Comparative analysis of physical performance and educational value in artistic roller skating: a preliminary study

Análisis comparativo del rendimiento físico y el valor educativo en el patinaje artístico sobre ruedas: un estudio preliminar

Authors

Tiziana D'Isanto [1]
Serena Lambertini [1]
Pompilio Cusano [1]
Manuele Taleb [1,2]
Giuseppe Giardullo [1,2]

[1] University of Pegaso (Italy)
[2] University of Verona (Italy)

Corresponding author:
Manuele Taleb
manuele.taleb@univr.it

Received: 20-03-26
Accepted: 04-05-26

How to cite in APA

D'Isanto, T., Lambertini, S., Cusano, P., Taleb, M., & Giardullo, G. (2026). Comparative analysis of physical performance and educational value in artistic roller skating: a preliminary study. *Retos, 81*, 144-156. https://doi.org/10.47197/retos.v81.119073

Abstract

Introduction: Artistic roller skating is a complex sport discipline integrating physical, technical, expressive, and educational components. Despite its international competitive development, scientific evidence remains limited, particularly regarding studies combining objective performance indicators with perceptual and educational dimensions.
Objective: This longitudinal observational study aimed to analyze changes in physical performance parameters and educational perceptions associated with artistic roller skating in elite athletes.
Methodology: Thirty Italian athletes (15 Junior and 15 Senior; mean age 17.8 ± 3.4 years) were assessed at two different time points. Data collection included field-based motor tests evaluating core strength and endurance, lumbar and lower-limb flexibility, and an exploratory perceptual questionnaire (α = 0.81).
Results: Significant improvements emerged in several physical parameters. Junior athletes showed increases in sit-up performance, flexibility, and plank endurance ($p < 0.01$). Senior athletes demonstrated significant improvements in sit-up performance and lumbar flexibility ($p < 0.01$). Between-group analyses revealed higher plank endurance values among Senior athletes at both assessment periods. Perceptual findings highlighted a strong attribution of educational value to artistic roller skating and to the role of the coach. Significant correlations were also observed between self-discipline, stress management, and perceived personal growth ($\rho = 0.47–0.55$; $p < 0.01$).
Conclusions: Artistic roller skating appears to represent a complex formative environment in which physical performance and educational dimensions are closely interconnected. However, the findings should be interpreted within the limits of an observational exploratory design and a relatively small sample.

Keywords

Artistic roller skating; physical performance; educational value; athlete perception.

Resumen

Introducción: El patinaje artístico sobre ruedas es una disciplina deportiva compleja que integra componentes físicos, técnicos, expresivos y educativos. A pesar de su desarrollo competitivo internacional, la evidencia científica sigue siendo limitada, especialmente en estudios que combinan indicadores objetivos de rendimiento con dimensiones perceptivas y educativas.
Objetivo: Este estudio observacional longitudinal tuvo como objetivo analizar los cambios en parámetros de rendimiento físico y percepciones educativas asociadas al patinaje artístico en atletas de élite. Metodología: Treinta atletas italianos (15 Junior y 15 Senior; edad media 17,8 ± 3,4 años) fueron evaluados en dos momentos diferentes mediante pruebas motoras de campo y un cuestionario perceptivo exploratorio (α = 0,81).
Resultados: Surgieron mejoras significativas en varios parámetros físicos. Los atletas Junior mostraron incrementos en el rendimiento abdominal, flexibilidad y resistencia en plancha ($p < 0,01$). Los atletas Senior demostraron mejoras significativas en el rendimiento abdominal y la flexibilidad lumbar ($p < 0,01$). Los análisis entre grupos revelaron mayores valores de resistencia en plancha entre los atletas Senior. Los hallazgos perceptivos destacaron una fuerte atribución de valor educativo al patinaje artístico y al papel del entrenador. También se observaron correlaciones significativas entre autodisciplina, gestión del estrés y crecimiento personal percibido ($\rho = 0,47–0,55$; $p < 0,01$).
Conclusiones: El patinaje artístico parece representar un entorno formativo complejo en el que el rendimiento físico y las dimensiones educativas están estrechamente interrelacionados. Sin embargo, los hallazgos deben interpretarse dentro de los límites de un diseño observacional exploratorio y de una muestra relativamente pequeña.

Palabras clave

Patinaje artístico; rendimiento físico; valor educativo; percepción de los deportistas.

Introduction

Artistic roller skating is a highly complex technical–combinatorial discipline, characterized by the integration of acrobatic elements, postural control, expressive abilities, and choreographic construction (Piotrowski et al., 2025). Athlete performance is based on the combination of jumps, spins, step sequences, and transitions, organized into programs of increasing difficulty and evaluated on both technical and artistic–expressive levels (Pantoja et al., 2014; Vila et al., 2013). Beyond the correct execution of elements, decisive factors include skating quality, flow, stability, and the ability to interpret music and convey emotional content to both the audience and the judging panel (Rebelo et al., 2022a). In recent years, the introduction of the Roll Art judging system has made evaluation more analytical and structured, assigning specific scores to individual technical elements and to program components (Skating Skills, Transitions, Performance, Choreography) (Olmi, 2015). This approach has shifted the focus from the mere difficulty of elements to the overall quality of performance, enhancing the value of transitions, choreographic coherence, and the integration of technical and expressive aspects (Zambrano-Cervantes et al., 2021). Consequently, training organization has undergone a significant evolution, requiring increasingly targeted and interdisciplinary planning (García-Ceberino et al., 2022). Within this context, physical preparation plays a central role (Barkhoff & Heiby, 2004). The execution of multiple jumps, prolonged spins, positions characterized by large ranges of motion, and high-intensity step sequences requires adequate levels of core strength and endurance, which are fundamental for stability, balance, and spinal protection (Aliberti et al., 2021; Raiola et al., 2025). Equally essential are good flexibility of the spine and lower limbs, necessary for assuming and maintaining extreme positions (frontal and sagittal splits, back arches, spin positions), as well as the ability to sustain prolonged isometric contractions without loss of postural control (Rebelo et al., 2022b; Bongiorno et al., 2024a). Despite the high competitive level of Italian artistic roller skating and the significant results achieved internationally, the scientific literature specific to this discipline remains limited. In particular, there is a lack of studies that systematically monitor, through longitudinal designs and repeated field-based testing, the temporal evolution of conditional and functional parameters in high-level athletes, as well as their relationship with athletes' subjective perceptions of their own preparation (Esposito et al., 2019; Raiola et al., 2025; Ceruso et al., 2019). At the same time, sport is increasingly recognized as an educational as well as performance-oriented context, capable of fostering the development of self-discipline, stress management, goal-oriented behavior, and the internalization of values such as respect, responsibility, and cooperation (Esposito et al., 2025; Altavilla & Raiola, 2017).

