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FOREWORD

It is our great pleasure to welcome you to the 1st Smarter Gymnastics Conference, held in conjunction with the 2026 European Gymnastics Championships in Zagreb, Croatia. As the inaugural edition of the conference, this event represents an important milestone in strengthening the connection between scientific research and gymnastics practice. Bringing together researchers, coaches, judges, athletes, educators, and other gymnastics professionals alongside one of Europe's most prestigious gymnastics events provides a unique opportunity to exchange knowledge, share experiences, and foster collaboration between science and practice.

The vision behind the Smarter Gymnastics Conference is to promote evidence-based practice and encourage interdisciplinary collaboration in gymnastics. Modern gymnastics increasingly relies on scientific knowledge to optimize athlete development and performance, improve judging systems, enhance coach education, prevent injuries, and safeguard athletes' physical and mental well-being. At the same time, practical experience continues to inspire new research questions and innovative solutions. The conference therefore aims to serve as a meeting point where science and practice complement one another, contributing to the sustainable development of gymnastics at all levels.

We are delighted by the strong international response to the first edition of the conference. A total of 38 contributions from 12 European countries have been accepted for presentation. The scientific programme reflects the multidisciplinary nature of contemporary gymnastics, bringing together original scientific studies, professional papers, systematic and narrative reviews, bibliometric analyses, and philosophical perspectives. The accepted contributions cover a broad spectrum of topics, including motor learning and skill acquisition, coaching and leadership, sports psychology and mental health, biomechanics and performance analysis, judging and the Code of Points, athlete growth and development, injury prevention, physical preparation, gymnastics education, digital technologies, and the broader societal impact of gymnastics. Together, these contributions demonstrate the diversity, quality, and growing scope of contemporary gymnastics research and professional practice.

The conference is particularly significant because it is organized alongside the European Gymnastics Championships, providing participants with a unique opportunity not only to discuss the latest scientific findings but also to observe elite international gymnastics at the highest level. We believe that this close interaction between research and high-performance sport will stimulate new ideas, inspire future collaborations, and further strengthen the role of science in the continued advancement of gymnastics.

We would like to express our sincere gratitude to all authors for sharing their work and contributing to the success of this inaugural conference. We also thank the members of the Scientific Committee for their careful review of the submitted



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SMARTER GYMNASTICS

abstracts, the Organizing Committee and volunteers for their dedication and commitment, and all partners whose support has made this event possible. Our special appreciation goes to European Gymnastics for recognizing the importance of scientific exchange and supporting the organization of the first Smarter Gymnastics Conference alongside one of its flagship championships.

We hope that the Smarter Gymnastics Conference will become a lasting tradition and an internationally recognized forum for presenting innovative research, exchanging professional experiences, and strengthening collaboration between researchers and practitioners. May this first edition serve as the foundation for many future conferences that will continue to advance gymnastics through knowledge, innovation, and cooperation.

We wish all participants an inspiring conference, fruitful discussions, and a pleasant stay in Zagreb.

Editors



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INVITED LECTURE

ARE CURRENT GYMNASTICS TRAINING PRACTICES ALIGNED WITH CONTEMPORARY SCIENTIFIC EVIDENCE?

Flavio Bessi

University of Freiburg, Institute of Sport and Sport Science, Freiburg, Germany

Coaching traditions in artistic gymnastics are often based on long-established practices that have been passed on over generations. However, advances in sport science challenge several commonly accepted training methods and coaching beliefs. This presentation aims to compare current coaching practices with contemporary scientific evidence and to identify practical implications for coaches working in artistic gymnastics. The presentation is based on a narrative review of current literature from sport science, biomechanics, motor learning, and coaching research. Scientific findings are integrated with practical coaching experience to critically examine four key areas of gymnastics training: flexibility development, maximal strength training, and biomechanical misconceptions related to rotational movements during skill acquisition. Current evidence suggests that active and combined stretching methods provide advantages over traditional passive static stretching for gymnastics-specific flexibility development. Furthermore, maximal strength training with relatively high loads and low repetitions appears to be more effective for improving relative strength and neural adaptations than traditional high-repetition approaches. Finally, biomechanical analyses demonstrate that several widespread coaching cues regarding rotational movements are inconsistent with the principles of angular momentum conservation. Bridging the gap between scientific evidence and coaching practice offers considerable potential to improve training effectiveness in artistic gymnastics. Coaches are encouraged to critically evaluate traditional methods and adopt evidence-informed approaches to flexibility training, strength development, biomechanical instruction, and communication in order to optimize athletic performance and long-term development.



INVITED LECTURE

MENS SANA IN CORPORE SANO: PAST, PRESENT, AND FUTURE

Professor Emeritus Ivan Čuk

Faculty of Sport, University of Ljubljana, Slovenia

Physical culture has old history. It is not known exact date when humans started to work out with the purpose, to become more physical fit, but according to the museum artefacts we can presume some time span when some activities were held. Physical culture has three important parts, education, competitions and recreation. Physical education can be defined as education to start with physical culture activities. Hunting, combating were the most important physical activities at the humans beginning as food source was rare. It is essential when you are trying to use spears, arrows and bows or some similar arms to pass certain training. For farming no extra training was needed, it was more form of everyday activity. With domesticating animals, e.g. horses, new ways of commuting required new knowledge, which was not easy to obtain without planned training. Combined activity, horse riding and combat skills at the same time required another level of training. Already ancient Egyptians, Greeks or Romans had programs of soldiers' education. Part of army education were also dueling, where competitiveness was included. During ancient Olympic games athletes were mostly soldiers. Enlighted teacher brought into our region also physical education, according to Roman citizen Juvenil moto Mens Sana in Corpore Sano. In last two centuries many living aspects changed dramatically. Less working time, less poverty, less illness, more safety at work, systematic education for all, including girls, are only few to mention. Gymnastics is an activity, a fundamental activity of physical culture, most developed, so today everybody can access it. It is important to emphasis, gymnastics is universal activity for all ages, genders and professions. Part of gymnastics is also sport, but only in part where competitions under certain rules are held. Gymnastics is ideal content of physical education. And where gymnastics should be headed towards future to maintain leading role in physical culture?



REVIEW ABSTRACT

MAPPING THE SCIENTIFIC DEVELOPMENT OF GYMNASTICS RESEARCH: A BIBLIOMETRIC ANALYSIS OF THE SCIENCE OF GYMNASTICS JOURNAL AND INTERNATIONAL DATABASE EVIDENCE

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Introduction / Purpose

The Science of Gymnastics Journal has become one of the most important specialized platforms for gymnastics research. However, its scientific development, thematic structure, citation base, and international collaboration patterns have not been sufficiently examined as a separate bibliometric corpus. Therefore, the purpose of this study was to analyze the publication output, dominant research themes, authorship patterns, collaboration networks, and citation structure of the Science of Gymnastics Journal from 2009 to 2026.

Methods

A bibliometric and scientometric study design was applied. The final corpus included 426 original scientific articles published across 50 issues of the journal from Vol. 1, Issue 1 in 2009 to Vol. 18, Issue 2 in 2026. Data were collected from the official journal archive and, where available, cross-checked with Web of Science Core Collection, Scopus, and InCites. The analysis included descriptive statistics, author and country productivity, co-authorship networks, keyword normalization, reference analysis, and thematic heat maps across three periods: 2009–2014, 2015–2020, and 2021–2026.

Results

The journal published an average of 8.44 articles per issue, with 3.29 authors per paper and 14,750 cited references. The most stable research areas were artistic gymnastics, apparatus-specific performance, biomechanics, judging, training methodology, and injury prevention. Over time, the thematic profile expanded toward rhythmic gymnastics, trampoline, acrobatics, Gymnastics for All, youth development, health, nutrition, psychology, technology, and inclusive topics. The most productive countries were Brazil, Greece, Slovenia, Germany, Spain, Portugal, and the United States, confirming the journal's broad international profile.



Conclusions

The findings show that the Science of Gymnastics Journal has developed into a stable, internationally visible, and thematically diverse platform for gymnastics scholarship. Its evolution reflects a shift from predominantly technical and apparatus-based studies toward a broader multidisciplinary research profile relevant to sport science, coaching, education, health, and gymnastics practice.

Keywords: *gymnastics, bibliometrics, citation analysis, co-authorship, research trends, sport science*

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References

- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W.M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296.
- Pritchard, A. (1969). Statistical bibliography or bibliometrics? *Journal of Documentation*, 25(4), 348–349.
- Cobo, M.J., López-Herrera, A.G., Herrera-Viedma, E., & Herrera, F. (2011). Science mapping software tools. *Journal of the American Society for Information Science and Technology*, 62(7), 1382–1402.



PROFESSIONAL ABSTRACT

TRAINING METHODS AND PRACTICAL APPLICATION OF ATHLETICS-BASED CONTENT IN THE AEROBIC TRAINING OF YOUNG FEMALE GYMNASTS

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Introduction / Purpose

Successful execution and refinement of elements in artistic gymnastics, as well as their harmonious integration into sequences, for example in floor routines, require hours of continuous repetition of highly complex and demanding elements on the apparatus. During such intensive training, several problems frequently arise, particularly among young female gymnasts (aged 7–14), including boredom, rapid onset of fatigue, and declining concentration over the course of training, especially toward the end of a session, which directly increases the risk of falls and injuries. Although artistic gymnastics is primarily classified as an anaerobic sport dominated by explosive power and strength, such a high training volume (3–5 hours per session) requires a stable aerobic base. Well-developed aerobic capacity is essential for accelerating the removal of metabolic by-products, facilitating faster replenishment of energy stores, and sustaining concentration and accuracy of performance over time. Consequently, it enables young female gymnasts to better tolerate prolonged training sessions, recover more efficiently between sets of repetitive exercises, develop greater confidence in their performance, and indirectly reduce the risk of injury.

Methods

Prolonged, monotonous running is not recommended in gymnastics; therefore, this paper proposes alternative forms of aerobic training designed to be engaging and gymnastics-specific through the use of content drawn from the queen of sports - athletics. The integration of specific athletics-based content (running drills, extensive interval training, and fartlek) is adapted to the different phases of gymnasts' conditioning. Practical solutions and guidelines for everyday training practice are also provided.



Conclusions

Systematic and appropriately dosed aerobic training that incorporates athletics-based content does not impair gymnastics-specific abilities (speed and take-off power); rather, it provides a foundation for achieving peak competitive form, accelerates recovery processes, and contributes to the long-term health of athletes.

Keywords: *artistic gymnastics, aerobic base, running drills, youth categories, training periodisation*

References

- Ma, D., Silva, R.M., Xu, Q., Wang, K., Zhao, Z. (2024). Jumping Interval Training: An Effective Training Method for Enhancing Anaerobic, Aerobic, and Jumping Performances in Aerobic Gymnastics. *Journal of Sports Science and Medicine*, 23(2):410-417. doi: 10.52082/jssm.2024.410.
- Sands, W. A. (2002). Injury Prevention in Women's Gymnastics. *Sports Medicine*, 32(7), 425–438.



ORIGINAL SCIENTIFIC ABSTRACT

MENTAL HEALTH LITERACY AND EATING DISORDERS IN GYMNASTICS: ARE COACHES READY TO HELP?

Renata Barić

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Introduction / Purpose

This constant performance pressure in athletes can negatively impact their physical and mental health. One of the serious threats is eating disorders (ED), which occur in 6-45% of athletes. Gymnastics as an aesthetic sport is a high-risk sport for developing ED, especially among adolescent girls, but these negative aspects of sports remain a taboo subject that is rarely discussed. Coaches can be risk factors for developing such issues, mainly due to limited knowledge and experience, as well as concerns and comments about athletes' appearance linked to performance. To prevent this, it's important to assess their mental health literacy (MHL) and understanding of the specific symptoms and dynamic of ED that are particularly resistant to improvement and recovery in athletes. The aim was to investigate how much gymnastics coaches know about ED and how gender, age, education, coaching experience as former athletes, athletes' performance level, and their MHL contribute to that knowledge. We also examined coaches' experience with ED and risk factors for developing it in gymnastics, and their competencies in recognizing symptoms or taking actions when a problem is identified.

Methods

We applied a Croatian version of MHL scale (O'Connor & Casey, 2015) and knowledge about ED (Turk et al., 2015) on the sample of 35 male and 30 female coaches, and we made a 20 in depth interviews to get a deeper insight to coaches competences and experience with ED.

Results

Hierarchical regression analysis showed that female gender ($\beta = .40$) and MHL ($\beta = .33$) significantly explained 42.8% of coaches' knowledge about ED. Conversely, the coaches' competitive level as athletes, the quality level of the athletes they train, age, and education level did not emerge as significant predictors. Coaches' knowledge about ED was 60%. Turk et al. (2015) note that for results below 70%, further education is necessary. Interviews showed that coaches mainly associate ED with anorexia and weight loss, leading to decreased energy and performance. No formal protocols exist; they rely on colleagues, parents, and specialists. They lack awareness of risk factors, citing gender, puberty, social media, and low self-esteem, but also appearance and comments from peers; aesthetic element of sport, and coach's behavior. All agree that there is ideal body type for gymnastics is slim, slender or muscular, with lower body weight, seen as important for performance and injury prevention. Coaches rate their ability to recognize ED as moderate and reject drugs and strict dieting for BMI regulation. 77% have personal experience with ED, indicating possible transmission of risky behaviors and values to athletes.



Conclusions

Results indicate the importance of additional education for coaches about mental health and specific mental disorders as ED in aesthetic sports that is the strongest prevention measure. Also, clearly defined protocol for action when an ED occurs, with a clear division of steps and responsibilities at different levels, is essential, which is the responsibility of the federation and psychological professional.

Keywords: *mental health, anorexia, sport, psychology, psychotherapy, coaches*

References

- O'Connor, M. & Casey, L. (2015). The Mental Health Literacy Scale (MHLS): A new scale-based measure of mental health literacy. *Psychiatry Research*, 229(1-2), 511-516.
<https://doi.org/10.1016/j.psychres.2015.05.064>
- Turk, J.C., Prentice, W.E., Chappell, S., Shields, E.W.(1999). Collegiate coaches' knowledge of eating disorders. *Journal of Athletic Training*, 34(1), 19-24.



