



Relative contribution of physical fitness determinants to skill performance in trampoline gymnastics: a multivariate analysis

Contribución relativa de los determinantes de la condición física al rendimiento técnico en la gimnasia de trampolín: un análisis multivariante

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Abstract

Introduction: Standardized physical fitness test batteries were widely used in trampoline gymnastics for evaluation and selection. However, the independent contribution of these determinants to judge-rated skill performance in youth athletes remained unclear. Therefore, this study examined the relative contribution of selected physical fitness variables using a multivariate approach.

Objective: To examine the relative contribution of selected physical fitness variables to judge-rated skill performance in youth trampoline gymnasts using a multivariate approach.

Methodology: A cross-sectional descriptive design was used. The study included 54 athletes aged 9–11 years assessed using a standardized physical fitness test battery. Skill performance was evaluated by judges and expressed as mean scores. Pearson correlation and stepwise multiple regression analyses were applied.

Results: Skill performance was associated with standing long jump ($r = 0.826$), standing vertical jump ($r = 0.887$), 20-meter sprint ($r = -0.674$), rapid trunk flexion ($r = 0.678$), kick to hold handstand ($r = 0.634$), rearward leg lifts ($r = 0.844$), rapid straight arm raises ($r = 0.702$), upper body lift ($r = 0.301$), forward trunk bend ($r = -0.512$), and backward arm–trunk angle ($r = 0.795$). The model explained 88.24% of variance, with standing vertical jump, backward arm–trunk angle, upper body lift, and sprint as key predictors.

Conclusions: Within an EGF-aligned battery, Standing long jump, Arm-Trunk angle backwards, Upper body lift, Sprint 20 meters extension provide the clearest practical indicators of judged trampoline skill performance in youth athletes. These measures can support streamlined monitoring and targeted strength–power and mobility development.

Keywords

Explosive power; flexibility; physical fitness; predictive modeling; trampoline gymnastics.

Resumen

Introducción: Las baterías estandarizadas de pruebas de condición física se han utilizado ampliamente en la gimnasia de trampolín para la evaluación y selección. Sin embargo, la contribución independiente de estos determinantes al rendimiento de las habilidades evaluadas por jueces en atletas jóvenes seguía sin estar clara. Por lo tanto, este estudio examinó la contribución relativa de variables seleccionadas de condición física mediante un enfoque multivariado. **Objetivo:** Examinar la contribución relativa de variables seleccionadas de condición física al rendimiento de habilidades evaluadas por jueces en gimnastas jóvenes de trampolín mediante un enfoque multivariado.

Metodología: Se utilizó un diseño descriptivo transversal. El estudio incluyó a 54 atletas de entre 9 y 11 años evaluados mediante una batería estandarizada de pruebas de condición física. El rendimiento de las habilidades fue evaluado por jueces y expresado como puntuaciones medias. Se aplicaron análisis de correlación de Pearson y regresión múltiple por pasos.

Resultados (resumen): El rendimiento de las habilidades mostró relaciones significativas con múltiples variables de condición física, destacando asociaciones fuertes con el salto vertical, el salto horizontal, las elevaciones rápidas de piernas hacia atrás y el ángulo brazo–tronco hacia atrás. También se observaron relaciones negativas con la carrera de 20 metros y la flexión anterior del tronco. El análisis de regresión explicó el 88.24% de la varianza, identificando como principales predictores el salto vertical, el ángulo brazo–tronco hacia atrás, la elevación del tren superior y la velocidad en 20 metros.

Conclusiones: Dentro de una batería alineada con la EGF, el salto horizontal, el ángulo brazo–tronco hacia atrás, la elevación del tren superior y la extensión en la carrera de 20 metros proporcionan los indicadores prácticos más claros del rendimiento de habilidades en trampolín evaluadas por jueces en atletas jóvenes. Estas medidas pueden apoyar el seguimiento simplificado y el desarrollo dirigido de la fuerza, potencia y movilidad.

Palabras clave

Potencia explosiva; flexibilidad; condición física; modelado predictivo; gimnasia de trampolín.