In artistic roller skating, the expressive dimension assumes a particularly relevant role, intertwining with athletes' personal and socio-emotional growth processes (Raiola et al., 2015; Barkhoff & Heiby, 2010). However, studies systematically analyzing how high-level athletes perceive the educational role of their sport and their relationship with the coach, as well as how these perceptions relate to factors such as self-discipline, pre-competition anxiety management, and emotional regulation in everyday life, are still scarce (Barkhoff et al., 2007; Medeiros et al., 2016). In this context, the lack of objective and longitudinal data on elite athletes represents a significant limitation, both for understanding the performance demands of the discipline and for designing truly targeted training interventions. In particular, the absence of systematic monitoring of key physical capacities, integrated with the analysis of athletes' subjective perceptions, makes it difficult to evaluate the effectiveness of training pathways and their impact not only on performance, but also on well-being and per-sonal growth. In light of these considerations, an integrated approach that jointly con-siders the performance-related and educational dimensions of high-level artistic roller skating appears necessary. Within this perspective, two main levels of analysis emerge: a performance-related level, concerning the evolution of specific key physical capacities in Italian juniores and senior professional athletes over the course of a season; and an educational–perceptual level, concerning the subjective representations athletes develop regarding their preparation and the formative value of the discipline.

The aim of the present study is therefore to jointly analyze the evolution of specific physical performance parameters and the educational and formative perceptions of artistic roller skating in a group of Junior and Senior athletes.

Method

Participants

The study adopted a longitudinal design with repeated measurements, based on the comparison of athletes' physical performance at two distinct time points: October 2025 and January 2026. The testing protocol was administered once per year under the same environmental conditions and using identical operational procedures in or-der to ensure the comparability of results. The final physical sample consisted of 30 elite-level athletes, divided into two competitive categories: 15 Junior and 15 Senior athletes. Although each national team category originally consisted of 20 athletes, only 15 athletes per category were included in the longitudinal physical performance analysis, as they were the only ones who participated in both annual testing sessions. The perceptual questionnaire was administered to all 40 athletes. The mean age of the physical performance sample was 17.8 ± 3.4 years, with age distributions consistent with the competitive categories (Junior: 15.2 ± 1.3 years; Senior: 20.4 ± 2.1 years). The sample included athletes of both sexes (18 females and 12 males). Participants competed in different artistic roller skating specialties (singles and pairs) while sharing the same annual strength and conditioning program. The mean sport experience was 13.17 ± 3.56 years, with an average weekly training volume of 8.97 ± 4.43 hours. Athletes practiced different artistic roller skating specialties while following the same annual physical preparation program.

Athletes were included in the study if they met the following inclusion criteria: membership in the Italian National Artistic Roller Skating Federation; attendance at both scheduled testing sessions; regular participation in the shared physical preparation program supervised by the technical staff; and absence of functional limitations that could prevent the execution of the planned motor tests. Athletes were excluded from the analysis if they did not participate in one of the two annual assessments, presented acute or chronic musculoskeletal injuries that could compromise test execution. The research was conducted in full compliance with the ethical principles established by the Declaration of Helsinki for research involving human participants. All participants were adequately informed about the aims, procedures, and data management of the study and provided written informed consent prior to the start of the research activities; for underage athletes, consent was obtained from both parents or legal guardians. The confidentiality of per-sonal data and the anonymity of participants were ensured at all stages of the study, from data collection to analysis and presentation of the results.

Procedure

Data collection involved the administration of field-based motor tests, conducted by the National Team strength and conditioning coach, and an anonymous perceptual questionnaire specifically developed for the present study. The questionnaire was conceived as a multidimensional exploratory tool aimed at assessing athletes' subjective perceptions related to physical, educational, and emotional aspects of sports practice. The internal reliability coefficient (Cronbach's $\alpha = 0.81$) refers to the overall consistency of the instrument and not to the individual subscales, which were not formally validated. Therefore, results derived from the questionnaire should be interpreted as descriptive and associative indicators of athletes' perceptions, rather than as objective or diagnostic measurements of specific psychological constructs. The five motor tests were selected to monitor physical capacities considered determinant in artistic roller skating, such as core strength, spinal and lower-limb flexibility, and isometric endurance:

1. Sit-Up Test: the test requires performing the maximum number of correct repetitions within a time limit of 30 seconds; the score is expressed as the total number of valid repetitions and represents an indicator of dynamic strength and endurance of the core musculature.
2. Sit & Reach Test: used to assess the flexibility of the lumbar spine and the hamstring muscles; the result is expressed in centimetres and corresponds to the maximum distance reached by the fingers on the graduated scale of the apparatus.
3. Sagittal splits (right and left): lower-limb mobility was assessed through the execution of sagittal splits; the distance from the floor was measured in centimetres, with lower values indicating greater joint mobility.
4. Frontal split: frontal flexibility of the lower limbs was measured in degrees (°) using a goniometer; higher values indicate a greater degree of flexibility.