ORIGINAL SCIENTIFIC ABSTRACT

UNCOVERING COACHING STYLES: LEADERSHIP AND MOTIVATIONAL PERSPECTIVES IN ARTISTIC GYMNASTICS

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Introduction / Purpose

Artistic gymnastics demands technical excellence, with the role of the coach being key to the athlete's development. Success is often associated with a strict and disciplined approach. Many believe that only a traditional, old-school method can lead to top performance. This mindset emphasizes rigorous training, high expectations, and a highly resolute attitude from coaches. Therefore, it is important to examine which leadership styles truly prevail in practice and what motivates coaches in their daily work, as the stereotype persists that softer, more modern coaching styles are less effective in achieving greatness in the sport. The aim of this study is to analyse the relationship between goal orientation and coaching leadership styles, as well as the gender differences in these factors sample of 60 Croatian coaches from all regions (MageF=34 yrs, MageM=38 yrs).

Methods

Coaches' leadership style were evaluated by Croatian version of Leadership Scale for Sports (LSS; Chelladurai & Saleh, 1980; Greblo, 2011) and Croatian version of goal orientation questionnaire CTEOSQ was applied to asses coaches+ goal orientation (Barić & Horga, 2026).

Results

The results show that coaches are predominantly task oriented, focused on learning, improvement, and skill development in their athletes. They mostly use democratic leadership style, emphasizing feedback and instruction with moderate levels of social support. Also, task orientation was positively associated with leadership dimensions such as instruction and positive feedback. The gender differences were not identified, both male and female coaches show similar leadership style that is characterised by a tendency for high effort investment and personal improvement in gymnastics skills, based on self-referenced, not on competitive criteria between teammates.



Conclusions

A modern coaching in gymnastics largely depends on the characteristics of the sport itself and situational factors, such as adapting to new generations and this flexible approach is increasingly linked to success in Croatian gymnastics. In conclusion, the study emphasizes the significance of prioritizing process-oriented development and athlete growth. The findings can serve as a valuable foundation for enhancing coach education and promoting leadership strategies that foster both athletes' technical skills and psychosocial well-being.

Keywords: *coaches, artistic gymnastics, leadership, motivation, gender*

References

- Barić, R., Horga, S. (2006). Psychometric Properties Of The Croatian Version Of Task And Ego Orientation In Sport Questionnaire (CTEOSQ). *Kinesiology*, 38 (2), 135-142. DOI: <https://hrcak.srce.hr/9075>
- Greblo, Z. (2011). Perfekcionizam u darovitih sportaša: uloga osobinskih i okolinskih činitelja. (Perfectionism in Gifted Athletes: The Role of Personal and Environmental Factors. Unpublished doctoral dissertation), Zagreb: University of Zagreb, Faculty of Humanities and Social Sciences.



REVIEW ABSTRACT

LEARNING AND CORRECTING THE KEY TECHNICAL POINTS OF THE ROUND-OFF THROUGH PHASE-BASED TEACHING PROGRESSIONS IN ARTISTIC GYMNASTICS

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Introduction / Purpose

The round-off is one of the fundamental acrobatic skills in artistic gymnastics and provides the foundation for learning more advanced tumbling elements, including the back handspring and backward somersaults (Farana et al., 2014; Brtva et al., 2023). Its successful execution depends on the efficient transformation of horizontal velocity into vertical propulsion while maintaining optimal body alignment and coordination throughout all movement phases. Biomechanical studies have identified hand placement, body alignment during inversion, and upper-limb loading as key determinants of performance quality and injury risk (Farana et al., 2014; Brtva et al., 2023). However, despite these findings, evidence-based methodological guidelines for teaching and correcting the round-off remain limited. The aim of this paper is to present a phase-based methodological model for learning and correcting the key technical points of the round-off.

Methods

The paper is based on a narrative review and synthesis of current literature on round-off biomechanics and motor learning, integrated with established methodological principles of artistic gymnastics instruction (Magill & Anderson, 2017). The skill is divided into five phases: approach and hurdle, hand support, body inversion, snap-down, and rebound. For each phase, the main technical objectives, common execution errors, methodological teaching procedures, corrective exercises, and coaching cues are systematically presented.



Conclusion

The proposed model integrates scientific evidence with practical coaching methodology to provide a structured framework for teaching and correcting the round-off. By addressing the key technical points within each movement phase, it supports progressive skill acquisition, improves movement efficiency and technical execution, and may reduce upper-limb loading and injury risk. The model offers coaches and teachers an evidence-informed approach to developing a technically sound round-off and establishing the prerequisites for learning more advanced acrobatic skills.

Keywords: *artistic gymnastics, round-off, methodology, motor learning, technical correction*

References

- Brtnva, P., Irwin, G., Williams, G. K., & Farana, R. (2023). Upper limb biomechanics and dynamics of a core skill on floor exercise in female gymnastics. *Journal of Sports Sciences*, 41(1), 27-35.
- Farana, R., Jandacka, D., Uchytíl, J., Zahradník, D., & Irwin, G. (2014). Musculoskeletal Loading During the Round-Off in Female Gymnastics: The Effect of Hand Position. *Sports Biomechanics*, 13(2), 123–134.
- Magill, R., & Anderson, D.I. (2010). *Motor learning and control* (pp. 66-82). New York: McGraw-Hill Publishing.



ORIGINAL SCIENTIFIC ABSTRACT

CODE OF POINTS VS. BIOMECHANICS: WHAT CONSTITUTES A “TECHNICALLY GOOD LANDING” IN ARTISTIC GYMNASTICS?

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Introduction / Purpose

Landings are critical in artistic gymnastics, linking performance evaluation with athlete health. While the Code of Points (CoP) evaluates landings mainly through visible stability, posture and corrective movements (Fédération Internationale de Gymnastique [FIG], 2024), biomechanical evidence emphasises impact absorption, joint flexion and lower-limb alignment to reduce mechanical load. This creates a potential gap between judged technical quality and athlete safety. Therefore, this study aimed to compare CoP landing deductions with biomechanical evidence on safe landings, deriving implications for coaching, judging and athlete health.

Methods

A systematic review following PRISMA 2020 searched SPORTDiscus and SPONET for studies published from 2000 to 2024. After duplicate removal, 525 records were screened; 13 studies were included in the synthesis. Eligible studies examined artistic gymnastics or comparable landing tasks and reported ground-contact biomechanics, including knee, hip or trunk angles, ground reaction forces or joint moments. Evidence was synthesised qualitatively and descriptively and compared with landing-related deductions in the 2025–2028 CoP for women’s and men’s artistic gymnastics.

Results

Knee flexion of approximately 75°–90° and trunk flexion of 40°–45° were associated with improved impact absorption and load distribution (Slater et al., 2015). Stiff landings, excessive trunk positions and asymmetrical lower-limb alignment were associated with increased mechanical stress. The clearest discrepancy concerned the women’s CoP deduction for “deep” landings when the hips reach knee height ($\approx 85^\circ$ knee flexion), which falls within the biomechanically favourable range.



Conclusions

The present study indicates discrepancies between biomechanical evidence and current landing deductions. Current scoring criteria may benefit from closer alignment with biomechanical principles to better define technically good landings and support athlete health. Accordingly, judging criteria might give greater consideration to lower-limb alignment while allowing functional knee and trunk flexion, thereby better reflecting current biomechanical evidence. Integrating such evidence into coaching and evaluation may reduce injury risk without compromising gymnastics' aesthetic identity.

Keywords: *landing biomechanics, injury prevention, athlete health, judging criteria, systematic review, performance evaluation*

References

- Fédération Internationale de Gymnastique (2024). 2025–2028 Code of Points: Women's artistic gymnastics.
https://www.gymnastics.sport/publicdir/rules/files/en_1.1%20-%20WAG%20COP%202025-2028.pdf
- Slater, A., Campbell, A., Smith, A., & Straker, L. (2015). Greater lower limb flexion in gymnastic landings is associated with reduced landing force: A repeated measures study. *Sports Biomechanics*, 14(1), 45–56.
<https://doi.org/10.1080/14763141.2015.1029514>



ORIGINAL SCIENTIFIC ABSTRACT

**IDIOPATHIC SCOLIOSIS AND HYPOKYPHOTIC
SAGITTAL SPINAL PROFILE IN RHYTHMIC GYMNASTS:
ASSOCIATIONS WITH BODY COMPOSITION****Ahsen Büyükaslan Bohinc, Maja Pajek**

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Introduction / Purpose

Adolescent idiopathic scoliosis (AIS) is a three-dimensional spinal deformity characterised by lateral deviation greater than 10° on anteroposterior radiography, axial rotation and hypokyphosis (flat back). The incidence of AIS is 10-fold higher in rhythmic gymnasts than in their peers. Rhythmic gymnasts represent a unique population in which multiple etiopathogenetic factors may converge: athletes exhibit high levels of generalised joint hypermobility, low BMI, repeatedly perform extreme hyperextension, often asymmetrical spinal movements and undergo early specialisation and high training volumes (Meyer et al., 2006; Watanabe et al., 2017). This study aimed to investigate etiopathogenetic factors of scoliosis in rhythmic gymnasts and the relationships between body composition and sagittal spinal alignment.

Methods

This cross-sectional study was conducted at the Faculty of Sport, University of Ljubljana, in 2024–2025 among 64 competitive rhythmic gymnasts aged 10–18 years from local clubs in Slovenia. All participants had at least 5 years of experience (PCF Tier 3). Sport-specific characteristics, pubertal maturity, hypermobility (Beighton score), clinical assessment of angle of trunk rotation (ATR) measured by scoliometer, body composition assessed by bioelectrical impedance analysis (BIA), and sagittal spinal alignment measured with a Spinal Mouse were evaluated. A generalised linear model (GENLIN) was used to examine the predictors of ATR. Spearman correlation coefficients were used to examine the associations between parameters.

Results

A GENLIN model showed T1–T12 kyphosis, Beighton hypermobility score, and menarche significantly predicted thoracic ATR ($\chi^2=80.81$, $p=0.032$), with reduced kyphosis as the strongest predictor of greater deformity. Lower values of BMI, fat-free mass, fat mass, axial muscle mass, skeletal muscle mass, and appendicular skeletal muscle mass were associated with reduced thoracic kyphosis (T1–T12) ($r=0.41$ – 0.64 , $p \leq 0.004$). In contrast, decreases in these parameters, except for axial muscle mass, were associated with increased lumbar lordosis (T12–L5) ($r=-0.32$ to -0.54 , $p=0.001$ – 0.022).



Conclusions

Reduced kyphosis appears to be the strongest predictor of greater deformity. Moreover, reduced muscle mass is linked to a hypokyphotic spinal profile characterised by decreased thoracic kyphosis and increased lumbar lordosis.

Keywords: *adolescent idiopathic scoliosis, spine deformity, rhythmic gymnastics, sagittal alignment, hypokyphosis, body composition*

References

- Meyer, C., Cammarata, E., Haumont, T., Devitterne, D., Gauchard, G.C., Leheup, B., Lascombes, P., & Perrin, P.P. (2006). Why do idiopathic scoliosis patients participate more in gymnastics? *Scandinavian Journal of Medicine and Science in Sports*, 16(4), 231–236.
<https://doi.org/10.1111/j.1600-0838.2005.00482.x>
- Watanabe, K., Michikawa, T., Yonezawa, I., Takaso, M., Minami, S., Soshi, S., Tsuji, T., Okada, E., Abe, K., Takahashi, M., Asakura, K., Nishiwaki, Y., & Matsumoto, M. (2017). *Physical Activities and Lifestyle Factors Related to Adolescent Idiopathic Scoliosis*. 284–294.



ORIGINAL SCIENTIFIC ABSTRACT

VISUAL BEHAVIOUR IN RHYTHMIC GYMNASTICS: COMPARING ISOLATED AND CONTEXTUALISED TASKS THROUGH AN ECOLOGICAL DYNAMICS LENS

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Introduction / Purpose

Rhythmic gymnastics requires continuous coordination between body movements, apparatus trajectories, and visual information. From an ecological dynamics perspective, such coordination emerges through perception-action coupling. Accordingly, Representative Learning Design emphasises that practice and assessment tasks should preserve the informational and action demands of competition. Based on this framework, this exploratory study compared gaze dispersion during the same ball throw performed as a non-representative isolated task and as part of a more representative choreographic sequence.

Methods

Four competitive female rhythmic gymnasts (age: 19.5 ± 1.3 years) competing in events organised by the Italian Gymnastics Federation completed five valid trials in two conditions: an isolated ball throw with two chainé rotations and a catch, and the same throw embedded within a choreographic sequence including a balance element and dance steps. Gaze behaviour was recorded using a wearable Pupil Labs eye tracker, while a frontal video camera was used to identify task phases and assess technical execution. Gaze dispersion was calculated in R for each gymnast and condition, with data analysed descriptively at both the individual and group levels.

Results

Gaze dispersion differed across gymnasts between conditions. Three athletes showed a reduction in mean gaze dispersion during the choreographic sequence compared with the isolated task, with two marked reductions (-11.2% and -11.7%) and one minimal reduction (-1.4%). The fourth gymnast showed a small increase in gaze dispersion in the contextualised condition ($+3.5\%$). At the group level, mean gaze dispersion was 5.7% lower in the contextualised than in the isolated condition.



Conclusions

Gaze dispersion tended to be lower in the more representative condition, although individual responses varied, suggesting that preserving competition-relevant information may promote more spatially concentrated gaze behaviour in some athletes. In line with ecological dynamics and Representative Learning Design, task context may influence gaze organisation, suggesting the potential value of representative training tasks in rhythmic gymnastics.

Keywords: *Ecological Dynamics, Representative Learning Design, Eye Tracking, Gaze Behaviour, Rhythmic Gymnastics.*

References

- Davids, K., Araújo, D., Vilar, L., Renshaw, I., & Pinder, R. (2013). An ecological dynamics approach to skill acquisition: Implications for development of talent in sport. *Talent Development and Excellence*, 5(1), 21-24.
- Pinder, R. A., Davids, K., Renshaw, I., & Araújo, D. (2011). Representative learning design and functionality of research and practice in sport. *Journal of Sport and Exercise Psychology*, 33(1), 146-155.
- Zhou, C., Cai, Y., Li, K., Zhang, X., & Tang, C. (2025). Research on visual search strategies during apparatus throw-and-catch in group rhythmic gymnastics. *Frontiers in Psychology*, 16, 1700617.



