aimed at evaluating the long term effects and benefits of off-ice spin board training in comparison to traditional programs with regards to rotational performance in young figure skaters. The participants included a total of 40 skaters, aged 9 to 14, who were selected from two established training centres in Ust-Kamenogorsk, Kazakhstan, and Minsk, Belarus. These specific locations were chosen for their track record and comparable athlete development programs and similar training environments.

To control for confounding variables which would otherwise lead to faulty associations between dependent and independent variables, participants were matched based on age, sex, and initial skill level. The skill level

match specifically focused on their proficiency in upright, sit, as well as camel spins. On one hand, the experimental group (n = 20) incorporated 3–4 off-ice training sessions per week using the hybrid modified spin board described before set to an 8 kg resistance. On the other hand, The control group (n = 20) continued their usual on-ice routines without any additional rotational training aids.

Ethical approval and participant recruitment

The research protocol followed by this study has been approved by the Kazakh National University Ethics Committee (Approval ID: KNU-2022-001 issued on February 1 2022). Also, all study procedures conform to the ethical guidelines of the Declaration of Helsinki. In line with the stated requirements, written informed consent was obtained from all participants' parents or legal guardians, and assent was secured from the athletes themselves. Utmost care was taken to ensure that all ethical parameters were taken care of meticulously.

The study ensured that eligible participants were actively competing at or above the 1st Sports Category level (or national equivalent) and demonstrated basic technical competency in the three standard spin types mentioned before. The exclusion criteria for this study included: previous exposure to spin boards as well as any diagnosed vestibular, orthopaedic, or neurological conditions. It was ensured that all participants went through a pre-participation medical examination and completed standard vestibular screening protocols to ensure suitability for rotational training.

Outcome measures

Primary outcome

The Rotational velocity (RPM) during camel spins was measured using a Vicon motion capture system (specifically sampling at 100 Hz, with an error margin of ±0.5 RPM). The essential Data Collection occurred at four points in time: baseline, and consequently after 12, 24, and 36 months of the training (standard and modified).

Secondary outcomes

To maintain reliability of data, the Spin success rate, or the percentage of attempts achieving ≥3 full rotations, was evaluated by certified coaches using a consistent rating scale. The Intraclass Correlation Coefficient (ICC) which ranges from 0 to 1, was employed as a statistical measure to quantify the agreement between independent raters. During the study the ICC was found to be 0.90 which not just conforms inter-rater agreement but points towards "*excellent reliability*". In other words, this value (ICC = 0.90) adds to the reliability of the data since independent raters came to almost identical conclusions about participant performance.

Age of mastery: The age of mastery in this study was recorded as the age at which participants consistently met performance criteria for a technically correct camel spin.

Confidence levels: The study assessed level of confidence through semi-structured interviews and a 5-point Likert scale. These were adapted from widely-tested tools used in youth sports psychology. The participants' responses to the interviews were audio-recorded and thematically analysed to ensure a high standard of academic reliability and rigor.

Data collection and analysis

The Quantitative data collected during the study were analysed using independent t-tests as well as mixed-effects regression models. These helped track group differences over time while adjusting for key covariates

such as age, Tanner stage, and weekly training volume. On the other hand, for categorical variables such as spin success rate, Chi-square tests were used instead. The justification for the use of T-tests and mixed-effects regression in the first instance rests on the fact that they are best suited for continuous numerical data (RPM, training volume etc) as they are helpful when comparing average values between two groups which can change over time. On the other hand, Chi-square tests, which are more suited to data that is categorical were employed in this study for spin success rate which has a yes/no outcome and is hence categorical.

Missing values

The missing values in this study accounted for less than 5% of the data and were managed using multiple imputation techniques, following best-practice statistical methods. The low percentage of missing values suggests that data collection was thorough, with minimal disruptions or in gathering participant information during interviews. This complements the fact that the Interview transcripts were rigorously and carefully analysed using thematic analysis as outlined by Braun and Clarke (2006). Also, the coding was conducted by two independent researchers, who maintained an inter-coder reliability of >85%. This further points to the great care taken to ensure the accuracy and trustworthiness of qualitative insights in this study.

RESULTS

Baseline characteristics

Firstly, no significant differences between groups were observed at baseline, thus confirming effective matching (Table 1). Secondly, high adherence rates were noted during the study in both experimental and control phases; with experimental adherence of 92% and control adherence of 89%. Thirdly, the absence of spin-related injuries during modified training further underscores protocol feasibility and safety.

Table 1. Baseline demographic and training characteristics.

Characteristic	Experimental (n = 20)	Control (n = 20)	*p*-value
Age (years, mean ± SD)	10.4 ± 0.7	10.3 ± 0.6	.65
Female (%)	60%	55%	.75
Weekly Training Hours	7.2 ± 0.8	7.0 ± 0.9	.50
Baseline RPM	700 ± 50	700 ± 45	.98

Table 2. Comparative performance outcomes at 36 months.