5. Plank Test: used to assess isometric core endurance; the result is expressed as the time the correct position is maintained, recorded in seconds up to a maximum of 180 seconds.

All tests were performed in the same session and were preceded by a standardized warm-up.

Subsequently, a 12-item ad hoc questionnaire was administered to the athletes, aimed at investigating:

- Perceptions of their own physical preparation (core, stretching, strength, flexibility)
- Educational and socio-emotional aspects related to sports practice
- The role of the coach as an educational figure
- The formative value of artistic roller skating

The items included 4-point Likert scales and two quantitative questions (years of practice, weekly training hours), as follows:

1. How many years have you practiced artistic roller skating? (whole years).
2. How many hours do you train on average per week? (hours/week).
3. Do you specifically train the "core"/abdominals (targeted exercises) in your routine?
4. Do you dedicate time to static stretching for the hamstrings and back (e.g., sit & reach, splits)?
5. Do you perceive yourself as having good core strength/endurance (iso-metric hold, stability)?
6. Do you perceive yourself as having good flexibility of the lower limbs and back (splits, stretching)?
7. Do you show self-discipline and consistency in following your training program (training sessions, home exercises)?
8. Do you manage pre-competition stress well (anxiety, pressure) without performance drops?
9. Does your coach also convey educational values beyond technique (respect, responsibility, cooperation)?
10. Do you believe that skating is an educational tool for young people (in addition to performance-related aspects)?
11. Do you believe that skating has taught you to better manage emotions in different life situations?
12. Do you believe that artistic roller skating promotes personal growth be-yond the technical-sporting aspect?

The choice of a 4-point Likert scale without a neutral option was motivated by the intention to reduce central tendency bias and to encourage athletes to take a clearer position regarding the proposed statements. In exploratory contexts and with small sample sizes, the absence of a neutral point helps limit ambiguous or convenience-based responses, promoting a more conscious evaluation of lived experience. This approach is particularly suitable in studies investigating perceptions related to sports practice, in which athletes possess direct and well-established experience with respect to the aspects under investigation (Bongiorno et al., 2024b).

Data analysis

Before proceeding with parametric analyses, data distribution was assessed using the Shapiro–Wilk test, which indicated an approximately normal distribution of the variables considered, thus allowing the application of the parametric statistical tests employed. To evaluate changes in athletes' physical capacities, a paired-samples t-test was used to determine whether the differences observed between the two annual measurements were significant for both the Junior and Senior categories (Aliberti et al., 2023). To compare the characteristics of the two categories within the same year, an independent-samples t-test was applied to verify the presence of physical differences between Junior and Senior athletes. Variables collected through the questionnaire were initially analyzed using descriptive statistics, with the aim of providing a clear overview of response distributions. To explore relationships among athletes' perceived dimensions (e.g., stretching, self-discipline, stress management, educational role of the

coach), correlation analyses were conducted using Spearman's rho coefficient. This choice was motivated by the ordinal nature of many questionnaire variables, making them more suitable for non-parametric analysis. Correlations with $p < 0.05$ (standard significance) and $p < 0.01$ (high significance) were considered statistically significant. Data were pro-cessed using SPSS version 27.0.

Results

Data analysis shows significant improvements in several performance parameters (Table 1). In particular, the number of sit-ups performed in 30 seconds ($p < 0.001$), spinal flexibility measured through the Sit & Reach test ($p = 0.004$), the frontal split ($p = 0.001$), and isometric endurance in the plank test ($p < 0.001$) demonstrated statistically significant increases. In contrast, right and left sagittal split measures did not show significant changes ($p > 0.05$), suggesting greater stability in these parameters. Overall, this indicates that over the course of the season, Junior athletes primarily developed core muscular endurance, lumbar and frontal flexibility, as well as an enhanced ability to maintain prolonged isometric positions.

Table 1. Physical performance parameters in the Junior category.

		Mean	SD	p	Cohen's d
Sit-Up Test (n° reps)	2025	18.9	3.2	0.000	-1.65
	2026	23.4	3.5		
Sit & Reach Test (cm)	2025	16.6	5.1	0.004	-0.87
	2026	19.6	3.9		
Sagittal splits Right(cm)	2025	5.6	6.5	0.182	0.36
	2026	4.6	5.7		
Sagittal splits left (cm)	2025	7.6	7.3	0.185	0.36
	2026	6.6	7.3		
Frontal split (°)	2025	142.0	20.4	0.001	-1.12
	2026	150.4	17.6		
Plank Test (sec)	2025	119.4	46.6	0.000	-1.26
	2026	157.0	22.1		

Among Senior athletes, significant improvements are observed in several performance parameters (Table 2). In particular, the number of sit-ups performed in 30 seconds ($p < 0.001$), the Sit & Reach test ($p = 0.004$), and the frontal split ($p < 0.001$) show statistically significant increases between 2025 and 2026. In contrast, the right sagittal split demonstrates a significant decline ($p = 0.026$), while the left sagittal split does not show significant changes ($p > 0.05$). Plank endurance also shows a mean increase in 2026; however, this improvement does not reach statistical significance ($p = 0.067$). These findings suggest that Senior athletes improved abdominal strength, lumbar flexibility, and frontal range of motion, but exhibited less progression in sagittal mobility and isometric endurance, likely due to factors related to training age and the high level of specialization of the group.

Table 2. Physical performance parameters in the Senior category.