ORIGINAL SCIENTIFIC ABSTRACT

JUDGING BIAS AT THE 1926 WORLD GYMNASTICS CHAMPIONSHIP IN LYON

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Introduction / Purpose

At the 8th World Gymnastics Championship in Lyon in 1926, the Yugoslav team finished second behind Czechoslovakia. Allegations that the Czechoslovak judges Havel (parallel bars) and Müller (pommel horse) had judged unfairly emerged immediately, documented in Sokol press reports and in Leon Štukelj's memoirs. This study, the first to test these allegations statistically, aimed to assess judging reliability, determine whether systematic national bias existed, and calculate whether correcting any identified bias would alter the final team ranking.

Methods

Individual scores awarded by twelve judges to 48 gymnasts from six teams were transcribed from the original FIG scoring tables published in Sokolski glasnik. Scores covered four apparatus in both compulsory and optional exercises. Judging reliability was assessed with the intraclass correlation coefficient ICC(3,1). Bias was quantified as the deviation between each judge's score and the mean score of the other two judges. Statistical analysis included t-tests, two-way analysis of variance, a linear mixed model, and non-parametric tests. The effect of bias correction on the final ranking was evaluated using both deterministic correction and bootstrap resampling (100,000 iterations).

Results

Judging reliability was satisfactory on all apparatus (ICC 0.822 to 0.991), yet statistically significant national bias was detected. Havel awarded Czechoslovak gymnasts, on average 0.741 points more than other judges, while Müller underscored Yugoslav gymnasts by 1.428 points and overscored Czechoslovaks by 0.375 points. The Yugoslav judges also favoured their own gymnasts although to a lesser extent (0.175 and 0.147 points). Removing the identified biases did not alter the final team ranking, as Czechoslovakia remained first in all bootstrap iterations. However, biased judging nearly doubled the official winning margin, indicating that the true difference in competitive quality was only about half the official one.



Conclusions

The study provides the first statistically grounded evaluation of a century-old controversy, demonstrating that national judging bias inflated the official margin victory without affecting the final outcome. It also presents a reproducible methodological template for investigating judging bias at historical competitions where only archival scoring tables are available.

Keywords: *gymnastics, judging, national bias, 1926 World Championship, statistical analysis*

References

Ansorge, C.J. in Scheer, J.K. (1988). International bias detected in judging gymnastic competition at the 1984 Olympic Games. *Research Quarterly for Exercise and Sport*, 59(2), 103–107.

Sokolski glasnik: Zvaničan organ Sokolskog saveza Srba, Hrvata i Slovenaca. (1926). *Sokolski glasnik*, 8(17).

Štukelj, L. (1989). *Mojih sedem svetovnih tekmovanj*. Dolenjska založba.



ORIGINAL SCIENTIFIC ABSTRACT

INITIAL PREDICTORS OF BASIC ARTISTIC GYMNASTICS SKILL ACQUISITION IN SEVEN-YEAR-OLD CHILDREN

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Introduction / Purpose

The acquisition of basic artistic gymnastics skills during early childhood depends on several biological and motor-related factors. However, the relative contribution of anthropometric characteristics, motor abilities, Fundamental Movement Skills (FMS), and physical activity level to gymnastics skill acquisition remains insufficiently understood. Therefore, the aim of this study was to determine the relative contribution of these variables in predicting basic artistic gymnastics skill acquisition following an 18-week beginner gymnastics program.

Methods

The study included 70 seven-year-old children (40 girls and 30 boys) enrolled in a beginner artistic gymnastics program. Baseline assessment included anthropometric characteristics, motor abilities, four domains of Fundamental Movement Skills (FMS) (object manipulation, mastering obstacles, mastering resistance, and mastering space), and physical activity level assessed using the Netherlands Physical Activity Questionnaire (NPAQ) completed by parents. The gymnastics program lasted 18 weeks (39 instructional sessions). At the end of the program, the acquisition of twelve basic artistic gymnastics skills was evaluated independently by five expert judges. The mean score was used as the criterion variable. Multiple regression analysis was applied.

Results

The regression model was statistically significant ($R = 0.81$; $R^2 = 0.66$; Adjusted $R^2 = 0.61$; $p < 0.001$), explaining 61% of the variance in basic artistic gymnastics skill acquisition. Standing Long Jump ($\beta = 0.322$), Straddle Forward Bend ($\beta = 0.324$), and the Fundamental Movement Skills domain of mastering obstacles, assessed using the Running Across Obstacles Test ($\beta = -0.230$), were identified as significant independent predictors. Anthropometric characteristics, physical activity level, and the remaining Fundamental Movement Skills domains did not significantly contribute to the final regression model.



Conclusions

Lower-limb explosive power, flexibility, and Fundamental Movement Skills related to mastering obstacles represent the most important independent initial predictors of successful basic artistic gymnastics skill acquisition in seven-year-old children. These findings may contribute to more effective planning of beginner gymnastics programs, individualized instruction, and objective assessment of children's motor potential.

Keywords: *artistic gymnastics, fundamental movement skills, motor abilities, motor learning, multiple regression, children.*

References

- Čuljak, Z., Delaš Kalinski, S., Kezić, A., & Miletić, Đ. (2014). Influence of fundamental movement skills on basic gymnastics skills acquisition. *Science of Gymnastics Journal*, 6(2), 73–82.
- Gallahue, D.L., Ozmun, J.C., & Goodway, J.D. (2019). *Understanding Motor Development: Infants, Children, Adolescents, Adults* (8th ed.). Jones & Bartlett Learning.
- Schmidt, R.A., Lee, T.D., Winstein, C., Wulf, G., & Zelaznik, H. (2019). *Motor Control and Learning: A Behavioral Emphasis* (6th ed.). Human Kinetics.



ORIGINAL SCIENTIFIC ABSTRACT

WHAT IS HIGHEST (AND LOWEST) STRESSFUL FOR YOUNG FEMALE GYMNASTS

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Introduction / Purpose

According to Lazarus and Folkman (1984), primary cognitive appraisal refers to an individual's evaluation of whether a situation is important and potentially stressful. Previous qualitative research identified skill performance, evaluation, competition, mistakes, expectations, time pressure, environmental conditions, and injury as the main sources of stress in young gymnasts (Duda & Gano-Overway, 1996). The aim of this study was to quantitatively assess the primary appraisal of stressfulness across a wide range of competition-related situations in young female artistic gymnasts.

Methods

The study included 48 female artistic gymnasts from eight Croatian clubs, aged 10–18 years (12.83 ± 1.95), who had started gymnastics training at 5.04 ± 1.90 years of age. Participants completed the Primary Appraisal of Situation Stressfulness in Artistic Gymnastics Questionnaire (PASS-ArtGy; Milavić & Delaš Kalinski, 2024), which assesses the perceived stressfulness of 80 competition-related situations that had either been experienced or imagined. Stressfulness was rated on a 7-point Likert scale ranging from 1 (not at all stressful) to 7 (completely stressful). The highest- and lowest-rated situations were analysed.

Results

Three situations were rated as very highly stressful (e.g., falling off the apparatus; national championships), while seven were rated highly stressful (e.g., waiting for the judges' start signal, declining ranking during competition, worrying about performance quality, competing against stronger gymnasts, and the 30-second touch warm-up). Five situations received moderate stress ratings, including international competitions, worrying about making mistakes, and not meeting personal expectations. In nine situations, the most frequent responses were the two highest stress ratings. Conversely, eleven situations were rated as extremely low in stressfulness (e.g., leading the competition based on scores, competing against weaker gymnasts, not meeting parents' expectations, and the week before an important competition), while four were rated as very low (e.g., team competitions and two to three days before regional or national competitions).



Conclusions

Young female gymnasts rated the most stressful situations associated with: important and high-level competitions; making mistakes in performance; worrying about the quality of performance; not meeting expectations and losing; the time immediately before the performance. They rated the lowest stressful situations associated with: competitions in which they are leading; not meeting parents' expectations; competing in familiar environment; longer pre-competition period; regular and constant competitive situations. These findings provide insight into the primary appraisal of competitive stress and support further research aimed at developing psychological preparation strategies for young gymnasts.

Keywords: *artistic gymnastics, primary appraisal, sources of stress, stress, women gymnastics*

References

- Duda, J. L., & Gano-Overway, L. A. (1996). Anxiety in elite young gymnasts: part II – Sources of stress. *USA Gymnastics Online: Technique*, 16(6), 4–6.
- Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal and coping*. New York, NY, USA: Springer.
- Milavić, B., & Delaš Kalinski, S. (2024). Primary Appraisal of Situation Stressfulness in Artistic Gymnastics Questionnaire (PASS-ArtGy). Split: University of Split, Faculty of Kinesiology (unpublished material).



REVIEW ABSTRACT

EXECUTIVE FUNCTIONS AND ARTISTIC GYMNASTICS IN CHILDREN: SYNTHESIS OF EVIDENCE FROM A SYSTEMATIC REVIEW

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Introduction / Purpose

There is consistent evidence on the benefits of sport in the development of executive functions (EF) in children and how these can improve athletic and cognitive performance, as well as the long-term mental health of athletes. Artistic gymnastics (AG) is a sport with high cognitive demands, and its different competition apparatuses present various states of activation. We synthesize the available evidence on the relationship between the practice of AG and EF in the child population, based on a systematic review of the literature on sport and EF in children aged 6 to 12 years.

Methods

The PRISMA 2020 guidelines were followed, and a search was conducted in five databases: Web of Science, PubMed, PsycINFO, Scopus, and ScienceDirect. Of the included studies, those related to AG were identified, and a specific synthesis of their findings was performed.

Results

Six articles incorporating AG were obtained. The study participants exhibited considerable heterogeneity in terms of experience, ranging from individuals with no prior experience to competitive gymnasts with years of training. Five studies included participants of both sexes. However, only one of them analyzed differences based on gender. The cognitive functions assessed were inhibition (IN), working memory (WM), cognitive flexibility (CF), and planning (PL), using various standardized neuropsychological tests. Two studies supplemented these with brain activity recordings using EEG or fNIRS. The WM (visuospatial, spatial and verbal) emerged as the cognitive component that presented the most consistent evidence of improvement and association with athletic performance in gymnasts. When different age categories were considered, it was observed that the child population showed improvements in general EF parameters.



Conclusions

The specific associations of WM and the performance of gymnasts in the child population observed coincide with findings described in studies carried out in the adult population. Other subcomponents of EF, such as IN, CF and PL, may require further analysis, looking for a potential of AG, such as continuous adaptation to increasing difficulties, the demand for self-control and error correction, and the planning and monitoring of movement. Further research could benefit training strategies and early specialization approaches.

Keywords: *executive functions, cognitive control, sports, children, preadolescent*

References

- Bidzan-Bluma, I., & Lipowska, M. (2018). Physical Activity and Cognitive Functioning of Children: A Systematic Review. *International Journal of Environmental Research and Public Health*, 15(4), 800.
<https://doi.org/10.3390/ijerph15040800>
- Lin, C.C., Kao, S.C., Hung, C.L., Tsai, C.L., Huang, C.J., Chang, Y.K., & Hung, T.M. (2025). The Effects of Gymnastics Programs with Different Cognitive Loads on Working Memory and Prefrontal Cortex Oxygenation: A Randomized Controlled Trial. *Medicine and science in sports and exercise*, 57(6), 1123–1136.
<https://doi.org/10.1249/MSS.0000000000003648>
- Laureys, F., Collins, D., Deconinck, F.J.A., & Lenoir, M. (2024). Executive functions and psycho-behavioural skills in artistic gymnasts: age, developmental stage and sex-related differences. *International Journal of Sport and Exercise Psychology*, 22(4), 1048–1069.
<https://doi.org/10.1080/1612197X.2023.2180069>



ORIGINAL SCIENTIFIC ABSTRACT

WHAT DISTINGUISHES SUCCESSFUL FROM UNSUCCESSFUL ROCHE VAULTS? A BIOMECHANICAL ANALYSIS OF THE RUN-UP APPROACH IN ELITE MEN'S ARTISTIC GYMNASTS

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Introduction / Purpose

Although approach velocity is considered a key determinant of vault performance in men's artistic gymnastics, little is known about the biomechanical factors underlying successful and unsuccessful Roche vaults under competition conditions. Previous studies have primarily investigated general run-up characteristics, while biomechanical comparisons between successful and unsuccessful executions of the same vault remain scarce (Bradshaw, 2004; Takei et al., 2007; Schärer et al., 2019). Therefore, the aim of this study was to identify biomechanical differences in run-up parameters between successful and unsuccessful Roche vaults performed by elite men's artistic gymnasts.

Methods

Nine elite male gymnasts competing at the 2024 FIG World Challenge Cup (Koper, Slovenia) performed Roche vaults classified as successful (n=5) or unsuccessful (n=4) according to the FIG Code of Points and official judging outcomes, verified using the Elevien video and scoring system. Run-up parameters (average speed in last 8 steps, maximal run-up speed, average step length – last 8 steps, average flight time – last 8 steps, penultimate step contact time, last step contact time) were measured using the OptoGait photoelectric cell system (1000Hz). Independent-samples t-tests and Cohen's effect sizes were used for group comparisons.

Results

Successful Roche vaults tended to demonstrate a slightly lower average approach speed in the last 8 steps compared with unsuccessful attempts (7.50 ± 0.27 vs. 7.67 ± 0.32 m/s; $d=0.58$), whereas maximal run-up speed was nearly identical between groups (8.75 ± 0.27 vs. 8.74 ± 0.24 m/s; $d=0.02$). Successful vaults also tended to demonstrate a slightly shorter average step length during the last 8 steps (153.13 ± 7.49 vs. 155.72 ± 7.29 cm; $d=0.35$), a longer average flight time (0.088 ± 0.013 vs. 0.083 ± 0.010 s; $d=0.47$), and a shorter penultimate step contact time (0.110 ± 0.010 vs. 0.115 ± 0.006 s; $d=0.59$). Last-step contact time did not differ between successful and unsuccessful vaults (0.110 s; $d \approx 0$).