Introduction

Trampoline gymnastics is an acrobatic discipline in which athletes perform sequences of ten consecutive skills while repeatedly transforming bed deformation into vertical impulse. Athlete's strong competing performance is evaluated through a compound scoring system that joins execution quality and technical difficulty with equitable flight metrics, notably time of flight and horizontal displacement, inclusive of penalties (Fédération Internationale de Gymnastique [FIG], 2022). Because athletes must repeatedly achieve high take-off velocity while maintaining precise landing location and body alignment, trampoline performance is strongly constrained by the athlete's ability to produce force quickly, coordinate complex aerial postures, and regulate whole-body orientation across repeated stretch-shortening cycles.

From a biomechanical perspective, higher time of flight reflects greater vertical take-off velocity and an enhanced capacity to re-use elastic energy across consecutive contacts, whereas minimal horizontal displacement reflects superior control of the center of mass relative to the bed's optimal landing zone. Force- and sensor-based measurement systems have improved the feasibility of quantifying flight and landing precision time objectively in both laboratory and competition-like contexts (Ferber & Hackbarth, 2017; Ferger et al., 2019; Ferger et al., 2020; Woltmann et al., 2023). These developments reinforce that trampoline performance is simultaneously power-limited (height/flight) and control-limited (precision and posture), with execution deductions accumulating when posture, landing alignment, or temporal rhythm deterioration.

Accordingly, key physical determinants are expected to include lower-limb explosive power and reactive strength (to generate vertical impulse repeatedly), speed-strength and neuromuscular coordination (to regulate fast transitions between shapes), and sport-specific mobility/flexibility (to achieve required body positions safely and with minimal compensation) (Dyas et al., 2023; Markovic, 2007; Mayorga-Vega et al., 2014; Suchomel et al., 2016). Recent evidence in elite trampolining indicates that jump-based characteristics relate to maximal jumping performance (Dyas et al., 2023). Moreover, intervention evidence suggests that targeted strength development (e.g., isometric strength training) can increase time of flight in junior elite trampoline gymnasts (Dyas et al., 2025), supporting a plausible pathway between strength-power development and competitive flight outcomes.

It is quite difficult to transfer these observations to the development of youth in general. Young athletes exhibit great variety in biological evolution, training history, and movement ability that can influence physical test performance and its relationship to sport outcomes. Consensus endorsements in youth athletic development accentuate acted, evidence-informed advancement and vigilance against over-interpreting isolated performance tests without contextual information (Bergeron et al., 2015). Within gymnastics, talent identification research indicates that multi-dimensional profiles—including power-speed, strength, flexibility, and technical foundations—better represent developmental potential than isolated measures. The identification of talent shows that multi-dimensional profiles are much better than isolated measures. (Mkaouer et al., 2018).

A regulated physical test battery for trampoline athletes, providing a realistic and united approach for athlete screening and periodic monitoring is dictated by the Egyptian Gymnastics Federation (EGF). However, the predictive validity of specific tests is rarely quantified within the local competitive ecosystem. Furthermore, trampoline skill performance is typically evaluated by expert judges; while judging systems are structured, conspecific tastes can still vary with the weighting and reliability of judging components (Heinen & Krepela, 2016). Determining which physical tests meaningfully predict judged skill performance is therefore central to evidence-based monitoring and the prioritization of training targets.

Because common field tests are interrelated, bivariate correlations alone can misrepresent the unique contribution of a determinant. Regression-based modeling can estimate the relative contribution of multiple physical predictors simultaneously, clarify redundancy among measures, and improve interpretability for applied decision-making (Field, 2018; Hair et al., 2019; Tabachnick & Fidell, 2019).

Therefore, this study quantified (a) bivariate associations between EGF-based physical test outcomes and judged trampoline skill performance and (b) the relative contribution of these determinants using multivariate predictive models (stepwise regression) in youth trampoline gymnasts.



Research Problem

Despite the implementation of standardized physical fitness test batteries by the Egyptian Gymnastics Federation (EGF) to evaluate trampoline gymnasts, there is a lack of empirical evidence regarding the predictive value of these tests for judged skill performance in youth athletes. Current assessment practices often rely on isolated physical measures or subjective judging scores without clearly identifying which physical determinants meaningfully contribute to performance outcomes when considered simultaneously. Furthermore, the interdependence among physical fitness components may lead to inaccurate conclusions when using simple correlational analyses, limiting the effectiveness of performance evaluation and training prioritization. Therefore, there is a need to apply multivariate analytical approaches to determine the relative and unique contribution of physical fitness determinants to judged skill performance in youth trampoline gymnasts within the EGF testing framework.