		Mean	SD	p	Cohen's d
Sit-Up Test (n° reps)	2025	21.4	4.5	0.000	-1.29
	2026	24.9	3.8		
Sit & Reach Test (cm)	2025	18.8	5.0	0.004	-0.87
	2026	20.7	4.1		
Sagittal splits right (cm)	2025	5.5	6.3	0.026	0.64
	2026	2.9	3.4		
Sagittal splits left (cm)	2025	3.7	5.1	0.155	0.38
	2026	3.1	4.4		
Frontal split (°)	2025	148.3	16.9	0.000	-1.30
	2026	151.7	14.7		
Plank Test (sec)	2025	162.7	35.7	0.067	-0.51
	2026	174.1	14.3		

The comparison between Junior and Senior athletes, conducted using an independent-samples t-test, highlights several significant differences between the two categories (Table 3). In 2025, the variable that

most clearly differentiates the groups is isometric plank endurance (p = 0.008), with significantly higher values observed in Seniors compared to Juniors. The other parameters analyzed, namely dynamic abdominal strength, lumbar flexibility (Sit & Reach), mobility in sagittal splits, and frontal flexibility, do not show statistically significant differences, although some trends favoring Seniors emerge for left sagittal mobility (p = 0.099) and abdominal strength (p = 0.095).

In 2026, the pattern appears partially overlapping. Once again, plank endurance is confirmed as the main discriminating variable between the categories (p = 0.018), with better performance in Seniors. All other parameters do not reveal statistically significant differences, suggesting a progressive homogenization of physical performance levels between the two groups. Overall, the results indicate that Senior athletes are characterized by greater isometric core endurance, while Junior and Senior athletes are largely comparable in terms of dynamic abdominal strength and flexibility, particularly after one year of training. This trend may reflect, on the one hand, the effectiveness of training programs in reducing the gap between categories and, on the other hand, the role of experience and physical maturity in enabling Senior athletes to maintain superior muscular endurance capacities.

Table 3. Comparison of physical performance parameters between juniors and seniors.

Year	Tests performed	t	df	p	Cohen's d	95% confidence interval of the difference	
						Lower	Upper
2025	Sit-Up Test (n° reps)	-1.7	28	0.095	-0.63	-5.3	0.5
	Sit & Reach Test (cm)	-1.1	28	0.254	-0.42	-5.9	1.6
	Sagittal splits right (cm)	0.08	28	0.932	0.03	-4.6	5.0
	Sagittal splits left (cm)	1.7	28	0.099	0.62	-0.8	8.7
	Frontal split (°)	-0.9	28	0.366	-0.33	-20.3	7.7
	Plank Test (sec)	-2.8	28	0.008	-1.03	-74.3	-12.2
2026	Sit-Up Test (n° reps)	-1.0	28	0.307	-0.38	-4.2	1.4
	Sit & Reach Test (cm)	-0.7	28	0.455	-0.27	-4.1	1.9
	Sagittal splits right (cm)	0.9	28	0.337	0.35	-1.8	5.2
	Sagittal splits left (cm)	1.6	28	0.112	0.59	-0.9	8.1
	Frontal split (°)	-0.2	28	0.841	-0.07	-13.3	10.9
	Plank Test (sec)	-2.5	28	0.018	-1.03	-31.1	-3.2

With regard to qualitative and quantitative data, descriptive statistics relating to years of skating experience and hours of training are shown in Table 4.

Table 4. Descriptive statistics for training experience and weekly training volume.

Items	N	Min	Max	Mean	SD
Q1. How many years have you practiced artistic roller skating? (whole years).	40	7	23	13.1	3.5
Q2. How many hours do you train on average per week? (hours/week).	40	2.0	20.0	8.9	4.4

The frequencies and percentages of the questionnaire relating to athletes' perceptions of their own abilities and opinions on the educational/training value of skating are shown in Table 5.

Table 5. Frequency and percentage distribution of responses to the perceptual questionnaire items.

Items	Options	Frequency	%
Q3. Do you specifically train the "core"/abdominals (targeted exercises) in your routine?	1	4	10.0
	2	9	22.5
	3	24	60.0
	4	3	7.5
Q4. Do you dedicate time to static stretching for the hamstrings and back (e.g., sit & reach, splits)?	1	3	7.5
	2	20	50.0
	3	17	42.5
Q5. Do you perceive yourself as having good core strength/endurance (isometric hold, stability)?	2	9	22.5
	3	25	62.5
	4	6	15.0
Q6. Do you perceive yourself as having good flexibility of the lower limbs and back (splits, stretching)?	1	4	10.0
	2	18	45.0
	3	14	35.0
	4	4	10.0

Q7. Do you show self-discipline and consistency in following your training program (training sessions, home exercises)?	1	2	5.0
	2	6	15.0
	3	15	37.5
	4	17	42.5
Q8. Do you manage pre-competition stress well (anxiety, pressure) without performance drops?	1	4	10.0
	2	12	30.0
	3	17	42.5
	4	7	17.5
Q9. Does your coach also convey educational values beyond technique (respect, responsibility, cooperation)?	1	1	2.5
	2	1	2.5
	3	13	32.5
	4	25	62.5
Q10. Do you believe that skating is an educational tool for young people (in addition to performance-related aspects)?	3	9	22.5
	4	31	77.5
Q11. Do you believe that skating has taught you to better manage emotions in different life situations?	1	2	5.0
	2	1	2.5
	3	10	25.0
	4	27	67.5
Q12. Do you believe that artistic roller skating promotes personal growth beyond the technical-sporting aspect?	2	1	2.5
	3	8	20.0
	4	31	77.5

Spearman's correlation was used to relate the variables in the perceptual questionnaire. Significant relationships emerged between:

- A negative correlation emerged between Q4 (Stretching) and Q2 (Weekly training hours) ($\rho = -0.428$, $p < 0.01$): a greater number of training hours does not correspond to more stretching; on the contrary, athletes who train more tend to devote less time to static stretching.
- A significant positive correlation emerged between Q7 (Self-discipline) and Q4 (Stretching) ($\rho = 0.363$, $p < 0.05$); athletes who show greater self-discipline also tend to devote more time to static stretching.
- A significant positive correlation emerged between Q8 (Pre-competition stress management) and Q1 (Years of practice) ($\rho = 0.352$, $p < 0.05$): a greater number of years of practice is associated with better management of pre-competition stress and anxiety.
- A significant positive correlation emerged between Q11 (Emotion management in daily life) and Q7 (Self-discipline) ($\rho = 0.459$, $p < 0.01$): athletes with greater self-discipline perceive that skating has helped them better manage their emotions.
- A very strong positive correlation emerged between Q11 (Emotion management in daily life) and Q8 (Pre-competition stress management) ($\rho = 0.552$, $p < 0.01$): effective management of competitive anxiety is associated with a better ability to manage emotions in everyday life.
- A significant positive correlation emerged between Q11 (Emotion management in daily life) and Q9 (Coach conveys educational values) ($\rho = 0.417$, $p < 0.01$): having a coach who also transmits educational values is associated with a greater perceived ability to manage emotions in life.
- A significant positive correlation emerged between Q12 (Personal growth through skating) and Q7 (Self-discipline) ($\rho = 0.474$, $p < 0.01$): more disciplined athletes are more likely to perceive skating as a tool for personal growth.
- A significant positive correlation emerged between Q12 (Personal growth) and Q11 (Emotion management in daily life) ($\rho = 0.511$, $p < 0.01$): athletes who recognize that skating has helped them manage their emotions also tend to view it as a formative experience for personal growth.

A detailed description is shown in Table 6.

Table 6. Correlation analysis.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
Q1. How many years have you practiced artistic roller skating? (whole years).	1											

Q2. How many hours do you train on average per week? (hours/week).	-0.017	1										
Q3. Do you specifically train the "core"/abdominals (targeted exercises) in your routine?	-0.004	0.051	1									
Q4. Do you dedicate time to static stretching for the hamstrings and back (e.g., sit & reach, splits)?	0.032	-.428**	0.128	1								
Q5. Do you perceive yourself as having good core strength/endurance (isometric hold, stability)?	-0.095	0.274	-0.138	-0.141	1							
Q6. Do you perceive yourself as having good flexibility of the lower limbs and back (splits, stretching)?	-0.141	-0.286	-0.251	0.123	-0.096	1						
Q7. Do you show self-discipline and consistency in following your training program (training sessions, home exercises)?	-0.004	-0.196	-0.167	.363*	0.008	0.153	1.000					
Q8. Do you manage pre-competition stress well (anxiety, pressure) without performance drops?	.352*	-0.191	0.045	-0.047	-0.208	0.039	0.055	1				
Q9. Does your coach also convey educational values beyond technique (respect, responsibility, cooperation)?	-0.029	-0.151	0.246	0.143	0.033	0.124	0.161	0.271	1			
Q10. Do you believe that skating is an educational tool for young people (in addition to performance-related aspects)?	0.141	-0.275	0.065	0.110	-0.157	-0.145	0.164	0.242	0.217	1		
Q11. Do you believe that skating has taught you to better manage emotions in different life situations?	0.170	-0.264	-0.069	0.198	-0.028	0.294	.459**	.552**	.417**	0.249	1	
Q12. Do you believe that artistic roller skating promotes personal growth beyond the technical-sporting aspect?	0.082	-0.286	0.056	0.286	0.217	0.247	.474**	0.101	0.194	0.300	.511**	1

Discussion

The overall analysis of the results highlights how athlete development in artistic roller skating constitutes a complex and multifactorial process, in which physical, psychological, and educational dimensions interact dynamically, making an integrated interpretation of performance necessary. From a performance perspective, in the Junior category statistically significant improvements were observed between 2025 and 2026 in several functional indicators closely related to the biomechanical demands of

the discipline. In particular, core strength and dynamic endurance show a relevant in-crease, accompanied by improvements in lumbar flexibility, posterior chain flexibility, and frontal split range. Core isometric endurance also shows a significant increase, indicating a greater capacity for postural control under conditions of prolonged effort. Overall, these adaptations suggest a positive evolution of the conditional and functional capacities most involved in stability, balance, and technical execution in artistic roller skating, confirming the effectiveness of the athletic preparation program in enhancing fundamental motor qualities already in the early stages of the competitive pathway. These findings are consistent with previous literature (Yu et al., 2025; Dong et al., 2023), which emphasizes the central role of core stability and flexibility in disciplines requiring high levels of postural control and technical precision. In this perspective, the improvements observed in Junior athletes may reflect not only training effects but also early neuromuscular adaptations that facilitate the acquisition of complex motor skills, supporting a developmental trajectory aligned with models proposed in similar aesthetic sports. In the Senior category, the evolution of performance shows a partly similar trend, although less uniform across the different motor qualities analyzed. Significant increases are found in dynamic abdominal strength, lumbar flexibility, and frontal split range, whereas sagittal mobility shows greater variability. In particular, the improvement observed in the right sagittal split, compared with the stability of the left side, suggests that in more mature athletes the processes of adaptation are influenced by individual factors such as motor history, degree of specialization, and possible functional asymmetries. The comparison between Junior and Senior athletes highlights a progressive convergence in performance levels across the main physical capacities, with the exception of core isometric endurance. In both years of assessment, the plank test is significantly higher in Seniors, suggesting that experience and neuromuscular maturity contribute to a more stable consolidation of postural control and the ability to sustain prolonged muscular tension. The other parameters, although sometimes showing higher values in Seniors, do not present statistically significant differences, indicating that Junior athletes reach comparable levels after a relatively short period of structured training. This convergence may be interpreted as the result of effective training programs capable of enhancing the conditional capacities of younger athletes at an early stage and reducing the performance gap between categories, while in Seniors the need emerges for increasingly targeted and individualized interventions, consistent with the demands of highly specialized athletes.