Conclusions

Successful Roche performances tended to be characterized by shorter penultimate step contact time and slightly longer flight time, suggesting more efficient temporal coordination. In contrast, unsuccessful attempts demonstrated higher approach velocities despite inferior performance outcomes, suggesting that greater speed alone may not ensure successful performance. These findings suggest that coaches may benefit from emphasizing step rhythm, reactive strength and control during the penultimate step rather than focusing solely on increasing overall approach speed.

Keywords: *Roche vault, artistic gymnastics, biomechanics, run-up, OptoGait.*

References

- Bradshaw, E. (2004). Gymnastics: Target-directed running in gymnastics: A preliminary exploration of vaulting. *Sports Biomechanics*, 3(1), 125–144.
- Schärer, C., Haller, N., Taube, W., & Hübner, K. (2019). Physical determinants of vault performance and their age-related differences across male junior and elite top-level gymnasts. *PLoS ONE*, 14(12), e0225975.
- Takei, Y., Dunn, J.H., & Blucker, E.P. (2007). Somersaulting techniques used in high-scoring and low-scoring Roche vaults performed by male Olympic gymnasts. *Journal of Sports Sciences*, 25(6), 673–685.



PROFESSIONAL ABSTRACT

AESTHETIC IMPRESSION IN RHYTHMIC GYMNASTICS

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Introduction / Purpose

Aesthetics, as a philosophical discipline that studies the concepts of beauty, art, and perception in detail, holds an extremely important place in the field of rhythmic gymnastics. In the current Code of Points (2025–2028), the final score of a routine is the sum of the difficulty, execution, and artistry scores. In a routine, a gymnast should only include those elements (body and apparatus difficulties) that they can perform with a high level of technical success. (FIG, 2025).

Discussion

Aesthetics in rhythmic gymnastics isn't just about analyzing beauty or the overall impression of a performance, it sets specific criteria and standards for evaluating the aesthetic impression of a routine, which is also called artistic expression. These criteria include symmetry of movement, harmony between the body and the apparatus, elegance, creativity, and the overall performance on the floor.

Choreography can be designed by an expert who has fully mastered the sport's techniques, knows all its technical requirements perfectly, and also has a keen sense of rhythm and general musical education (Wolf-Cvitak, 2004).

In training, it's equally important to develop all these components so that the beauty of the gymnast's movements is expressed in every motion that the coach has envisioned in the choreography.



Conclusions

Although the regulations and scoring systems try to make judging more objective, it's important to point out that the judges' subjective perception can still play a significant role in the final score. That's why further research and the development of innovative methods to objectify aesthetic criteria are necessary, which would allow for even fairer and more precise evaluation of performances. By establishing clearer standards and increasing the expertise of judges, the level of objectivity can be further improved, while also encouraging the development of the artistic aspect of this sport.

Keywords: *artistic impression, motor style, rhythm, harmony of movement*

References

- FIG. (2025). FIG <https://www.gymnastics.sport/site/>
Wolf-Cvitak, J. (2004). *Ritmička gimnastika*. Zagreb: Kugler.



ORIGINAL SCIENTIFIC ABSTRACT

HAND PLACEMENT AND SEGMENTAL ALIGNMENT ON THE TRAINING MUSHROOM: A SKILL-LEVEL ANALYSIS

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Introduction / Purpose

The pommel horse requires continuous upper-limb support, rotation, and precise body control. The circle, its fundamental movement, depends on coordinated control of the center of mass, segmental alignment, and hand placement. Learning the circle on a mushroom is the standard method for acquiring this basic motor skill. Early mastery is essential, as it provides the foundation of nearly all subsequent pommel horse elements.

Yamasaki et al. (2024) showed that wrist torques modulate body posture around a dynamic equilibrium. Poor hand placement can therefore disrupt the balance and consequently lead to a fall. Yet the spatial characteristics of hand placement have never been characterized, as prior literature focused on other aspects (for example, ankle trajectory for Baudry et al., 2008). If expertise translates into reduced motor variability, hand placement should follow the same stabilization pattern. This pilot study characterized timing, hand placement and segmental angles across skill levels, using statistical parametric mapping (SPM). Comparing kinematic curves point-by-point, reveals the exact moments where gymnasts' motor profiles diverged from an expert.

Methods

Eleven gymnasts (13.9 ± 4.3 years; 9.3 ± 2.6 years of practice) performed circle series on a mushroom. A markerless Qualisys/Theia system (14 cameras, 85 Hz) reconstructed hand trajectories and segmental angles: arm flexion/extension and abduction/adduction; leg-trunk flexion/extension; AP/ML hand positions; and support timing (single/double support). SPM compared each gymnast's normalized curves against an expert to identify windows with significant difference.

Results

Leg-trunk angles correlated with skill level ($r=0.83-0.86$; $p<0.001$), as did reduced intra-cycle variability of segmental angles ($r=-0.75$ to -0.83 ; $p\leq 0.008$). ML hand position related to skill level ($r=0.65$; $p=0.041$) and years of practice ($r=0.86$; $p=0.001$). Support timing was highly reproducible ($CV < 5\%$), unlike AP position. Differences with the expert tend to decrease with skill level.



Conclusions

Segmental angle variability and leg-trunk alignment are the most sensitive kinematic variables for discriminating skill level on the mushroom. This information provides coaches with objective, quantifiable feedback beyond standard assessment. Since convergence toward expert patterns progresses at different rates across gymnasts, SPM allows to focus coaching on the gymnast's motor parameters the furthest from the expert's one.

Keywords: *markerless, motion capture, variability, regulation, circles, mushroom*

References

- Baudry, L., Seifert, L., & Leroy, D. (2008). Spatial consistency of circle on the pedagogic pommel horse: influence of expertise. *Journal of strength and conditioning research*, 22(2), 608–613.
<https://doi.org/10.1519/JSC.0b013e31816346f3>
- Yamasaki, T., Nishiwaki, K., Nawa, M., Yamawaki, K., Nakamura, Y., Xin, X., & Izumi, S. (2024). Dynamic balance of circles with one support point on pommel horse exercise. *Scientific reports*, 14(1), 20886.
<https://doi.org/10.1038/s41598-024-70698-8>



ORIGINAL SCIENTIFIC ABSTRACT

EFFECTS OF ELASTIC BAND TRAINING ON TECHNICAL EXECUTION OF RHYTHMIC EXERCISES AND BALANCE IN YOUNG FEMALE GYMNASTS

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Introduction / Purpose

The development of motor skills and technical execution in young female gymnasts represents a key aspect of sports training in the early selection phase. Elastic bands are becoming an increasingly popular training method for developing strength, flexibility, and stability in the preparatory part of training. The aim of this study was to examine the effects of an eight – week elastic band program on the quality of rhythmic jump execution and balance on the floor and beam in girls aged 6 – 8 years who train and compete in women's artistic gymnastics.

Methods

The study was conducted on a sample of 18 healthy female gymnasts, divided into an experimental group (EXP, N=11) and a control group (CON, N=7). During the eight – week period (24 training sessions), the EXP group performed elastic band exercises within the introductory – preparatory part of training (modified warm – up), lasting 20 minutes, while the CON group attended only regular training of the same volume with a standard warm – up. The quality of execution of 10 exercises was assessed by expert judges using a constructed scale (range 1 – 7) at pretest and posttest. The Wilcoxon signed – rank test (within – group differences) and the Mann – Whitney U test (between – group differences) were applied.

Results

The Mann – Whitney U test showed no statistically significant differences between the groups on any variable at pretest ($p > .05$ for all variables), confirming sample homogeneity. The Wilcoxon signed – rank test revealed statistically significant improvement in the EXP group on almost all monitored variables between the initial and final measurement ($Z = -2.683$ to -2.934 , $p = .003 - .021$), while improvement in the CON group was statistically non-significant for the majority of variables ($p > .05$).



Conclusions

The results indicate that an eight – week elastic band program within the introductory – preparatory part of the training significantly improves the quality of rhythmic jump execution and balance on the floor and beam in young female gymnasts, while standard training without a supplementary program does not lead to changes at a statistically significant level. The findings have practical implications for optimising the preparatory part of the training in women's artistic gymnastics during the early selection phase.

Keywords: *elastic bands, artistic gymnastics, warm – up, young athletes, strength training*

References

- Fang, Q., Zhang, X., Xia, Y., & Huang, F. (2023). Integrating elastic band into physical education classes to enhance strength training. *Frontiers in Psychology, 14*, 1037736.
- Ozsu, I. (2018). Effects of 6-week resistance elastic band exercise on functional performances of 8-9 year-old children. *Journal of Education and Training Studies, 6*(12a), 17–23.
- Struhar, I., Dovrtelova, L., & Kapounkova, K. (2014). Effect of exercise with elastic cord on postural stability in a group of elite gymnasts. *Journal of Human Sport and Exercise, 9*(1), S495–S503.



ORIGINAL SCIENTIFIC ABSTRACT

PERFORMANCE ENHANCEMENT THROUGH THE SIMULTANEOUS PRESENTATION OF VIDEO SELF- AND EXPERT-MODELING

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Introduction / Purpose

Performance enhancement, defined as systematic improvement of movement execution quality, can be facilitated through video-based feedback methods that present either the athlete's own performance (self-modeling, SM) or an idealized reference performance (expert-modeling, EM). Both models can also be displayed simultaneously via split-screen presentation (combined self- and expert-modeling, CSEM). Ste-Marie et al. (2020) postulated that observing two model types contributes to greater performance enhancement, than observing a single model type. The present study aimed to compare SM and CSEM in the context of a technically demanding uneven-bars dismount.

Methods

Thirty female preservice physical education teachers ($M = 22.5$ years, $SD = 2.4$) participated in the quasi-experimental investigation. Over a four-week intervention period, participants practised the underswing-straddle, with 180° turn to stand from the high bar, completing one practice session per week. In each session, one group received SM feedback, whereas the other received CSEM feedback. Pre-test and post-test performances were independently evaluated by two expert raters using a 10-point scoring scale.

Results

Interrater reliability was high. A repeated-measures ANOVA revealed a significant main effect of time, indicating that both groups improved from pre-test to post-test, $F(1, 28) = 37.78$, $p < .001$, $\eta^2_{\text{art}} = .57$. Additionally, a significant interaction between feedback condition and time emerged, $F(1, 28) = 4.31$, $p = .047$, $\eta^2_{\text{art}} = .13$, showing greater improvement in the CSEM feedback group.



Conclusions

The findings provide empirical evidence that the training was effective, as both groups improved significantly. CSEM feedback amplified that improvement, indicating that feedback type meaningfully influenced learning gains. CSEM yields superior performance enhancement compared with SM feedback. Based on these results, CSEM feedback is recommended for video-based training of complex motor skills.

Keywords: *observational training, video-feedback, self-modeling, expert-modeling, performance enhancement*

References

Ste-Marie, D.M., Lelievre, N. & St. Germain, L. (2020). Revisiting the Applied Model for the Use of Observation: A Review of Articles Spanning 2011–2018. *Research Quarterly for Exercise and Sport*, 91(4), 594–617.
<https://doi.org/10.1080/02701367.2019.1693489>



ORIGINAL SCIENTIFIC ABSTRACT

INDIVIDUAL MOTOR AND TECHNICAL PROFILING OF WOMEN'S ARTISTIC GYMNASTS NOMINATED FOR THE EUROPEAN CHAMPIONSHIPS

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Introduction / Purpose

Elite performance in women's artistic gymnastics is influenced by multiple physical and technical factors (Forminte et al., 2021). Although physical and technical characteristics are commonly evaluated (Nassib et al., 2020), individual profiling approaches in women's artistic gymnastics remain limited. Therefore, this study aimed to establish individual motor and technical profiles of gymnasts nominated for the European Championships using reference ranges derived from non-nominated gymnasts.

Methods

The study included 11 junior and senior women's artistic gymnasts, including four gymnasts nominated for the European Championships and seven non-nominated gymnasts (age: 15.45 ± 2.81 years). The motor profile comprised lower- and upper-limb power, Reactive Strength Index, handstand hold, and rope-climbing performance. The technical profile was based on the execution score (E-score) of selected skills and skill combinations on vault, uneven bars, balance beam, and floor exercise, evaluated independently by five judges. For the reference group ($n = 7$), the mean and standard deviation were calculated for each variable. Based on these values, nominated gymnasts were classified into three reference categories: above mean + SD (2 points), within mean $\pm$ SD (1 point), and below mean - SD (0 points). Motor and technical scores were summed separately to establish individual profiles and compare the ranking of gymnasts.

Results

The motor profile differentiated the nominated gymnasts. Gymnast G2 achieved the highest motor score (9 points), followed by G4 (8 points), whereas G1 and G3 each scored 7 points. The technical profile yielded the highest scores for G2 and G4 (7 points), while G1 and G3 each obtained 6 points. Overall, technical execution was within or above the reference ranges, with the strongest performance observed on the uneven bars.



Conclusions

Reference-range profiling provides a simple and practical approach for the individual evaluation of motor and technical characteristics in women's artistic gymnasts. The gymnasts with the highest motor scores also achieved the highest technical scores, while differences among the remaining profiles reflected the individual nature of gymnastics performance. This approach may help identify areas requiring further development and support individualized training planning.

Keywords: athlete profiling, physical performance, execution score, expert evaluation, reference values

References

- Forminte, V.N., Micu, R., Potop, V., & Grosu, E.F. (2021). The relationship between the indicators of physical preparation and the scores attained in competitions by the junior female gymnasts. *Journal of Physical Education and Sport*, 21(3), 1607–1612.
<https://doi.org/10.7752/jpes.2021.03203>
- Nassib, S. H., Mkaouer, B., Riahi, S. H., Wali, S. M., & Nassib, S. (2020). Prediction of gymnastics physical profile through an international program evaluation in women artistic gymnastics. *Journal of Strength and Conditioning Research*, 34(2), 577–586.
<https://doi.org/10.1519/JSC.0000000000001902>

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ORIGINAL SCIENTIFIC ABSTRACT

KINEMATIC AND FLEXIBILITY PARAMETERS OF THE SPLIT LEAP JUMP IN ARTISTIC AND RHYTHMIC GYMNASTICS

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Introduction / Purpose

This study compared selected kinematic and flexibility parameters associated with the split leap jump in young artistic and rhythmic gymnasts. The main aim was to analyze the length of the last approach step before take-off and to evaluate the technical execution of the split leap using expert assessment. In addition, active and passive lower-limb flexibility were examined to determine their contribution to jump performance.