Study Objectives

To address the identified gaps, the present study aimed to:

1. Examine the relationships between selected physical fitness determinants (e.g., explosive power, speed-strength, coordination, and flexibility) and judge-rated skill performance in youth trampoline gymnasts.
2. Analyze the bivariate associations between EGF-based physical fitness test outcomes and judged skill performance using Pearson's correlation coefficient.
3. Determine the relative and unique contribution of the investigated physical fitness variables in predicting skill performance through the application of multivariate regression analysis (step-wise method).
4. Identify the most influential physical determinants of trampoline skill performance, thereby providing evidence-based insights for performance monitoring, training prioritization, and talent development in youth trampoline gymnasts.

Method

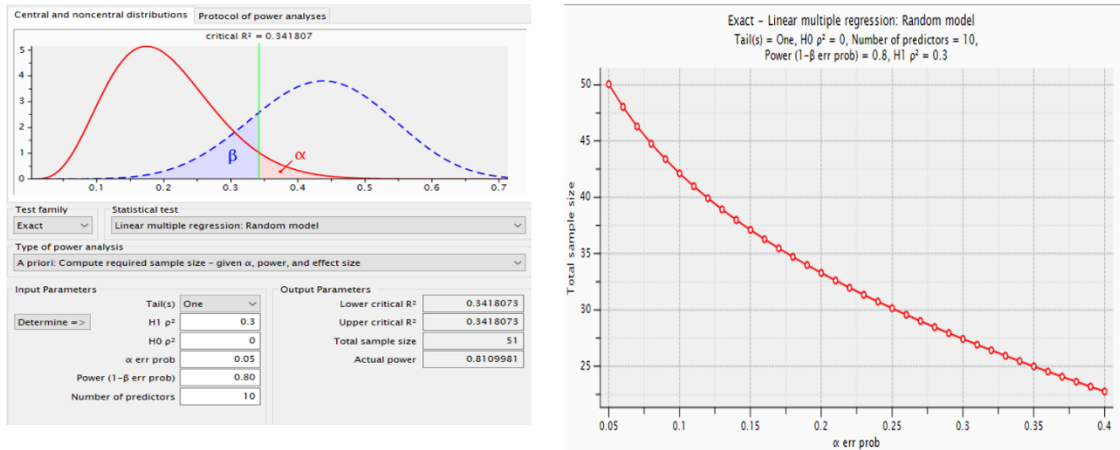
Study design

A correlational cross-sectional design was used. Physical test outcomes were treated as predictors and skill performance as the criterion outcome.

Participants

The participants comprised youth trampoline gymnasts ($n = 54$) aged 9–11 years (mean age = 10.22 ± 0.70 years), who were tested during the 2024–2025 competitive season within the Egyptian Gymnastics Federation (EGF) context. To ensure the adequacy of the sample size relative to the number of predictors, an a priori power analysis was conducted using G*Power version 3.1.9.7 (Exact test family; Linear multiple regression: Random model). The analysis assumed a medium effect size ($H1 \rho^2 = 0.30$), an alpha level of 0.05, statistical power ($1 - \beta$) of 0.80, and 10 predictors. The results indicated that the minimum required sample size was $N = 51$, with an achieved power of 0.81, exceeding the conventional threshold of 0.80 in behavioral and educational research. The critical R^2 value was 0.341, indicating adequate model sensitivity to detect the hypothesized effect size. Accordingly, the obtained sample size was considered sufficient for the planned regression analysis.

Figure 1. Sample size calculation



Procedure

Physical determinants were measured using the standardized EGF trampoline battery (Egyptian Gymnastics Federation., 2024). The battery included standing long jump, standing vertical jump, 20 m sprint, trunk and upper-body strength-endurance tasks, flexibility tests, and a skill-linked control test (kick to hold handstand). A reproducible English protocol is provided in Appendix A.

Skill performance was evaluated by a judging committee; the analysis outcome was the mean of judges' scores.

The athletes' skill performance was evaluated in accordance with the Egyptian Trampoline Gymnastics Federation Code of Points. The judging panel consisted of one Chair of Judges and six execution judges responsible for assessing performance deductions. The highest and lowest scores were excluded, and the remaining four judges' scores were computed to obtain the execution score for the routine. Subsequently, the total score of the four judges was divided by two, resulting in the final routine deduction score.

Additionally, the horizontal displacement (line deduction) was evaluated by two displacement judges. The scores provided by both judges were summed and then divided by two, yielding the final displacement deduction score.