The international literature in related disciplines, such as figure skating, supports the evidence emerging from the present study, showing that performance indicators such as strength, flexibility, and agility differ significantly according to competitive level, with Junior and Senior athletes achieving higher results than less experienced levels in the main physical tests (Sharrock et al., 2011; Slater et al., 2016). These differences can be attributed not only to increased training loads, but also to processes of neuromuscular maturation and to greater technical efficiency developed over time. Comparisons between Junior and Senior athletes in related disciplines with high technical and coordinative demands, such as artistic gymnastics, further confirm that factors related to biological maturation and competitive experience can influence the development of strength and flexibility capacities, reinforcing the interpretation of the results observed in the present study. By complementing the physical data with perceptual data, it emerges that artistic roller skating is experienced by athletes not only as a performance context but also as a broad formative environment, characterized by a strong educational and emotional component. Correlation analyses highlight that some self-regulatory dimensions, particularly self-discipline, are associated with functional behaviors related to preparation, such as regular stretching, as well as with a stronger perception of personal growth. Self-discipline therefore appears as a cross-cutting variable, capable of supporting both adherence to training practices and the construction of formative meanings attributed to the sporting experience. This interpretation aligns with the theoretical perspective proposed by Höög & Andersson (2021), according to which self-regulatory processes represent a key mechanism linking training behaviors and broader developmental outcomes. In this sense, self-discipline can be understood not only as a behavioral trait but as a mediating factor between structured practice and the internalization of educational values. Of particular interest is also the relationship between sporting experience and the management of pre-competition stress, as well as the strong link between the ability to control competitive anxiety and the perception of better emotional management in everyday life. These results suggest that competitive experience may represent a privileged context for emotional learning, in which athletes develop regulatory skills that extend beyond the sporting domain and can be applied to situations in daily life (Aliberti et al., 2025; Rogowska et al., 2022). Within this framework, the role of the coach emerges as a central element of the formative process. The perception

of receiving educational values from the coach is associated with a greater capacity for emotional management and with a stronger attribution of formative value to sport (Gorghiu et al., 2024). Descriptive data confirm this centrality, showing a high percentage of athletes who recognize the coach as an educational figure in addition to a technical one, and who consider artistic roller skating an effective tool for personal growth, self-discipline, and the management of emotions. Overall, the results outline artistic roller skating as a complex educational space in which bodily learning, emotional regulation, internalization of values, and the consolidation of functional habits are continuously intertwined (Raiola & Di Tore, 2012). Performance therefore does not emerge simply as the outcome of physical training, but as the result of a dynamic interaction between physical, psychological, and relational components. From this perspective, the holistic approach does not represent an abstract theoretical framework but rather a methodological necessity for understanding and supporting the development of elite athletes, promoting integrated training pathways capable of combining technical performance with personal growth (Asensio Castañeda et al., 2023; Ribeiro et al., 2026). From an applied perspective, the integration of physical and perceptual findings suggests the need for training programs that systematically combine the development of conditional capacities with the promotion of self-regulatory and emotional skills. In particular, the central role of self-discipline and perceived coach support highlights the importance of structuring training environments that encourage athlete autonomy, consistency, and reflective engagement with practice (D'Isanto et al., 2022). For coaches, these results underline the relevance of adopting an educational approach that goes beyond technical instruction, incorporating strategies aimed at fostering emotional regulation and personal responsibility (Giardullo et al., 2026). Consequently, coach education programs in artistic roller skating could benefit from the inclusion of pedagogical and psychological competencies, in order to better align performance objectives with athletes' holistic development.

The present study has several limitations that should be considered when interpreting the results. First, the limited sample size, related to the specificity of the elite context and the exclusive participation of national team athletes, reduces the statistical power of the analyses and requires caution in interpreting the findings. The evidence that emerged should therefore not be generalized to broader populations or to different sporting contexts but rather interpreted as indicative of trends observable within a highly selected sample. Second, the perceptual questionnaire used, although consistent with the exploratory aims of the study, has not undergone full validation. This was due to time and organizational constraints related to the longitudinal nature of the study and the limited availability of the sample. Moreover, standardized and previously validated instruments in sport psychology were not adopted, as they were not fully suited to capture the specific combination of physical and context-dependent perceptual variables characterizing the present sample; therefore, an ad hoc tool was developed. Furthermore, the absence of a control group and the observational nature of the research de-sign do not allow for causal inferences. An additional limitation concerns the multiplicity of statistical comparisons conducted, particularly in the analyses of the physical tests across years and categories. Although the statistical tests were selected consistently with the study design, corrections for multiple comparisons were not applied. Finally, the federative context and the athletes' relationship with the technical staff may have influenced the perceptual responses, introducing possible social desirability bias. The integration between the performance and educational dimensions represents one of the conceptual strengths of the study; however, the observed correlations, although statistically significant, show moderate effect sizes, suggesting the need for a cautious interpretation of the results. The perceptual variables analyzed reflect the athletes' subjective experiences and do not constitute objective measurements of educational or emotional competencies; therefore, the results describe personal representations and meanings attributed to the sporting experience, which cannot be directly equated with objective indicators of psychosocial development. Moreover, it is not possible to exclude a potential learning effect in the motor tests repeated one year apart, related to familiarization with the assessment procedures. Although the protocol was administered under standardized conditions, this aspect represents an additional factor to consider when interpreting the improvements observed. Parametric analyses were applied considering the distribution of the data and the reference literature; however, future studies could incorporate more thorough verification of normality assumptions and the use of alternative statistical approaches. Furthermore, future research should aim to validate context-specific instruments or integrate established validated scales to strengthen the robustness of perceptual measures.

Conclusions

This study proposes an integrated interpretation of artistic roller skating as an elite discipline, highlighting how performance arises from the interaction between physical, perceptual, and educational components. The results show significant improvements in several performance parameters over the two-year period analyzed, with a progressive reduction in differences between Junior and Senior athletes, except for core iso-metric endurance, which remains higher in Seniors. On the perceptual level, athletes attribute a strong educational value to artistic roller skating, recognizing sport and the relationship with the coach as a relevant context for the development of self-discipline, stress management, and personal growth. The relationships observed, although moderate in magnitude, outline a coherent framework between sporting experience and the educational dimension. Overall, the findings suggest that performance in artistic roller skating cannot be interpreted exclusively as the outcome of physical training, but rather as the product of a dynamic interaction between conditional, experiential, and educational components. From this perspective, the role of the coach and the relational context assume a central function in supporting not only athletic performance but also the athlete's personal development. Given the observational nature of the study, the limited sample size, and the use of an exploratory perceptual instrument, the results should be interpreted with caution and in associative terms. Future studies, with more controlled designs and larger samples, will be necessary to further investigate the relationships identified and to consolidate integrated models of training and education in artistic roller skating.