Methods

The study involved 16 female gymnasts aged 8–10 years, divided into two groups: artistic gymnastics (AGG; $n = 8$) and rhythmic gymnastics (RGG; $n = 8$). The length of the final approach step was measured using the My Jump 2 application, flexibility was assessed using Fédération Internationale de Gymnastique (FIG) flexibility tests, and technical performance was evaluated from high-speed video recordings by two expert judges. Statistical differences between groups were analyzed using the Mann–Whitney U test at a significance level of $p \leq .05$.

Results

The results revealed significant differences between the groups in several monitored variables. Artistic gymnasts performed significantly longer final approach steps before take-off than rhythmic gymnasts ($U = 61.00$; $p = .001$). Rhythmic gymnasts achieved significantly higher expert evaluation scores for split leap execution ($U = 13.50$; $p = .042$) and demonstrated significantly greater passive lower-limb flexibility in both the dominant ($U = 15.00$; $p = .044$) and non-dominant legs ($U = 11.50$; $p = .030$). No statistically significant differences were found in active flexibility variables ($p > .05$).



Conclusions

The findings indicate sport-specific differences in split leap performance. Artistic gymnasts appear to rely more on dynamic take-off characteristics, reflected in a longer final approach step, whereas rhythmic gymnasts benefit from superior passive flexibility, contributing to higher technical quality and aesthetic execution of the skill. These results may contribute to a better understanding of the biomechanical and flexibility-related determinants of split leap performance and may help coaches optimize training programs in both gymnastics disciplines.

Keywords: *artistic gymnastics, rhythmic gymnastics, split leap, kinematic analysis, flexibility, lower limbs, expert evaluation*

Acknowledgement

This study was supported by the Scientific Grant Agency of the Ministry of Education, Research, Development and Youth of the Slovak Republic (No. 1/0712/24)

References

- Aji-Putra, R.B., Soenyoto, T., Darmawan, A., & Irsyada, R. (2021). Contribution of leg flexibility, limb length, and leg power to split leap skills in rhythmic gymnastics athletes. *International Journal of Human Movement and Sports Sciences*, 9(4), 648–653.
<https://doi.org/10.13189/saj.2021.090407>
- Coppola, V., Gervasi, M., Scurati, R., Alberti, G., & Zago, M. (2020). Kinematic analysis of split leap performed with different approaches in rhythmic gymnastics. *Journal of Human Sport and Exercise*, 15(Proc4), S1020–S1029.
- Putra, R.B.A., Soenyoto, T., Darmawan, A., & Irsyada, R. (2020). Basic movements of the split leap in rhythmic gymnastics. *In Proceedings of the 5th International Seminar of Public Health and Education (ISPHE 2020)*. <https://doi.org/10.4108/eai.22-7-2020.2300304>



ORIGINAL SCIENTIFIC ABSTRACT

BRIDGING SCIENCE AND COACHING: 3D KINEMATIC MODELING OF JUMP ACQUISITION IN AEROBIC GYMNASTICS

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Introduction / Purpose

Acquiring gymnastic skills requires precise modeling and objective feedback to optimize performance and prevent technical deductions. In aerobic gymnastics, complex airborne elements demand rigorous timing and spatial precision. This study aimed to identify the multi-camera 3D kinematic characteristics of a specific difficulty element 1/1 Turn Split Jump to Split and to analyze execution errors to enhance subsequent coaching feedback models.

Methods

A cross-sectional case study design examined a senior female gymnast (age: 20 years, body mass: 52 kg, height: 160 cm, sports age: 8 years). Four consecutive trials of the jump (difficulty value 0.7p) were recorded using the Simi Motion 3D system with eight synchronized high-speed cameras operating at the Laboratory of Biomotorics, Masaryk University. Passive retroreflective markers were attached to 14 anatomical landmarks. Data were processed using descriptive statistics, standard deviation, and coefficient of variation (%) to evaluate intra-individual kinematic and spatiotemporal variability.

Results

The average element duration was 2.85 s. Spatiotemporal analysis revealed high preparatory phase variability, prolonging by 87.10% between Trial 1 (0.31 s) and Trial 4 (0.58 s) due to cumulative fatigue. Airborne, the mean split angle was $169.69^\circ \pm 4.19^\circ$ (CV = 2.47%). The mandatory 170° criteria was met in Trial 1 (172.45°) and Trial 4 (175.32°), but a 6.95% drop (12.19° difference) occurred in Trial 2 (163.13°). This corresponds with prior evidence [1] confirming flexibility and take off explosive strength are key determinants causing multi-planar instability under fatigue. Optimal Trial 4 correlated with the highest center of gravity culmination (1.12 m) and landing deceleration (-8.29 m.s^{-2}), aligning with multi-camera phase tracking patterns validated in literature [2]. Systematic technical errors included insufficient arm extension and asymmetrical knee flexion across all trials.



Conclusions

The descriptive kinematic and variability analysis successfully quantified critical movement deviations and execution instability undetected by visual observation alone. Integrating 3D kinematic modeling as an objective feedback tool allows coaches to monitor intra-individual technical fluctuations during motor learning stabilization, bridging scientific diagnostics and practical coaching applications in gymnastics.

Keywords: *motor learning, technical deductions, split position, airborne phase, spatiotemporal variables.*

Acknowledgement

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References

- Korpová, D., Krnáčová, A., Cihová, I., & Kyselovičová, O. (2025). Explosive strength and flexibility: Key determinants in the switch leap performance? *Science of Gymnastics Journal*, 17(1), 91–103.
- Akkari-Ghazouani, H., Mkaouer, B., Amara, S., & Chtara, M. (2020). Kinetic and kinematic analysis of three different execution modes of stag leap with and without throw-catch ball in rhythmic gymnastics. *Science of Gymnastics Journal*, 12(3), 255–264.



ORIGINAL SCIENTIFIC ABSTRACT

CAN A SINGLE IMU SEGMENT THE SEVEN PHASES OF ARTISTIC GYMNASTICS VAULTS

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Introduction / Purpose

Recently, multiple research papers have advocated for the use of Inertial Measurement Units (IMU) in artistic gymnastics (Boylen et al., 2025). Wearable IMU appears as an innovative tool that can be used outside laboratory settings and could be worn by the athlete as an artificial vestibular system, allowing to save and replay the characteristics of the movement. The purpose of this study was to evaluate the accuracy of IMU-based segmentation of the seven vault phases (Running, Hurdle, Springboard support, first flight, table support, second flight, landing (Atiković & Smajlović, 2011)) and to investigate whether gyroscope signals could discriminate between vault difficulties.

Methods

Four subjects (18.4±2.5years, 168±8cm, 53±4kg) performed between 14 and 18 vaults each, leading to 61 captured performance (54 handsprings and 7 handsprings with half twists). Delsys FSR sensors (1926Hz) were attached in both hands and under both feet of the athletes with elastic kinesiology tape to accurately measure contact and flight time and segment the vault. The BlueTrident IMU (1600Hz, ±200g, ±2 000°/s) was attached to the trunk of the athletes with an elastic belt at the sternum level. The synchronization between the two systems was achieved using three counter movement jumps performed before each vault. Based on a custom signal-processing algorithm, IMU segmentation was performed with threshold detection on the norm of the trunk acceleration signal.

Results

The mean absolute differences (±standard deviation) between phase durations measured by the FSR system and estimated from the IMU signal ranged between 0.0120s (±0.0111s) for the First flight phase and 0.0372s (±0.0425s) for the Table support phase. Gyroscope signals also revealed distinct rotational signatures between different difficulties.



Conclusions

IMU-based segmentation showed promising absolute accuracy, although relative errors remained high for very short phases such as springboard and table support (Čuk & Karacsony, 2004). Further development needs to take place to improve the accuracy of the segmentation before IMU can be used to objectify training progress. Additionally, the gyroscope signals allow the visualization of the orientation of the body as well as the instantaneous axis of rotation. These findings support the potential of wearable IMUs as a practical tool for objective acrobatic activities analysis in both research and coaching environments.

Keywords: *vault, training, performance*

References

- Atiković, A., & Smajlović, N. (2011). Relation between vault difficulty values and biomechanical parameters in men's artistic gymnastics. *Science of Gymnastics Journal*, 3(3), 91–105. <https://doi.org/10.52165/sj.3.3.91-105>
- Boylen, A.M., Campbell, R.A., Drinkwater, E.J., & Bradshaw, E.J. (2025). Current biomechanical methods and practices of physical training load monitoring in women's artistic gymnastics: A scoping review. *Journal of Sports Sciences*, 43(18), 1992–2006. <https://doi.org/10.1080/02640414.2025.2528442>
- Čuk, I., & Karacsony, I. (2004). *Vault: Methods, ideas, curiosities, history*. ŠTD Sangvinčki.



REVIEW ABSTRACT

SMART JUDGING IN ARTISTIC GYMNASTICS: OPPORTUNITIES AND CHALLENGES OF DIGITAL JUDGING SYSTEMS

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Introduction / Purpose

As one of the founding Olympic sports, artistic gymnastics depends on human-based judging systems. Although judges are highly trained, subjective assessment may occasionally lead to scoring inaccuracies and potential bias, which can influence final rankings and medal distribution (Mercier & Heiniger, 2018). Recent technological developments have encouraged the implementation of computer-assisted judging systems designed to support more objective and consistent performance evaluation (Allen et al., 2021). The purpose of this paper is to provide an overview of current technological innovations in judging artistic gymnastics and discuss their potential benefits and challenges.

Methods

A narrative review of recent literature related to digital judging systems, electronic scoring technologies, and artificial intelligence (AI) applications in artistic gymnastics was conducted. Scientific publications addressing the implementation, effectiveness, and stakeholder perceptions of technology-assisted judging were analyzed.

Results

The reviewed literature suggests that the introduction of digital judging support systems contributes to greater scoring consistency, reduced influence of human error, and improved transparency in performance evaluation processes (Allen et al., 2021). Previous research has identified inconsistencies and potential sources of bias in gymnastics judging, highlighting the need for approaches that may improve the objectivity and reliability of performance evaluation (Mercier & Heiniger, 2018). In addition, athletes generally reported positive attitudes toward electronic judging systems, highlighting their potential to enhance fairness, reduce subjective influences, and increase confidence in competition outcomes (Mazurova & Penttinen, 2020). Nevertheless, existing literature highlights several limitations, including technological constraints, high implementation costs, and ongoing concerns about the appropriate role of human judges in complex evaluative contexts (Allen et al., 2021).



Conclusions

Digital technologies and artificial intelligence are increasingly recognized as tools that can enhance objectivity, reliability, and fairness of judging in artistic gymnastics. Current evidence suggests that these systems should not replace human judges but rather function as supportive mechanisms that assist decision-making processes and reduce potential biases (Allen et al., 2021; Mercier & Heiniger, 2018). The findings suggest that wider acceptance of technology-assisted judging may support its future implementation in gymnastics competitions, although further research is needed to examine its effectiveness in different competitive settings (Mazurova & Penttinen, 2020).

Keywords: *performance evaluation, reliability, fairness, objectivity*

References

- Allen, E., Fenton, A., & Parry, K. D. (2021). Computerised gymnastics judging scoring system implementation—an exploration of stakeholders' perceptions. *Science of Gymnastics Journal*, 13(3), 357-370.
- Mazurova, E., & Penttinen, E. (2020). Probing Athletes' Perceptions Towards Electronic Judging Systems: A Case Study in Gymnastics. In Annual Hawaii International Conference on System Sciences. Hawaii *International Conference on System Sciences*.
- Mercier, H., & Heiniger, S. (2018). Judging the judges: Evaluating the performance of international gymnastics judges. *arXiv preprint arXiv:1807.10021*.



PROFESSIONAL ABSTRACT

HAND SKIN INJURIES IN ARTISTIC GYMNASTS

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Introduction / Purpose

Hand skin injuries, including blisters, calluses, skin tears, and abrasions, commonly occur in artistic gymnasts due to repetitive gripping, friction, and mechanical loading during apparatus practice. Although usually not severe, these injuries may cause pain, interrupt training, and impair performance. While hand and wrist problems have been recognized in gymnastics, evidence specifically addressing hand skin injuries remains limited (Weiker, 1992). Therefore, this paper aimed to analyze the mechanisms of hand skin injury development, contributing factors, and prevention strategies in artistic gymnastics.

Methods

This professional paper is based on a review of scientific and professional literature on friction-related hand skin injuries, complemented by practical coaching and teaching experience. The analysis focused on injury mechanisms, risk factors, and preventive measures relevant to gymnastics.

Results

Hand skin injuries are primarily associated with repetitive friction, high training volume, poor callus management, skin dryness or excessive moisture, and improper grip use. Although calluses protect the skin, excessive thickening increases the risk of blistering and skin tears. Preventive measures include regular hand inspection, maintaining smooth calluses, moisturizing the skin after training, minimizing excessive moisture and friction, appropriate use of chalk and grips, and early intervention when burning sensations occur. Previous gymnastics-specific evidence suggests that brief cryotherapy may reduce blistering and skin tearing (Larson, 1975; Knapik et al., 1995). Once skin tears develop, recommended care includes removal of loose skin and proper disinfection.



Conclusions

Hand skin injuries represent an important practical issue in artistic gymnastics. Despite limited gymnastics-specific evidence, available literature supports incorporating daily skin care and preventive education into regular training practice.