Figure 2. Duties of Judges for Horizontal Displacement

22. DUTIES OF JUDGES FOR HORIZONTAL DISPLACEMENT

- 22.1 When the evaluation is done by judges, deduction will apply for each element when any part of the body obviously touches outside the outer line of a defined zone.
- 22.2 When the evaluation is done by judges, for the elements performed to the feet, when any part of a foot lands in a zone (obviously outside the outer line), the deduction related to this zone will be applied (see Guide of Judging - Drawings section).
 - Landing deduction of each element according to the zones on the bed 0.0 - **-0.30** pts

0.3	0.2	0.3
0.2	0.1	0.2
0.3	0.2	0.3

- 22.3 When the evaluation is done by judges, for the elements performed to front, back or seat (because a larger portion of the body touches the bed), the hip joint portion of the body touching the bed should be used to determine where the body lands.

Leg raise forward right	1.00	90.00	16.31	15.83	0.25	16.76
Upper body lift	4.00	10.00	6.89	1.73	-0.05	-0.82
Trunk bend forward	-11.00	-5.00	-8.04	1.30	0.39	0.34
Arm-Trunk angle backwards	11.00	22.00	15.85	3.15	0.22	-0.92
Skill Performance	21.00	27.00	24.20	2.27	-0.04	-1.85

It is evident from Table (1), which presents the statistical description of the research sample in the basic, physical, and skill-performance variables under investigation for the study group in both the pre- and post-measurements, that the data of the overall sample are moderate, non-scattered, and characterized by a normal distribution. The skewness values range between (-0.33 to 0.53), which are close to zero, confirming the normality and moderation of the data for the research sample.

Bivariate Analysis

Bivariate analysis was conducted to examine the relationships between individual physical fitness variables and skill performance. Pearson's correlation coefficient was used to assess the strength and direction of associations between variables. The level of statistical significance was set at $p < 0.05$. This analysis provided preliminary insight into the relationships among study variables prior to multivariate modeling.

Table 2. The Relationship Between the Physical Variables Under Investigation for the Study Group and Skill Performance

Variables	Standing long jump	Standing ver cal jump	Sprint 20 meters	V - Snaps (rapid trunk flexion)	Kick to hold handstand	Leg lifts rearward	Rapid straight arm raises	Leg raise forward left	Leg raise forward right	Upper body lift	Trunk bend forward	Arm-Trunk angle backwards	Skill Performance
Standing long jump	1												
Standing ver cal jump	0.956**	1											
Sprint 20 meters	-0.871**	-0.859**	1										
V - Snaps (rapid trunk flexion)	0.894**	0.855**	-0.936**	1									
Kick to hold handstand	0.689**	0.676**	-0.667**	0.636**	1								
Leg lifts rearward	0.953**	0.933**	-0.835**	0.863**	0.736**	1							
Rapid straight arm raises	0.901**	0.882**	-0.940**	0.955**	0.633**	0.881**	1						
Leg raise forward left	-0.041	-0.035	0.022	-0.080	-0.159	-0.074	-0.094	1					
Leg raise forward right	0.063	0.055	-0.064	0.039	-0.105	0.036	0.050	0.778**	1				
Upper body lift	0.228	0.243	-0.236	0.111	0.539**	0.248	0.093	0.126	-0.052	1			
Trunk bend forward	-0.375**	-0.467**	0.317*	-0.168	-0.467**	-0.376**	-0.193	-0.061	0.108	-0.687**	1		
Arm-Trunk angle backwards	0.642**	0.694**	-0.543**	0.457**	0.722**	0.680**	0.477**	0.088	0.059	0.695**	-0.752**	1	
Skill Performance	0.826**	0.887**	-0.674**	0.678**	0.634**	0.844**	0.702**	-0.052	0.044	0.301*	-0.512**	0.795**	1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