Financing

This research received no external funding. The authors acknowledge the Research Center of Physical Education and Exercise, University of Pegaso, and the Department of Neuroscience, Biomedicine and Movement, University of Verona, for their institutional and scientific support.

References

Aliberti S., Calandro A., Esposito G., Altavilla G., & Raiola G. (2021). Three workouts compared: interval training, intermittent training and steady state training for the improvement of VO2 max and BMI. *Sport Science and Health, 11*(2), 197–204. https://doi.org/10.7251/SSH2102197A

Aliberti S., D'Elia F., & Cherubini D. (2023). Tips for statistical tools for research methods in exercise and sport sciences. *Physical Education Theory and Methodology, 23*(3), 470–477. https://doi.org/10.17309/tmfv.2023.3.20

Aliberti S., D'Elia F., Giardullo G., & Raiola G. (2025). Agonism and performance in adolescent football players in informal physical education settings. *Frontiers in Sports and Active Living, 7*, 1511719. https://doi.org/10.3389/fspor.2025.1511719

Altavilla, G., & Raiola, G. (2017). Physiological effects of warm-up and problems related to team sports. *Sport Science*, 57-61.

Asensio Castañeda, E., Navarro, R. M., Chamorro, J. L., & Ospina-Betancurt, J. (2023). A holistic vision of the academic and sports development of elite Spanish track and field athletes. *International Journal of Environmental Research and Public Health*, *20*(6), 5153. https://doi.org/10.3390/ijerph20065153

Barkhoff H., & Heiby E.M. (2004). Differences in mood among elite athletes in artistic roller, figure, and inline speed skating before and after competition. *European Journal of Sport Science, 4*(3), 22-32. https://doi.org/10.1080/17461390400074302

Barkhoff, H., & Heiby, E. M. (2010). The relations between self-efficacy, competition success, delight, self-esteem, and body-care among elite artistic roller skaters. *Journal of Behavioral Health and Medicine, 1*(1), 43–51. https://doi.org/10.1037/h0100540

Barkhoff, H., Heiby, E. M., & Pagano, I. S. (2007). Self-regulation skills of a competitor type vs. a training champion athlete in artistic roller skating: A season long case study in elite sport competitions. *Athletic Insight: Online Journal of Sport Psychology*, *9*(2), 43-57.

Bongiorno, G., Sisti, G., Dal Mas, F., Biancuzzi, H., Varrecchia, T., Chini, G., Ranavolo, A., Pellegrini, B., Bortolan, L., & Miceli, L. (2024a). The kinematic and electromyographic analysis of roller skating

at different speeds on a treadmill: A case study. *Sensors*, *24*(17), 5738. https://doi.org/10.3390/s24175738

Bongiorno, G., Sisti, G., Biancuzzi, H., Dal Mas, F., Minisini, F. G., & Miceli, L. (2024b). Training in roller speed skating: Proposal of surface electromyography and kinematics data for educational purposes in junior and senior athletes. *Sensors*, *24*(23), 7617. https://doi.org/10.3390/s24237617

Ceruso, R., Esposito, G., & D'Elia, F. (2019). Analysis and evaluation of the qualitative aspects of the young players. *Journal of Physical Education and Sport*, *19*, 1814-1819. https://doi.org/10.7752/jpes.2019.s5266

D'Isanto, T., Altavilla, G., Esposito, G., D'Elia, F., & Raiola, G. (2022). Heuristic learning and sport: Theoretical lines and operational proposals. *Encyclopaideia, 26*(64), 69–80. https://doi.org/10.6092/issn.1825-8670/14237

Dong, K., Yu, T., & Chun, B. (2023). Effects of core training on sport-specific performance of athletes: A meta-analysis of randomized controlled trials. *Behavioral Sciences, 13*(2), 148. https://doi.org/10.3390/bs13020148

Esposito, G., Ceruso, R., & D'Elia, F. (2019). The importance of a technical-coordinative work with psychokinetic elements in the youth sectors of soccer academies. *Journal of Physical Education and Sport*, *19*, 1843-1851. https://doi.org/10.7752/jpes.2019.s5272

Esposito, G., Aliberti, S., Ceruso, R., Tessitore, A., & Raiola, G. (2025). Maximum strength development in martial arts and perception and awareness: New approach for training methods. *Frontiers in Sports and Active Living*, *7*, 1676250. https://doi.org/10.3389/fspor.2025.1676250

García-Ceberino, J. M., Feu, S., Gamero, M. G., & Villafaina, S. (2022). Creativity in recreational figure roller-skating: A pilot study on the psychological benefits in school-age girls. *International Journal of Environmental Research and Public Health, 19*(18), 11407. https://doi.org/10.3390/ijerph191811407

Giardullo, G., Ceruso, R., Di Lascio, G., Taleb, M., Esposito, G., & D'Elia, F. (2026). Comparison of traditional and ecological dynamical training approaches in Brazilian Jiu-Jitsu: Effects on force development, reactivity, and distress perception. *Frontiers in Psychology, 17*, 1794709. https://doi.org/10.3389/fpsyg.2026.1794709

Gorghiu, G., Sherborne, T., Kowalski, R., Vives-Adrián, L., & Ribeiro, S. (2024). Enhancing teachers' self-efficacy supported by coaching in the content of open schooling for sustainability. *Sustainability, 16*(22), 10131. https://doi.org/10.3390/su162210131