Keywords: *artistic gymnastics, hand skin injuries, blisters, calluses, skin tears, injury prevention*

References

- Knapik, J. J., Reynolds, K. L., Duplantis, K. L., & Jones, B. H. (1995). Friction blisters: Pathophysiology, prevention and treatment. *Sports Medicine*, 20(3), 136–147.
<https://doi.org/10.2165/00007256-199520030-00002PubMed>
- Larson, W. E. (1975). Effect of cryotherapy in preventing blistering and tearing of hands of Utah State University male gymnasts [Master's thesis, Utah State University]. DigitalCommons@USU.
<https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=4206&context=etd>
- Source**
- Weiker, G. G. (1992). Hand and wrist problems in the gymnast. *Clinics in Sports Medicine*, 11(1), 189–202. [https://doi.org/10.1016/S0278-5919\(20\)30563-9](https://doi.org/10.1016/S0278-5919(20)30563-9)



REVIEW ABSTRACT

METHODOLOGICAL AIDS IN RYTHMIC GYMNASTICS FOR IMPROVED MOTOR DEVELOPMENT

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Introduction / Purpose

Rhythmic gymnastics is a sport that combines movement, music, aesthetics and technical precision. In educational and training contexts, it plays an important role in the development of children's motor abilities, including coordination, balance, flexibility, precision and rhythm. Training aids are important tools in the teaching and learning process as they facilitate the acquisition of movement patterns and enhance motivation during training sessions. The purpose of this paper was to examine the role and significance of training aids in rhythmic gymnastics and their contribution to the motor development in children and adolescents.

Methods

This scientific review is based on a theoretical analysis of relevant scientific and professional literature related to rhythmic gymnastics, motor development and instructional aids in physical education and sports training. The sources included a book and graduate theses addressing the application of training aids in teaching and coaching practice. The analysis is therefore focused on identifying different types of training aids and their practical application in rhythmic gymnastics training.

Results

The analysis showed that training aids significantly enhance the learning and execution of rhythmic gymnastics elements. Standard equipment, such as balls, hoops, ribbons, clubs and ropes, supports the development of coordination, rhythm, flexibility and precision, all of which are essential for skill progression. Improvised aids, including balloons, scarves and plastic bottles, improve accessibility and allow greater adaptability in various training environments. Special aids, such as elastic bands and balance boards, contribute to the development of flexibility, balance and other specific motor abilities. Their appropriate use increases children's motivation and engagement, thereby contributing to improved motor performance.



Conclusions

Training aids represent an important component of rhythmic gymnastics training. Their proper and creative application contributes not only to motor development but also to children's emotional and social growth. Coaches and teachers play a crucial role in selecting appropriate aids and ensuring their safe and effective use. The integration of training aids in rhythmic gymnastics can significantly improve training quality and support holistic child development.

Keywords: *rhythmic gymnastics, training aids, motor development, coordination, children, education*

References

- Andrić, T. (2017). Ritmička gimnastika [Bachelor's thesis, Juraj Dobrila University of Pula]. <https://repozitorij.unipu.hr/object/unipu:1729/FILE0>
- Findak, V. (1995). *Metodika tjelesne i zdravstvene kulture u predškolskom odgoju*. Školska knjiga.
- Fiolić, I. (2015). Metodika elemenata ritmičke gimnastike za djecu vrtićke dobi [Master's thesis, Faculty of Kinesiology, University of Zagreb]. <https://repozitorij.kif.unizg.hr/object/kif:167/FILE0>



ORIGINAL SCIENTIFIC ABSTRACT

RELEVANCE OF JUNIOR SUCCESSES FOR LATER SENIOR SUCCESSES AMONG EUROPEAN GYMNASTS

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Introduction / Purpose

Recent research (Güllich et al., 2023) suggests that elite junior and senior athletes largely constitute two distinct populations, as most successful juniors do not replicate their success as seniors, and vice versa. Overlap rates between junior and senior success were estimated at 17% (participants) and 12% (medalists). However, artistic gymnastics (AG) is underrepresented in these analyses. This study aims to investigate whether these overarching findings apply to AG.

Methods

In contrast to the review by Güllich et al. (2023), this study uses complete population data rather than retrospective or prospective design. We analyzed European female (WAG, birthyears 1990–2008) and male (MAG, birthyears 1986–2005) artistic gymnasts competing between 2004 and 2025 in junior (YOG, JWCh, JECh, EYOF) and senior (OG, WCh, ECh, EOG) competitions. Gymnasts were categorized by achievement (participation, individual medals) and age group. Frequencies and 95%-Confidence Intervals (CI95) were calculated for three pathways: success exclusively at junior age, at both junior and senior ages, or exclusively at senior age. Relative risks were calculated to compare the proportion of athletes successful at both junior and senior ages (overlap rates) with estimates from Güllich et al. (2023).

Results

Overall, 1683 female and 1340 male European gymnasts from the selected cohorts were analyzed. Among participants, 40.4% (38.1%–42.7%) of WAG and 44.9% (42.2%–47.6%) of MAG athletes competed successfully at both junior and senior ages, while 42.3% (39.9%–44.7%) and 42.9% (40.3%–45.5%), respectively, competed only as juniors and 17.3% (15.5%–19.1%) and 12.2% (10.4%–14.0%) only as seniors. Among medalists, overlap rates were substantially lower, reaching 27.2% (21.0%–33.4%) in WAG and 18.9% (14.0%–23.8%) in MAG. Junior-only medalists accounted for 45.1% (38.1%–52.1%, WAG) and 56.8% (50.6%–63.0%, MAG), whereas senior-only medalists represented 27.7% (21.4%–34.0%, WAG) and 24.3% (18.9%–29.7%, MAG), respectively.

**Conclusions**

These findings show that over 40% of participants and 19% (MAG) to 27% (WAG) of medalists competed successfully at both junior and senior ages. Compared with the sport-wide estimates reported by Güllich et al. (2023), overlap rates were 2.4–2.6 times (WAG-MAG) higher among participants and 1.6–2.3 times (MAG-WAG) higher among medalists. These discrepancies question whether overarching meta-analytical conclusions accurately reflect the specific developmental pathways in AG.

Keywords: *long-term athlete development, pathway to senior elite success*

References

- Güllich, A., Barth, M., Macnamara, B. N., & Hambrick, D. Z. (2023). Quantifying the Extent to Which Successful Juniors and Successful Seniors are Two Disparate Populations: A Systematic Review and Synthesis of Findings. *Sports Medicine*, 53(6), 1201–1217.
<https://doi.org/10.1007/s40279-023-01840-1>



REVIEW ABSTRACT

POMMEL HORSE-SPECIFIC PHYSICAL PREPARATION AND ENDURANCE IN MEN'S ARTISTIC GYMNASTICS: A NARRATIVE REVIEW

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Introduction / Purpose

The pommel horse (PH) is considered one of the most technically demanding apparatuses in men's artistic gymnastics (MAG), requiring exceptional levels of upper-limb strength, muscular endurance, shoulder stability, coordination, and precise movement control. Gymnasts performing at the elite level on PH exhibit high heart rates, elevated blood lactate concentrations, and considerable oxygen consumption during routines, indicating significant contributions from both anaerobic and aerobic energy systems (Seemann-Sinn et al., 2024). Furthermore, recent investigations have demonstrated that although general gymnastics physical preparation can improve overall endurance, optimal performance on the pommel horse requires highly specific physical preparation programs that closely replicate the technical and metabolic demands of the apparatus (Seemann-Sinn et al., 2025). Therefore, understanding the physiological characteristics and physical preparation requirements specific to the pommel horse is essential for designing effective training programs that enhance performance while minimizing fatigue-related technical errors.

Methods

A narrative review of the literature was conducted using peer-reviewed studies investigating the physiological demands, specific physical preparation strategies, endurance training, and performance characteristics of men's artistic gymnastics, with particular emphasis on the pommel horse. Additional literature addressing gymnastics-specific energy metabolism and physical preparation principles relevant to elite performance was also included.

Results

Evidence indicates that pommel horse performance places high physiological demands on gymnasts, characterized by elevated heart rate, oxygen uptake, and post-exercise blood lactate concentrations, reflecting the combined contribution of aerobic and anaerobic energy systems (Seemann-Sinn et al., 2024). Although gymnastics-specific high-intensity interval training improves overall endurance, Seemann-Sinn et al. (2025) reported limited improvements in pommel horse-specific performance, suggesting that physical preparation should closely replicate the apparatus's technical and biomechanical demands. Similarly, Corlaci et al. (2019) highlighted the importance of shoulder and trunk muscular endurance for maintaining movement quality under fatigue. Overall, the evidence supports integrating apparatus-specific physical preparation with technical training to optimize performance.



Conclusions

Successful pommel horse performance requires an integrated approach that combines technical skill acquisition with apparatus-specific physical preparation and endurance development. Current evidence supports the inclusion of targeted physical preparation protocols that reproduce the physiological and mechanical demands of competition. Nevertheless, the available literature remains limited, and further studies involving elite gymnasts are needed to establish evidence-based conditioning strategies capable of enhancing performance while reducing injury risk.

Keywords: *pommel horse, training, endurance, specific physical preparation*

References

- Seemann-Sinn, A., Rüdrich, P., Gorges, T., Sandau, I., Naundorf, F., & Wolfarth, B. (2024). Determining Physiological and Energetic Demands during High-Level Pommel Horse Routines Using a Modified Method Based on Heart Rate–Oxygen Uptake Functions. *Sports*, 12(1), 27
- Seemann-Sinn, A., Rüdrich, P., Sandau, I., Naundorf, F., Wolfarth, B. (2025) High-intensity interval training modifies energy supply in male artistic gymnastics and improves floor-specific but not pommel horse-specific endurance performance. *Frontiers in Sports and Active Living*, 7,1601074.
- Corlaci, I., Solcanu, M., & Bidiugan, S. (2019). Specific demands of the effort on the pommel horse in artistic gymnastics. In V. Grigore, M. Stănescu, M. Stoicescu, & L. Popescu (Eds.), *Education and Sports Science in the 21st Century*, vol 55. European Proceedings of Social and Behavioural Sciences (pp. 215-224). *Future Academy*.
<https://doi.org/10.15405/epsbs.2019.02.27>



ORIGINAL SCIENTIFIC ABSTRACT

THE ABILITY OF GIRLS AGED 11–14 WHO PRACTISE ACROBATIC GYMNASTICS TO MAINTAIN STATIC BALANCE

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Introduction / Purpose

A high level of postural control enables the correct execution of balancing elements, jumps and safe landings in acrobatic gymnastics. Balance assessment may involve both static and dynamic conditions; however, it remains unclear which type of test better reflects the specific requirements of this discipline. The aim of the study was to assess the ability to maintain static balance in girls aged 11–14 who train in sports acrobatics and to compare the results obtained with those of a group of peers not participating in organised physical activity.

Methods

The study involved 53 girls aged 11–14. The test group consisted of 18 competitive acrobatic gymnastics athletes, whilst the control group comprised 35 girls who did not regularly participate in sport. Balance assessment was carried out using the freeSTEP STANDARD stabilometric platform. Romberg's tests were performed whilst standing on both feet and on one leg (right and left lower limb), with eyes open and closed. The centre of pressure path length (PL), centre of confidence ellipse area (CEA), mean centre of pressure velocity (MV), and X-RMS and Y-RMS indices were analysed. The Mann–Whitney U test was used for intergroup comparisons.

Results

Under conditions with eyes open, significant differences were observed only for the X-RMS parameter whilst standing on the right leg ($p = 0.006$) and for the mean velocity of the centre of pressure whilst standing on the left leg ($p = 0.042$).



Conclusions

Female acrobatic gymnasts demonstrate a level of static balance similar to that of their peers who do not practise sport. This suggests that static balance tests may have limited ability to distinguish between levels of sporting proficiency in this discipline. An assessment of static balance alone does not fully reflect the effects of specialised acrobatic training and should be supplemented by measurements of dynamic balance.

Keywords: *acrobatic gymnastics, postural control, Romberg test*

References

- Omorczyk, J., Staszkievicz, R., Wrześniewski, K., & Puszczałowska-Lizis, E. (2022). Static Balance in Female Artistic Gymnasts and Non-Training Girls. *Applied Sciences*, 12(23), 12454.
<https://doi.org/10.3390/app122312454>



ORIGINAL SCIENTIFIC ABSTRACT

2026 EUROPEAN GYMNASTICS CHAMPIONSHIPS: SUSTAINABLE BENEFITS FOR LOCAL RESIDENTS

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Introduction / Purpose

Although empirical research on the impacts of international gymnastics championships remains limited, previous studies that have examined residents' perceptions of large-scale sporting events using cross-sectional designs indicate that different impacts are to be expected (Johnston, Naylor, & Dickson, 2023; Lohmann et al., 2026). Such events generate benefits by strengthening community engagement, enhancing destination visibility, and supporting the involvement of new generations. The purpose of this study is to present baseline findings on residents' perceptions of the 2026 European Gymnastics Championships in Zagreb.

Methods

Data were collected four months before the 2026 European Gymnastics Championships through an online survey of 725 residents of the City of Zagreb. The questionnaire measured perceived economic, social, environmental, community, and destination-related impacts, together with residents' support for hosting the championship. The data were analysed to characterise residents' perceptions across the assessed dimensions.

Results

In anticipation of this event, local residents generally expressed positive attitudes towards hosting the European Gymnastics Championships. Increased destination visibility and an enhanced image, as well as opportunities for residents to learn about and enjoy top-class gymnastics and to meet new people, received the highest evaluations. Economic benefits were not perceived as particularly significant. Residents are not worried about security or environmental issues, but identified a lack of parking as a major problem. Finally, on average they express strong support for this and similar sporting events in Zagreb.



Conclusions

This study contributes to the sport event management literature by demonstrating that residents' support for international gymnastics championships is better explained by community- and destination-oriented perceptions than by expected economic benefits. It offers practical implications for organisers, destination managers and policy-makers seeking to maximise the long-term legacy of international gymnastics events.