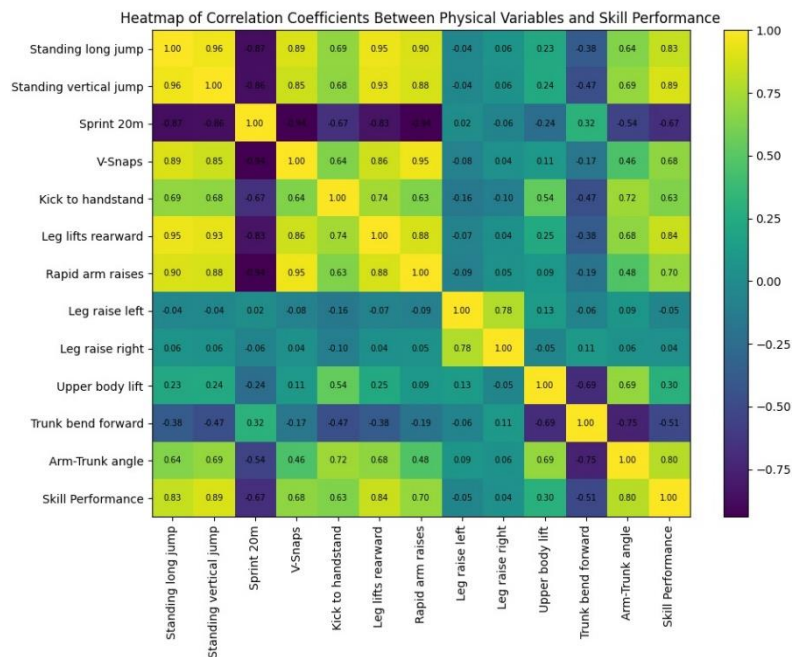


It is evident from Table (2) showing the relationship between the physical variables under investigation for the study group and skill performance that there is a statistically significant relationship between some physical variables and skill performance. The calculated (r) values ranged between (0.301 and 0.887), which are higher than the tabulated (r) values at the 0.05 and 0.01 significance levels. The results were as follows:

There is a significant positive correlation between skill performance and each of the following variables (Standing long jump, Standing vertical jump, V – Snaps (rapid trunk flexion), Kick to hold handstand, Leg lifts rearward, Rapid straight arm raises, Upper body lift, Arm-Trunk angle backwards)

There is a significant negative correlation between skill performance and each of the following variables (Sprint 20 meters, Trunk bend forward)

Figure 4. Heatmap Correlation Matrix



Multivariate Analysis

Multivariate analysis was conducted using multiple linear regression to examine the combined and independent contributions of selected physical fitness variables to skill performance in trampoline gymnastics. All physical fitness variables were entered simultaneously into a single model as predictor variables, while skill performance was treated as the dependent variable. This analysis aimed to identify the most influential predictors and to evaluate the overall explanatory power of the model. The level of statistical significance was set at $p < 0.05$. Results were interpreted based on regression coefficients and model fit. This approach allowed for the assessment of the relative contribution of each physical fitness component in predicting performance outcomes.

Table 3. Multiple Linear Regression Analysis Between Physical Variables and Skill Performance

N	Model	B	Std. Error	Beta	t	Sig.	R ² (%)	Collinearity Statistics	
								Tolerance	VIF
1	(Constant)	19.91	0.34		58.12*	0.00	78.6	1.00	1.00
	Standing long jump	0.16	0.01	0.89	13.82*	0.00			
2	(Constant)	17.10	0.68		25.26*	0.00	84.85	0.52	1.93
	Standing long jump	0.12	0.01	0.65	8.53*	0.00			
	Arm-Trunk angle backwards	0.25	0.05	0.35	4.58*	0.00		0.52	1.93
3	(Constant)	17.01	0.63		27.05*	0.00	87.2	0.41	2.46
	Standing long jump	0.10	0.01	0.53	6.73*	0.00			
	Arm-Trunk angle backwards	0.43	0.08	0.59	5.53*	0.00		0.22	4.48



	Upper body lift	-0.32	0.10	-0.24	-3.04*	0.00		0.41	2.47
	(Constant)	10.07	3.39		2.97*	0.00			
	Standing long jump	0.14	0.02	0.75	5.84*	0.00		0.15	6.83
4	Arm-Trunk angle backwards	0.38	0.08	0.53	4.88*	0.00	88.24	0.21	4.87
	Upper body lift	-0.26	0.10	-0.20	-2.50*	0.02		0.38	2.64
	Sprint 20 meters	1.47	0.71	0.21	2.08*	0.04		0.24	4.17

*The value is significant

It is evident from Table (3) related to the multiple regression analysis using the stepwise method that the contribution of these variables (Standing long jump, Arm-Trunk angle backwards, Upper body lift, Sprint 20 meters) to skill performance is 88.24%.