Höög, S., & Andersson, E. P. (2021). Sex and age-group differences in strength, jump, speed, flexibility, and endurance performances of Swedish elite gymnasts competing in TeamGym. *Frontiers in Sports and Active Living, 3*, 653503. https://doi.org/10.3389/fspor.2021.653503

Medeiros, A. R., Tonello, L., Gasparini, N., Foster, C., & Boullosa, A. D. (2016). Lowered heart rate response during competition in figure skaters with greater aerobic fitness. *International Journal of Performance Analysis in Sport*, *16*(2), 581–589. https://doi.org/10.1080/24748668.2016.11868910

Olmi, G. (2015). Failure of the chassis of roller skates for agonistic figure skating. *Case Studies in Engineering Failure Analysis, 3*, 62–67. https://doi.org/10.1016/j.csefa.2014.08.002

Pantoja, P. D., Mello, A., Liedtke, G. V., Kanitz, A. C., Cadore, E. L., Pinto, S. S., Alberton, C. L., & Kruel, L. F. (2014). Neuromuscular responses of elite skaters during different roller figure skating jumps. *Journal of Human Kinetics*, *41*, 23–32. https://doi.org/10.2478/hukin-2014-0029

Piotrowski, T., Makaruk, H., Tekień, E., Feleszko, W., Kołodziej, M., Albrecht, K., Grela, K., Makuch, R., Werner, B., & Gąsior, J. S. (2025). Fundamental movement/motor skills as an important component of physical literacy and bridge to physical activity: A scoping review. *Children, 12*(10), 1406. https://doi.org/10.3390/children12101406

Raiola, G., & Di Tore, P. A. (2012). Bodily communication skills and its incidence on female volleyball championship to enhance didactics. *Journal of Human Sport and Exercise, 7*(2), 365–375. https://doi.org/10.4100/jhse.2012.72.03

Raiola, G., Tafuri, D., & Altavilla, G. (2015). Physical activity and its relation to body and ludic expression in childhood. *Mediterranean Journal of Social Sciences, 6*, 293–296. https://doi.org/10.5901/mjss.2015.v6n3s2p293

Raiola, G., Esposito, G., Aliberti, S., & D'Elia, F. (2025). Effects on performance, perception, and awareness of plyometric training in youth volleyball: A novel methodological approach to training. *Applied Sciences, 15*(3), 1581. https://doi.org/10.3390/app15031581

Rebelo, A., Valamatos, M. J., & Tavares, F. (2022a). Anthropometric characteristics and physical qualities of artistic roller and figure skaters: A narrative review. *Science & Sports, 37*(8), 688–702. https://doi.org/10.1016/j.scispo.2021.06.007

Rebelo, A., Valamatos, M. J., Franco, S., & Tavares, F. (2022b). Physical and physiological characteristics of female artistic roller skaters based on discipline and level of expertise. *Polish Journal of Sport and Tourism, 29*(1), 30–38. https://doi.org/10.2478/pjst-2022-0006

Ribeiro, T., Maia, J., Conceição, F., Baxter-Jones, A. D. G., Guimarães, E., Vasconcelos, O., Dias, C., Santos, C., Paulo, A., Aleixo, P., Pinto, P., Teixeira, D., Massuça, L. M., & Pereira, S. (2026). EXcellence and PERformance in track and field (EXPERT)—A mixed-longitudinal study on growth, biological maturation, performance, and health in young athletes: Rationale, design, and methods (Part 1). *Journal of Functional Morphology and Kinesiology, 11*(1), 25. https://doi.org/10.3390/jfmk11010025

Rogowska, A. M., Tataruch, R., Niedźwiecki, K., & Wojciechowska-Maszkowska, B. (2022). The mediating role of self-efficacy in the relationship between approach motivational system and sports success among elite speed skating athletes and physical education students. *International Journal of Environmental Research and Public Health, 19*(5), 2899. https://doi.org/10.3390/ijerph19052899

Sharrock, C., Cropper, J., Mostad, J., Johnson, M., & Malone, T. (2011). A pilot study of core stability and athletic performance: Is there a relationship? *International Journal of Sports Physical Therapy, 6*(2), 63.

Slater, L. V., Vriner, M., Zapalo, P., Arbour, K., & Hart, J. M. (2016). Difference in agility, strength, and flexibility in competitive figure skaters based on level of expertise and skating discipline. *Journal of Strength and Conditioning Research, 30*(12), 3321–3328. https://doi.org/10.1519/JSC.0000000000001452

Vila, M. H., Abraldes, J. A., Rodríguez, N., Manchado, C., & Ferragut, C. (2013). The anthropometric profile of elite roller figure skaters. *Journal of Human Sport and Exercise, 8*(3), S633–S641. https://doi.org/10.4100/jhse.2013.8.Proc3.09

Yu, T., Xu, Y., Zhang, Z., Sun, Y., Zhong, J., & Ding, C. (2025). The impact of core training on overall athletic performance in different sports: A comprehensive meta-analysis. *BMC Sports Science, Medicine and Rehabilitation, 17*, 112. https://doi.org/10.1186/s13102-025-01159-6

Zambrano-Cervantes, A. K., Nivón-Pellón, A., & García-Pitol, J. A. (2021). Redesign of the platform for Rollart's skate, centered on the needs of Mexican athletes. *Journal of Technological Prototypes/Revista de Prototipos Tecnológicos, 7*(20), 35–44. https://doi.org/10.35429/JTP.2021.20.7.35.44

Authors and translators' details:

Tiziana D'Isanto	tizidisanto@gmail.com	Author
Serena Lambertini	serenalambertini91@gmail.com	Author
Pompilio Cusano	pompilio.cusano@unipegaso.it	Author
Manuele Taleb	manuele.taleb@univr.it	Author and Translator
Giuseppe Giardullo	giuseppe.giardullo@univr.it	Author