Keywords: *sport event management, European Gymnastics Championships, impact of the event, residents' perceptions, community support*

References

- Johnston, M., Naylor, M., & Dickson, G. (2023). Local resident support for hosting a major sport event: the role of perceived personal and community impacts. *European Sport Management Quarterly*, 23(3), 877–896. <https://doi.org/10.1080/16184742.2021.1937263>
- Lohmann, P., Swart, K., Virkki, K., Cohen, M., Feller, R. (2026). FIFA World Cup Qatar 2022: Perceptions and Experiences Through the Lens of Tourists, Residents, and Overseas Spectators. *Event Management*, 30(4), 529–546. <https://doi.org/10.3727/152599525X17551312270841>



ORIGINAL SCIENTIFIC ABSTRACT

TYPES AND SEQUENCE OF ERRORS DURING CIRCLES ON THE POMMEL HORSE

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Introduction / Purpose

Circles are a fundamental elements on the pommel horse, because most of the harder elements and routines on this apparatus are built on them. Even though technique keeps improving, top-level gymnasts still has many errors and falls, especially in the finals of big competitions. So far, the literature does not clearly say which biomechanical variable is the first thing that starts the breakdown of the movement. This prospective study aims to identify biomechanical changes associated with technical errors and falls, determine whether errors occur in a characteristic sequence, examine agreement between gymnasts' perceived causes of falls and measured biomechanical variables, and assess associations between anthropometric characteristics and error patterns.

Methods

The study will include 35 adult male gymnasts able to perform at least 30 consecutive circles on the pommel horse. Anthropometric characteristics and body composition will be assessed using a 3D body scanner and InBody 720, followed by 3D kinematic recording with a 12-camera Qualisys Oqus motion-capture system at 180 Hz. Each gymnast will perform three trials of circles until failure, with 10 minutes of rest between trials. After each trial, gymnasts will report their perceived cause of the fall. Joint angles, angular velocities, support-phase durations, error sequences, and associations with anthropometric characteristics will be analysed.

Results

Preliminary pilot data were obtained from one elite Slovenian gymnast. The horizontal trajectories of the center of mass of the whole body, head and trunk, and lower limbs were analysed. The observed movement patterns were consistent with those reported by Fujihara et al. (2009): the whole-body centre of mass followed an elliptical path oriented across the longitudinal axis of the pommel horse, the head-and-trunk centre of mass followed an ellipse aligned with this axis, and the lower-limb centre of mass followed a more circular trajectory. These preliminary findings support the feasibility of the measurement and analysis protocol and provide a reference pattern for subsequent analyses of movement breakdown.



Conclusions

The pilot findings support the feasibility of the proposed biomechanical protocol. The full study is expected to identify the sequence of technical errors and biomechanical variables that may serve as early indicators of movement breakdown. These findings could enable coaches to monitor performance more objectively, detect critical deviations earlier, and individualize technical and conditioning programmes to reduce errors and falls in competition.

Keywords: *pommel horse, circles, biomechanics, 3D kinematics, technical errors, fall*

References

- Baudry, L., Leroy, D., Thouvarecq, R., & Chollet, D. (2009). Effect of fatigue on sagittal plane kinematics of the pommel horse circle. *Journal of Sports Sciences*, 27(2), 119–131. <https://doi.org/10.1080/02640410802422171>
- Fujihara, T., Gervais, P., & Kunimasa, Y. (2009). Coordination between the rotation of the center of mass and the body's long axis rotation in pommel horse circles. *Journal of Biomechanics*, 42(14), 2341–2347. <https://doi.org/10.1016/j.jbiomech.2009.06.027>
- Fujihara, T., & Gervais, P. (2010). Movement of the center of mass and its relationship to rotation in pommel horse circles. *Sports Biomechanics*, 9(3), 143–157. <https://doi.org/10.1080/14763141.2010.511674>



ORIGINAL SCIENTIFIC ABSTRACT

GYMNASTICS ROTATION PREFERENCES IN NOVICES: A QUANTITATIVE STUDY ON POSSIBLE ROTATION DIRECTION RELATIONSHIPS

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Introduction / Purpose

Certain combinations of rotation directions across skills provide technical advantages or enable further movement learning (Bessi & Pfeifer, 2018; Crumley, 1998). Experienced gymnasts often display a bilateral rotation scheme (Bessi & Pfeifer, 2018). It remains unclear whether this scheme also occurs in individuals without gymnastics experience or whether it develops primarily through gymnastics-specific training. This study examined the relationship between rotation directions in fundamental gymnastics skills among novices.

Methods

N=843 applicants of the sports aptitude test at the German Sport University Cologne participated in this study. After considering exclusion-criteria (i.e., 1: incomplete documentation or incorrect skill-specific execution [n=33], 2: inter-rater disagreement [n=12], 3: gymnastics-specific experience [n=108]), 690 participants remained for further statistical analyses. The participants were observed during the floor component, where pairs of two independent raters documented the rotation direction of the straight jump with a half turn and the side of the support leg of the cartwheel for each participant. Inter-rater reliability was calculated using Cohen's kappa, following the initial exclusion criterion (1). A chi-square test of independence and Cramér's V were calculated to determine a potential relationship between the turning directions. Relative frequencies were used to examine the direction of relationship. Statistical analyses were performed using R-Studio. Level of significance was set at $\alpha = .05$.

Results

The inter-rater reliability was near-perfect for both skills ($\kappa = .98$). A significant but small relationship between the rotation directions of the two skills was found ($\chi^2 = 12.78$, $df = 1$, $p < .001$, Cramér's $V = .14$). A bilateral rotation scheme was used by 60.00% of participants, who rotated in opposite directions in upright and inverted skills.



Conclusions

Even without gymnastics-specific training, the bilateral rotation scheme occurs more frequently than the unilateral scheme, although less often than in experienced gymnasts (Bessi & Pfeifer, 2018). This suggests that gymnastics-specific influences might strengthen an already existing tendency. Coaches should consider athletes' rotation preferences from early training stages to support advantageous rotation combinations.

Keywords: *laterality, rotation scheme, bilateral, unilateral, motor development, sports aptitude test*

References

- Bessi, F., & Pfeifer, J. (2018). Rotation schemes of the best female gymnasts in the world. *Science of Gymnastics Journal*, 10(3), 401–411.
<https://doi.org/10.52165/sgj.10.3.401-411>
- Crumley, K. (1998). Optimal skill continuity. *Technique*, 18(6), 1–5.



REVIEW ABSTRACT

UNDERSTANDING ARTISTIC IMPRESSION IN RHYTHMIC GYMNASTICS: A PHILOSOPHICAL REVIEW

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Introduction / Purpose

Artistic impression is one of the four components of performance evaluation in rhythmic gymnastics, yet its conceptual foundations remain insufficiently discussed within sport science literature. While previous reviews have documented the historical development of artistry and aesthetic evaluation in rhythmic gymnastics, less attention has been devoted to the philosophical nature of artistic impression itself. Although the FIG Code of Points specifies detailed evaluation criteria, artistic impression continues to involve aesthetic judgement, interpretation, and embodied perception that cannot be fully explained by technical performance alone. The purpose of this review is to clarify the conceptual nature of artistic impression as an evaluative construct by examining how philosophical aesthetics, phenomenology, and hermeneutics contribute to understanding artistic evaluation in rhythmic gymnastics.

Methods

A systematic literature search was conducted using scientific databases to identify peer-reviewed publications addressing philosophical aesthetics, philosophy of sport, artistic impression, rhythmic gymnastics, judging, embodiment, and movement interpretation. Publications published between 1990 and 2026 were eligible for inclusion. A narrative review combined with qualitative content analysis was used to identify philosophical concepts explaining how artistic impression is constituted, experienced, and interpreted within the judging process.

Results

The reviewed literature suggests that artistic impression represents an emergent and relational phenomenon rather than an isolated performance characteristic. It arises through the interaction between movement, music, performer, observer, and cultural context, making it only partially reducible to technical evaluation. Philosophical aesthetics provides a framework for understanding beauty, harmony, and expressive quality in movement, while phenomenology conceptualises the body as the primary medium through which artistic meaning is embodied and communicated. Hermeneutic perspectives further explain artistic evaluation as an interpretive process in which meaning is co-constructed through the relationship between performer, judge, and spectator. Together, these approaches demonstrate that artistic impression extends beyond observable movement characteristics and includes aesthetic perception, interpretation, and lived experience, helping to explain why complete objectification of artistic judging remains philosophically unattainable despite increasingly detailed evaluation criteria.



Conclusions

Artistic impression in rhythmic gymnastics should be understood as a relational and interpretive construct emerging through the interaction between performer, movement, music, and observer. Philosophical perspectives complement sport science by providing a conceptual framework for understanding dimensions of artistic evaluation that cannot be fully captured through technical criteria alone. This framework may support the refinement of judging systems, coach education, and future empirical research aimed at operationalising artistic impression while acknowledging the inherently interpretive nature of aesthetic judgement.

Keywords: *rhythmic gymnastics, artistic impression, philosophy of sport, aesthetics, embodiment, judging*

References

- Kant, I. (2007). *Critique of the Power of Judgment*. Oxford University Press. (Original work published 1790).
- Merleau-Ponty, M. (2012). *Phenomenology of Perception*. Routledge. (Original work published 1945).
- Parry, J. (2011). Sport and aesthetics. In M. McNamee & W.J. Morgan (Eds.), *Routledge Handbook of the Philosophy of Sport* (pp. 245–256). Routledge.



ORIGINAL SCIENTIFIC ABSTRACT

BRIDGING THEORY AND PRACTICE THROUGH FLIPPED LEARNING IN GYMNASTICS EDUCATION

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Introduction / Purpose

In gymnastics, linking theory and practice is a central instructional challenge, reflected in gymnastics educational and coaching research (Jeraj et al., 2015). However, student evaluations in physical education teacher education and coach education indicate a gap between acquiring theory and applying it in teaching or coaching situations. Flipped classroom approaches may strengthen theory-practice integration by shifting knowledge acquisition to asynchronous phases and using sessions for application and reflection (O'Flaherty & Phillips, 2015). Therefore, this study investigated whether a platform-based flipped classroom enhances student teachers' perceptions of theory-practice integration in university gymnastics teacher education compared with a traditional instructional format.

Methods

A quasi-experimental design was implemented in six university gymnastics course groups. Students were assigned to either a flipped classroom intervention or a traditional instructional format. A questionnaire was developed based on semi-structured interviews with physical education teachers, module descriptions, and institutional quality standards. Internal consistency was examined using Cronbach's α . Group differences were analysed using Mann-Whitney U tests with Benjamini-Hochberg correction for multiple testing and effect sizes (r). Statistical significance was set at $\alpha=.05$.

Results

Significant differences in favour of the flipped classroom were, for instance, found for teaching theoretical background ($U=1530.5$, $p<.01$, $r=.37$) and learning opportunities for teaching preparation ($U=1402.5$, $p<.05$, $r=.27$). For integration with the biomechanics lecture ($U=1074.0$, $p>.05$, $r=.20$) and theory-practice transfer between biomechanics and gymnastics ($U=1166.0$, $p>.05$, $r=.21$), no group differences remained statistically significant after correction for multiple testing.



Conclusions

To conclude, the flipped classroom performed often better than and at least as well as the traditional instructional format. Although item-specific differences require cautious interpretation, the findings suggest that flipped classroom approaches strengthen theory-practice integration in gymnastics teacher education. The concept may also transfer to coach education by increasing the perceived practical relevance of theoretical learning.

Keywords: *educational methodology, blended learning, instructional design, knowledge application, perceived competence*

References

- Jeraj, D., Veit, J., Heinen, T., & Raab, M. (2015). How do gymnastics coaches provide movement feedback in training? *International Journal of Sports Science & Coaching*, 10(6), 1015–1024.
<https://doi.org/10.1260/1747-9541.10.6.1015>
- O'Flaherty, J., & Phillips, C. (2015). The use of flipped classrooms in higher education: A scoping review. *The Internet and Higher Education*, 25, 85–95. <https://doi.org/10.1016/j.iheduc.2015.02.002>



ORIGINAL SCIENTIFIC ABSTRACT

CORE MUSCLE FUNCTION AS A DETERMINANT OF LANDING STABILIZATION IN FEMALE ARTISTIC GYMNASTS

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Introduction / Purpose

Effective trunk stabilization is essential for athletic performance and injury prevention in artistic gymnastics. During landings, gymnasts are exposed to high impact forces that require efficient trunk muscle activation to absorb loads, maintain postural control, and coordinate movement. Although trunk function is considered important, its contribution to landing stabilization has not been sufficiently investigated. This study examined the relationship between trunk muscle activity, trunk strength endurance, and postural stabilization during different gymnastics landing tasks.

Methods

Seventeen competitive female artistic gymnasts (14.2 ± 2.2 years) performed four landing tasks: drop landing (DL), forward somersault (FS), backward somersault (BS), and an acrobatic series (round-off – back handspring – tucked backward somersault; AS). Postural stabilization was assessed using an inertial measurement unit positioned at the lumbar spine by analyzing sagittal and frontal-plane angular velocities during the first 1 and 3 s after landing. Surface electromyography recorded activity of the rectus abdominis, external oblique, and erector spinae muscles from 300 ms before to 300 ms after ground contact. Trunk strength endurance was evaluated using the Bourban Trunk Muscle Strength Test and the Y-Balance Test Upper Quarter. Principal component analysis and multivariate regression identified associations between trunk function and landing stabilization.

Results

Significant associations were found only in the sagittal plane during DL and FS. Greater external oblique activity before and after ground contact and higher trunk flexor endurance were associated with better postural stabilization across both assessment intervals. In contrast, greater rectus abdominis activity immediately after landing was associated with poorer stabilization. No significant relationships were observed for BS or AS, and no significant associations were found in the frontal plane.



Conclusions

Optimal trunk function contributes to landing stabilization in female artistic gymnasts. Increased external oblique activation and trunk endurance appear beneficial, whereas excessive rectus abdominis activation may impair stabilization. These findings support the inclusion of trunk-focused conditioning to improve landing performance and potentially reduce injury risk.