The results of the stepwise multiple regression analysis clearly indicate the significance of the coefficients linking physical variables to skill performance, revealing that:

- Standing long jump contributed 78.60%
- Arm-Trunk angle backwards contributed 6.24%
- Upper body lift contributed 2.36%
- Sprint 20 meters contributed 1.04%

The total contribution of these variables amounts to 88.24%.

Model Equation1

$$Y = B_0 + B_1 X_1$$

$$\text{Skill Performance} = 19.91 + 0.16 * \text{Standing long jump}$$

Model Equation2

$$Y = B_0 + B_1 X_1 + B_2 X_2$$

$$\text{Skill Performance} = 17.10 + 0.12 * \text{Standing long jump} + 0.25 * \text{Arm-Trunk angle backwards}$$

Model Equation3

$$Y = B_0 + B_1 X_1 + B_2 X_2 + B_3 X_3$$

$$\text{Skill Performance} = 17.01 + 0.10 * \text{Standing long jump} + 0.43 * \text{Arm-Trunk angle backwards} - 0.32 * \text{Upper body lift}$$

Model Equation4

$$Y = B_0 + B_1 X_1 + B_2 X_2 + B_3 X_3 + B_4 X_4$$

$$\text{Skill Performance} = 10.07 + 0.14 * \text{Standing long jump} + 0.38 * \text{Arm-Trunk angle backwards} - 0.26 * \text{Upper body lift} + 1.47 * \text{Sprint 20 meters}$$

The following table serves as a measure of the model's quality and applicability, and it is calculated from the following analysis of variance table:

Table 4. Analysis of Variance for Assessing the Quality of the Multiple Linear Regression Model

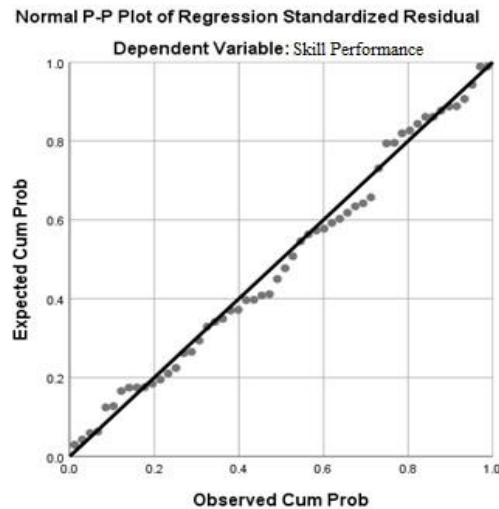
N	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	214.68	1	214.68	191.04*	0.00
	Residual	58.43	52	1.12		
	Total	273.11	53			
2	Regression	231.72	2	115.86	142.78*	0.00
	Residual	41.39	51	0.81		
	Total	273.11	53			
3	Regression	238.16	3	79.39	113.58*	0.00
	Residual	34.95	50	0.70		
	Total	273.11	53			
4	Regression	241.00	4	60.25	91.95*	0.00
	Residual	32.11	49	0.66		
	Total	273.11	53			

*The value is significant at level 0.05



It is evident from Table (4) that the multiple regression model is statistically significant, as the calculated F-value is greater than the tabulated F-value at the 0.05 significance level, with a p-value less than 0.05. This indicates a good fit of the model. From the above, it can be concluded that the model is reliable, significant, and applicable.

Figure 5. A Normal Probability Plot was presented to assess the normality of the random errors.



It is observed that most of the points are clustered close to the straight line, indicating that the random errors are normally distributed.

Discussion

This study examined how EGF-prescribed physical tests relate to judged skill performance in youth trampoline gymnasts and quantified the relative contribution of these determinants using multivariate models. The primary finding is that lower-limb explosive power—particularly standing vertical jump—explained the largest unique proportion of performance variance, while an arm–trunk extension measure contributed independently. These results support a dual requirement for successful youth trampolining: producing high vertical impulse repeatedly and maintaining the mobility/postural capacity needed to express technical shapes with minimal execution deductions.

Explosive power as the dominant determinant

Vertical jump height emerged as the strongest predictor across stepwise models. Vertical jump performance reflects the capacity to generate high concentric impulse rapidly and exploit stretch–shortening cycle behavior, qualities that are directly relevant to generating time of flight and maintaining amplitude across repeated jumps. This aligns with recent evidence in elite trampolining showing that jump-based characteristics relate to maximal jumping performance (Dyas et al., 2023). The present findings extend this rationale to a youth cohort assessed within a federation testing framework, suggesting that vertical jump ability may be a pragmatic surrogate indicator of flight potential in development settings.