Outcome	Experimental (n = 20)	Control (n = 20)	Statistical test
RPM at 36 months	1,150 ± 120	950 ± 130	$t(38) = 8.12$, $p < .001$
Success Rate (%)	78	62	$\chi^2(1) = 9.87$, $p = .002$
Mastery Age (years)	10.8 (95% CI 10.5–11.1)	11.6 (95% CI 11.3–11.9)	$t(38) = 4.23$, $p = .04$
Confidence Score (1–5)	4.2 ± 0.6	3.5 ± 0.7	$t(38) = 3.21$, $p = .003$

Primary and secondary outcomes

By the end of this study, the experimental group demonstrated a statistically visible and practically observable significant increase in camel spin rotational velocity (1,150 ± 120 RPM) compared to the control group which could not achieve comparable results (950 ± 130 RPM; t (38) = 8.12, $p < .001$, Cohen's d = 1.56). The study demonstrates how Spin Success Rates improved markedly (78% vs. 62%; $\chi^2(1) = 9.87$, $p = .002$), and while the age of mastery was reduced by an average of 0.8 years (10.8 vs. 11.6 years; $t(38) = 4.23$, $p = .04$) thus accelerating athletic growth and success. Additionally, the high Confidence scores reflected enhanced psychological readiness (4.2 ± 0.6 vs. 3.5 ± 0.7; $p = .003$) among the participants in the experimental group.

These results provide the tangible data to sufficiently demonstrate the efficacy of the spin board training protocol when employed for the training of young athletes in the field (Table 2).

Case study: Mariya Sosnovskaya

A key aspect of this academic study is the detailed observation of Mariya Sosnovskaya's progression which epitomizes the transformative potential of spin board training. Through a focused case study it was documented that Sosnovskaya who started her athletic journey at a spin velocity of 700 RPM and a 40% success rate at age 9, had, through the modified hybrid training suggested in this study, attained an outstanding Spin Velocity of 1200 RPM and an 80% success rate by age 11, culminating in a first-place finish at the VI Winter Spartakiad of the Republic of Kazakhstan 2025 with an outstanding score of 101.89 points. In contrast, her matched participant from the control group only achieved a spin velocity of 950 RPM, a 60% success rate, and only scored 90.00 points in the competition (Table 3). Furthermore, Qualitative interviews carried out with Sosnovskaya revealed increased spatial awareness, reduced dizziness, and heightened competitive confidence, thus confirming and supplementing the results of the quantitative analyses during the study.

Table 3. Case study comparison between Mariya Sosnovskaya and matched control.

Metric	**Age 9 (Baseline)**	**Age 11 (Post-Training)**	
RPM	700	1,200	
Success Rate (%)	40	80	
Competition Score	N/A	101.89	
Matched Control (Age 11)	**RPM**	**Success Rate (%)**	**Competition Score**
	950	60	90.00

DISCUSSION

Principal findings

This research study has successfully carried out and presented the findings of the first longitudinal study carried out to examine how off-ice spin board training with gyroscopic feedback can significantly accelerate the mastery of the camel spin in youth figure skaters. The study has collected reliable data and documented an impressive 200 RPM increase in rotational velocity as well as a significantly lower average mastery age which in turn points towards the effectiveness of the modified training in athletes' developmental progress. These gains stem from training protocol's emphasis on controlled, repetitive vestibular stimulation and motor learning while ensuring a safe and injury-free training environment that also taken into consideration young learner's psychological needs.

The competitive achievements of Sosnovskaya further support the applied value of the suggested intervention using modified spin boards to reduce the need for extensive and draining on-ice practice. The study has also furthered the cause advocated by previous research in the field and notably, effect sizes in this study exceed those reported in previous research on off-ice training modalities (Brown et al., 2020). It is also essential to mention that in addition to technical improvements, participants in the intervention group reported enhanced confidence which suggests that spin board training also contributes to building psychological resilience and performance readiness in young athletes in the field of figure skating.

Strengths and limitations

The study has demonstrated several strengths through qualitative and quantitative means which reinforce the findings. These strengths including the selection of a longitudinal design, the careful matching of

participants between the control and experimental group, high adherence to the training regimen, and the use of both objective and subjective outcome measures, especially with semi-structured interviews. The inclusion of a real-world case study offers further contextual support for the intervention's relevance to competitive performance.

However, the few limitations of this study that are inevitable, must be acknowledged. The sample size, while adequate for detecting key effects, limits the study's statistical power and future studies may work on larger sample sizes for greater validity. Also, some variation in coaching delivery, despite following the standardized protocols, is inevitable and could have influenced outcomes. Additionally, the study's regional scope due to being limited to two training centres, may contribute to reduced generalizability. Again, it is expected that future research with larger, more diverse samples across multiple training environments will address these limitation and provide more varied data.

Implications for practice and future research

The findings of this study suggest that off-ice spin board training using modified boards is a valuable supplement to conventional figure skating instruction, particularly for enhancing rotational skills in younger athletes. Further, the structured and safe format of this modified training makes it well-suited to youth development programs that aim at enhancing skill development and mastery while avoiding the risks involved with and the intense physical demands of repeated on-ice attempts during training.

In line with the findings of this study, future studies should explore the long-term effects of such training, as well as its role in injury prevention. Similarly focused research is need on the impact of this modified off-ice training on vestibular function and motor coordination. Ultimately, research across broader populations and skill levels will be essential to assess the general applicability of using off-ice training with modified spin boards and further studies are needed to refine its application in varied training environments.

CONCLUSION

The Off-ice spin board training with gyroscopic feedback, which was the main focus of this study, appears to be a promising supplement to traditional on-ice practice for young figure skaters. By supporting faster skill acquisition and greater psychological confidence on one hand, while reducing physical and psychological stress on the other, the hybrid training regime can help improve training outcomes in a safe and structured manner. The findings of this study are expected to contribute positively to growing research in support of evidence-based practices in youth sports, particularly to the highly competitive field of figure skating. However, further research will be needed to increase the generalizability and replication of this study beyond its current scope.

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No potential conflict of interest was reported by the author.

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