Keywords: *biomechanics, gymnastics, landing, muscle activity, stabilization, somersault*

Acknowledgement

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References

- Arai, A., Ishikawa, M., & Ito, A. (2013). Agonist–antagonist muscle activation during drop jumps. *European Journal of Sport Science*, 13(5), 490–498. <https://doi.org/10.1080/17461391.2013.764930>
- Glynn, B., Laird, J., Herrington, L., Rushton, A., & Heneghan, N.R. (2022). Analysis of landing performance and ankle injury in elite British artistic gymnastics using a modified drop land task: A longitudinal observational study. *Physical Therapy in Sport*, 55, 61–69. <https://doi.org/10.1016/j.ptsp.2022.01.006>
- Kerr, Z.Y., Hayden, R., Barr, M., Klossner, D.A., & Dompier, T.P. (2015). Epidemiology of National Collegiate Athletic Association Women's Gymnastics Injuries, 2009–2010 through 2013–2014. *Journal of Athletic Training*, 50(8), 870–878. <https://doi.org/10.4085/1062-6050-50.7.02>



ORIGINAL SCIENTIFIC ABSTRACT

DO JUDGES SEE WHAT MECHANICS MEASURE? COMPARING BIOMECHANICAL AND JUDGE-BASED EVALUATION OF THE WATANABE DISMOUNT

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Introduction / Purpose

International judging in men's artistic gymnastics demonstrates high inter-rater reliability (Atiković et al., 2011). Nevertheless, judging remains qualitative and susceptible to subjective influences, highlighting the need to objectify performance evaluation biomechanically (Fung et al., 2025). Judges' deductions and biomechanical measures represent complementary perspectives (e.g., on landings following dismounts); their correspondence remains unclear. This study presents a protocol for comparing biomechanically derived and judges' deductions for the Watanabe dismount on horizontal bar.

Methods

58 Watanabe dismounts with complete multi-camera data were recorded at the 2025 European Championships (Leipzig, Germany). Recordings used eight synchronized cameras (Baumer VLXT-31C) and markerless motion capture (SIMI Nemo, 100 Hz), with pose estimation performed by a gymnastics-specific acrobatic AI model. Independently, an additional camera recorded each dismount from the typical judging perspective, which international judges will view once and rate immediately. From the 3D motion-capture data, selected Code of Points criteria (e.g., flight height, landing below knee level, and leg separation) will be operationalised as biomechanical measures and combined into a biomechanical deduction score. Analyses will compare biomechanical and judge-based deductions using Bland-Altman analysis, with inter-judge agreement serving as the reliability ceiling.

Results

The processing pipeline and translation of judging criteria into biomechanical measures have been established. Several criteria can be quantified directly, whereas technical and aesthetic faults remain outside the model and are expected to define the limits of agreement. Agreement analyses will follow upon completion of data processing.



Conclusions

This protocol proposes comparing biomechanical measures with expert judging of the Watanabe dismount, treating both as complementary perspectives on landing quality. Translating judging criteria into objective mechanical measures provides a transferable framework for other apparatus and may inform judge training.

Keywords: *artistic gymnastics, horizontal bar, dismount, landing, judging, markerless motion capture*

References

- Atiković, A., Delaš Kalinski, S., Bijelić, S., & Avdibašić Vukadinović, N. (2011). Analysis results judging world championships in men's artistic gymnastics in the London 2009 year. *SportLogia*, 7(2), 95–101.
<https://doi.org/10.5550/sgia.110702.en.095a>
- Fung, S., Han, Y.-S., & Mickevics, A. (2025). Using structural equation modelling to reassess bias in judging the vault event in men's artistic gymnastics. *Scientific Reports*, 15(1), 22011.
<https://doi.org/10.1038/s41598-025-05939-5>



ORIGINAL SCIENTIFIC ABSTRACT

STUDENTS' PERCEPTIONS OF PERFORMANCE, ORGANIZATION, AND SPOTTING OF SAFE GYMNASTICS 4ALL WEBSITE**Peter Vončina**

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Introduction / Purpose

Safe and effective gymnastics instruction requires appropriate selection of elements, careful lesson organization, and adequate spotting skills. This study examined Faculty of Sport students' perceptions of selected gymnastics elements presented on the Safe Gymnastics 4All. The aim was to assess the perceived difficulty of performing the elements, organizing their instruction in school physical education and gymnastics training, and providing appropriate spotting.

Methods

A quantitative research design was used. The sample consisted of 41 undergraduate and graduate students from the Faculty of Sport, University of Ljubljana, selected using judgment sampling. Data were collected through an anonymous online questionnaire using the 1KA survey platform. Students rated the difficulty of performing selected gymnastics elements, organizing instruction, and spotting using a 5-point Likert scale (1 = very easy, 5 = very difficult). Data were analysed in SPSS using descriptive statistics (frequencies, percentages, means, and standard deviations) and independent-samples t-tests to examine gender differences.

Results

Students rated the selected gymnastics elements as moderately difficult on average. The highest difficulty ratings were assigned to elements requiring good movement coordination and high levels of arm and shoulder girdle strength. Students generally considered most elements suitable for teaching in Grades 7–9 of primary school. The greatest challenges in lesson organization were identified as heterogeneous levels of participants' knowledge and abilities (85.4%), large group sizes (80.5%), and insufficient equipment (78.0%). Spotting was perceived as particularly demanding for acrobatic elements involving greater height and rotation. No statistically significant gender differences were found in the perceived difficulty of performance ($p = .568$), organization ($p = .698$), or spotting ($p = .998$).



Conclusions

The findings indicate the importance of high-quality practical training in lesson organization and spotting techniques to strengthen students' confidence and support safer gymnastics instruction in schools and sports clubs. Elements perceived as more difficult were also considered more demanding to organize and spot, highlighting the need for professional expertise, careful preparation, and appropriate safety measures.

Keywords: *gymnastics, Safe Gymnastics 4All, organization, spotting, physical education*

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References

Hedbávný, P., Kalichová, M., Čuk, I., Pajek, M., Možnik, M., & Milčič, L. (2023). *Discipline orodne telovadbe*. Varna telovadba za vse. Masaryk University.

https://is.muni.cz/do/fsps/e_learning/safe_gymnastics_4all/pages_sl/discipline.html

Novak, D., & Kovač, M. (2021). *Gimnastična abeceda*. Univerza v Ljubljani, Fakulteta za šport, Inštitut za šport.

Jurak, G., Rankel, P., Slanič, K. B., Starc, G., Markelj, N., Potočnik, Ž. L., Meh, K., Videmšek, M., Fetih, J., Plesec, M., Gregorc, J., Štemberger, V., Geršak, V., Dolenc, N., Kovač, U., Volmut, T., Planinšek, J., & Kovač, M. (2023). Smernice za umestitev gibalnih dejavnosti v vzgojno izobraževalni vsakdan. *Šport*, 71(1/2), 239–262.



ORIGINAL SCIENTIFIC ABSTRACT

DOES GYMNASTICS TRAINING AFFECT GROWTH IN STATURE AMONG CHILDREN?

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Introduction / Purpose

The potential influence of intensive sports training on growth and maturation in children has been widely discussed. Previous studies have suggested that physical activity and systematic training may affect certain anthropometric characteristics; however, the impact of intensive gymnastics training on growth in stature remains a topic of interest. The aim of this study was to determine the influence of intensive gymnastics training on changes in body height, body mass, and upper arm circumference in young gymnasts.

Methods

The study followed 25 male gymnasts from Zagreb who were involved in an intensive training program over a period of 10 years. Anthropometric measurements were collected longitudinally and compared with measurements obtained from 63 age-matched school boys from Zagreb who were not involved in intensive sports activities. Changes in stature, body mass, and upper arm circumference were analyzed throughout the observed period.

Results

At the beginning of the observation period (at the age of 8 years), gymnasts had lower values of all measured anthropometric characteristics compared with their non-athlete peers. They were shorter, lighter, and had a smaller upper arm circumference. During the 10-year follow-up period, the growth curves for stature and body mass showed proportional development in both groups, with no significant deviations observed at any age. These findings indicate that intensive gymnastics training did not negatively affect height growth or body mass development. Although gymnasts also had a smaller upper arm circumference at the age of 8 years, a continuous increase was observed throughout the follow-up period, resulting in significantly greater values at the age of 18 years compared with school boys.



Conclusions

The results suggest that intensive gymnastics training does not impair growth in stature or body mass development in children. Furthermore, gymnastics training appears to contribute to a greater increase in muscle mass, reflected by the higher upper arm circumference values in adolescent gymnasts. Since body mass increased proportionally in both groups while gymnasts demonstrated greater muscular development, gymnastics training may influence a higher proportion of muscle mass within total body mass.

Keywords: *gymnastics, stature, body mass, upper arm circumference*

References

- Malina, R.M. (1993). Physical activity and training: Effects on stature and the adolescent growth spurt. *Medicine and Science in Sports and Exercise*, 26(6), 759–766.
- Medved, R., et al. (1989). Pokazatelji rasta školske djece i omladine muškog spola od 8. do 18. godine života. *Medicinski vjesnik*, 21(1–2), 1–4.
- Vuković, R. (1999). Longitudinalna studija rasta i razvoja nekih antropoloških obilježja gimnastičara (Master's thesis).



ORIGINAL SCIENTIFIC ABSTRACT

PERFORMANCE EFFICIENCY IN ELITE RHYTHMIC AND ARTISTIC GYMNASTS: THE ROLE OF COMPETENCIES, MOTIVATION, AND PSYCHOLOGICAL FACTORS

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Introduction / Purpose

Competencies are complex sets of characteristics that enable individuals to perform activities effectively and successfully. These include personal and environmental factors, as well as motivation, self-confidence, and anxiety management, which, together with physical and psychomotor abilities, play an important role in optimizing athletic performance. The aim of this study was to compare the competency profiles and development preferences of athletes in rhythmic gymnastics and artistic gymnastics, as well as an elite handball control group. Furthermore, the relationships between motivation, anxiety, self-confidence, and achievement goal orientations were examined. We hypothesized that there would be no significant differences in motivational factors between the two gymnastics disciplines, while differences would emerge in competency development preferences.

Methods

The participants were members of the Hungarian national teams in rhythmic gymnastics and women's artistic gymnastics ($N = 50$), as well as athletes from the Hungarian Handball Academies ($N = 40$). Data were collected using a battery of six standardized sport psychology questionnaires assessing motivation, self-confidence, anxiety, and psychological competencies.

Results

The findings are exploratory in nature. Across all sports examined, self-confidence was identified as the most important competency for development, followed by concentration. In rhythmic gymnastics, work capacity emerged as a key competency, whereas technical level was emphasized in artistic gymnastics. The rhythmic gymnastics group demonstrated a high mean motivational factor score ($M = 21.17$), indicating a relatively homogeneous motivational pattern. Different correlation patterns were observed between competencies and physical abilities in artistic gymnastics across the 120 possible relationships examined. In both gymnastics disciplines, a positive relationship was found between self-confidence and task orientation.

**Conclusions**

The intensity and internal variability of motivational factors differed across sports, reflecting the specific demands and psychological load of each discipline. Overall, the findings suggest that the development of psychological competencies requires a sport-specific approach. Although rhythmic gymnastics and artistic gymnastics share several characteristics, the relationships among motivational orientations, anxiety, and self-confidence appear to be influenced by the unique requirements of each sport. Future research will extend the study to male artistic gymnasts in order to gain a more comprehensive understanding of psychological characteristics across gymnastics disciplines.

Keywords: *rhythmic gymnastics, artistic gymnastics, competencies, self-confidence, anxiety*

References

- Wehovszky, V., Nagykalldi, C., Kalmár, Z., & Ökrös, C. (2025). Connections between competencies and abilities in female artistic gymnasts and handball players. *Frontiers in Sports and Active Living*, 7, 1681743.
- Wehovszky V. (2023) „Válogatott tornászleányok és ritmikus gimnasztikázók önértékelése a személyiségi tényezők és orientációk háttérében”. *Magyar Sporttudományi Szemle*, 24(4/104), 22-28.
- Wehovszky V. (2022) „Ritmikus gimnasztikázók önbizalma és versenyszorongása”. *Magyar Sporttudományi Szemle*, 2022 (6), 100, 78-83.



ORIGINAL SCIENTIFIC ABSTRACT

GYMNASTICS CONTENT IMPLEMENTATION IN SLOVENIAN LOWER SECONDARY SCHOOLS: A COMPARISON WITH THE 2007 STUDY

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Introduction / Purpose

Gymnastics is included in the Slovenian physical education curriculum and involves locomotor, stability, and body-control movements (Bučar Pajek et al., 2010; Kovač et al., 2011). This study examined the current implementation of gymnastics in Grades 7–9 and compared it with findings from 2007 (Turšič, 2007).

Methods

The study included 90 physical education teachers from Slovenian primary schools. An online questionnaire, partly based on the 2007 questionnaire, collected data on annual lesson numbers, planning, equipment, barriers, and teachers' opinions. Descriptive statistics and one-sample t-tests were used.

Results

Most teachers (88.9%) systematically included gymnastics in their annual teaching plans. Mean annual lesson numbers were 11.26 in Grade 7 ($n = 87$, $p = .129$), 10.66 in Grade 8 ($n = 87$, $p = .034$), and 10.46 in Grade 9 ($n = 84$, $p = .010$). Compared with 2007, no statistically significant difference was found in Grade 7, whereas the number of lessons was significantly higher in Grades 8 and 9. The most common barriers were insufficient student prior knowledge (64.7%), low student interest (42.4%), safety concerns (38.8%), and lack of equipment (35.3%).



Conclusions

Gymnastics remains part of physical education in the third cycle of Slovenian primary schools. Its lesson time has not decreased since 2007 and was higher in Grades 8 and 9. However, equipment, teacher education, and safe, progressive teaching remain important for improving implementation.

Keywords: *gymnastics, physical education, primary school, curriculum implementation, teachers*

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References

- Bučar Pajek, M., Čuk, I., Kovač, M., & Jakše, B. (2010). Implementation of the gymnastics curriculum in the third cycle of basic school in Slovenia. *Science of Gymnastics Journal*, 2(3), 15–27.
- Kovač, M., Markun Puhan, N., Lorenci, B., Novak, L., Planinšec, J., Hrastar, I., Pleteršek, K., & Muha, V. (2011). Učni načrt. Program osnovna šola. Športna vzgoja. Zavod Republike Slovenije za šolstvo.
- Turšič, B. (2007). Izpeljava gimnastičnih vsebin v tretjem triletju osnovne šole [Master's thesis, University of Ljubljana, Faculty of Sport].



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