Standing long jump also showed meaningful association with skill performance but contributed less unique variance once vertical jump was included, consistent with shared variance among power indicators. This suggests that, under practical constraints, a smaller number of well-chosen explosive power tests may capture most relevant information and reduce monitoring burden.

Lower-limb explosive power is considered one of the primary determinants of skill performance in trampoline gymnastics, as performance quality depends on the ability to generate high vertical impulse, enabling athletes to increase flight time and maintain jump amplitude across repeated actions. Standing jump tests—both horizontal and vertical—reflect neuromuscular efficiency in rapid force production,

which is directly aligned with the performance demands of trampolining. In this context, recent literature indicates that the development of strength and power through diverse training interventions significantly enhances multidimensional athletic performance by improving force output and motor coordination (Varghese et al., 2026). These findings further emphasize that performance does not rely on a single variable but rather on the synergistic integration of multiple physical capacities, thereby supporting the inclusion of explosive power indicators within multivariate predictive models.

Mobility and postural capacity: the role of arm–trunk extension

Arm–trunk extension contributed independently to predicting skill performance. Trampoline routines require repeated transitions between shapes, and technical execution is judged partly on line, shape, and stability. Adequate spinal and shoulder extension may facilitate straighter body lines and more consistent arm positions during take-off and flight, potentially reducing execution deductions. Gymnastics training is distinguished by high flexibility demands—particularly in the spine and shoulder complex—and these demands influence both performance expression and injury risk management (Sands et al., 2016).

Flexibility is considered a fundamental component of physical fitness in gymnastics, as it directly influences the quality of technical performance and the reduction of execution deductions. Tests such as leg raises, trunk flexion, and the arm–trunk angle reflect the athlete’s ability to achieve optimal body positions during performance. The literature indicates that flexibility is closely associated with physical performance, contributing to improved movement efficiency and reducing mechanical constraints that may hinder technical execution (Redondo Reynoso et al., 2026). Moreover, flexibility is linked to balance and motor coordination, making it an integrative component within the overall skill performance system, particularly in sports that require high movement precision such as trampoline gymnastics.

Core musculature also plays a pivotal role in achieving dynamic stability and controlling body positions during trampoline performance, as it serves as the functional link between the upper and lower extremities. Tests such as V-Snaps and upper body lifts reflect the strength and muscular endurance of the trunk, which contribute to more efficient force transfer and enhanced control during take-off, flight, and landing phases. The literature supports this perspective, emphasizing that athletic performance relies on the integration of muscular strength and neuromuscular coordination, and that improvements in these capacities lead to significant enhancements in skill execution (Varghese et al., 2026). Furthermore, core control represents a key element of balance and coordination, both of which are closely associated with complex motor performance (Efastri et al., 2026).

Speed/control measures and the sprint–performance relationship

Sprint time was negatively associated with judged skill performance in bivariate analyses, but its independent contribution was smaller than explosive power and mobility measures. Sprint performance may reflect general neuromuscular function and coordination; however, in youth samples it is also influenced by maturation and training exposure. Because the outcome here was a judged skill score (not an isolated time-of-flight metric), speed may contribute indirectly through rhythm regulation and movement consistency rather than through flight height alone. Future research should incorporate maturation indicators and analyze objective competition sub-scores separately from judged execution.

Speed represents an important indicator of neuromuscular efficiency and the athlete’s ability to produce rapid and coordinated motor responses. Although trampoline gymnastics does not directly require running, speed is associated with critical factors such as motor coordination, rhythm regulation, and reaction time, all of which indirectly influence the quality of skill performance. Previous studies have shown that performance in speed tests is affected by physical characteristics such as body composition, with higher body mass index being associated with lower performance in speed and endurance tasks (Redondo Reynoso et al., 2026). In addition, evidence suggests that speed is part of an integrated physical preparedness system that includes balance and coordination, both of which are essential for complex motor control (Efastri et al., 2026). Therefore, the role of speed in trampoline gymnastics is better understood within an integrative framework that links it with other components of performance.

Judged performance, measurement considerations, and model interpretation



Skill performance was evaluated by a judging panel, enhancing ecological validity. Prior work indicates that trampoline competition outcomes integrate multiple sub-scores and that judging variables can differ by age and competition context (Heinen & Krepela, 2016). Future federation-based studies should report and monitor judging reliability (e.g., inter-rater agreement). Additionally, stepwise procedures can overfit in small samples and are sensitive to correlated predictors; therefore, future work should apply cross-validation and consider regularized regression approaches when sample sizes permit.

Practical implications

These findings support prioritizing a compact monitoring set centered on explosive jump capacity (standing vertical jump) and a targeted mobility/posture indicator (arm–trunk extension). Training interventions should follow youth development guidance: progressive strength and power development, appropriately dosed plyometric exposure, and systematic mobility work integrated with technical practice (Bergeron et al., 2015; Faigenbaum et al., 2009).

Limitations and future directions

This study is correlational and cross-sectional; causal inference is limited. The sample reflects a specific developmental and scoring context, and results may not generalize to other ages or performance levels. Anthropometric and maturation variables were not modeled, and objective competition sub-scores were not analyzed separately. Future research should use longitudinal designs, integrate maturation and training history, and test whether targeted strength–power development produces improvements in both objective flight metrics and judged execution in youth trampoline gymnasts.

Contemporary evidence underscores that physical fitness determinants do not operate in isolation but rather interact synergistically to influence sport-specific skill performance, particularly in disciplines requiring high levels of neuromuscular coordination and movement precision such as trampoline gymnastics. In this context, Ricart-Luna et al. (2025) demonstrated that both weightlifting and plyometric training interventions implemented over a short-term mesocycle elicited significant improvements in key physical attributes, including muscular strength, lower-limb power, joint mobility, and running performance. Notably, the absence of clear superiority between training modalities suggests that performance enhancement is underpinned by a multidimensional integration of physical capacities rather than reliance on a single dominant factor.

This integrative perspective is further supported by evidence emphasizing the effectiveness of structured plyometric training in enhancing key physical qualities across different sports contexts. For instance, progressive plyometric training has been shown to significantly improve sprint performance and flexibility, reflecting enhanced neuromuscular efficiency and mechanical output (Rihatno et al., 2026). Similarly, previous research has confirmed that plyometric-based interventions contribute to improvements in speed, explosive power, and movement efficiency, which are critical components underlying skill execution in dynamic sport environments (Ramirez-Campillo et al., 2022). Collectively, these findings reinforce the premise that skill execution in complex motor tasks is contingent upon the relative contribution of multiple physical fitness components.

Accordingly, the application of multivariate predictive models provides a robust analytical framework to disentangle these interrelationships and quantify the relative contribution of each determinant to skill performance. Such approaches allow for a more precise understanding of how strength, power, flexibility, and coordination collectively influence performance outcomes, which is particularly relevant for trampoline gymnastics where optimal motor control and biomechanical efficiency are essential.

The current findings, supported by the scientific literature, indicate that skill performance in trampoline gymnastics is the result of a complex interaction among several physical determinants, including explosive strength, speed, trunk strength, balance, and flexibility. These variables do not operate in isolation; rather, they integrate within a dynamic system that directly affects performance quality. This perspective aligns with evidence emphasizing that enhancing athletic performance relies on multidimensional development of physical capacities, rather than on a single dominant variable (Varghese et al., 2026; Efastri et al., 2026). From this standpoint, multivariable predictive models provide an advanced analytical framework for understanding the relative contribution of each factor, thereby guiding training programs toward more precise and effective performance improvement.

Conclusions

The findings indicated that skill performance in youth trampoline gymnastics was predominantly influenced by the athlete's ability to efficiently generate explosive force while maintaining postural control during dynamic execution. Performance was not dependent on isolated physical attributes but reflected the combined effect of multiple interacting physical determinants.

The results also highlighted that variables related to trunk control and mobility played a meaningful role when analyzed within a multivariate context, suggesting their contribution to performance stability and execution quality under competitive conditions.

Furthermore, the applied analytical approach demonstrated that not all components of standard physical test batteries contribute equally to performance prediction, emphasizing the importance of prioritizing the most informative variables to improve assessment efficiency.

From a practical perspective, these findings support the development of targeted training programs that integrate explosive strength with control-oriented and mobility-focused exercises to enhance overall skill performance.

Future research should examine these relationships using longitudinal designs and explore how training interventions may modify the contribution of physical determinants across different stages of athlete development.

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