Developing sport-specific balance in rhythmic gymnastics: an evidence-informed training and assessment model

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Abstract

Balance is a central determinant of technical execution in rhythmic gymnastics, where athletes must combine a narrow base of support, large-amplitude body positions, pivots, apparatus handling and synchronization with music. This methodological study aimed to synthesize peer-reviewed evidence on postural control in rhythmic gymnasts and develop a structured, sport-specific eight-week balance-training and assessment model. A focused narrative synthesis considered published observational studies, intervention trials and balance-test development research. Evidence indicates that expert gymnasts demonstrate distinctive medio-lateral postural control; integrated core and plyometric training can improve selected balance outcomes; and sport-specific balance tests can capture demands absent from simple static tasks. On this basis, a three-phase training model is proposed, progressing from alignment and single-leg control to sensory challenges, apparatus integration and performance under task interference. An assessment battery combining static stance, standardized rhythmic-gymnastics balances, apparatus-related dual tasks and technical execution ratings is described. A prospective two-group evaluation protocol and statistical analysis plan are specified. No original athlete measurements were collected for this article; thus, the reported findings represent a synthesis of published evidence and a proposed methodology rather than proof of effectiveness of the new model. The model offers coaches a practical basis for individualization and researchers a reproducible intervention for future validation.

Keywords: rhythmic gymnastics, postural control, balance training, proprioception, motor coordination, apparatus handling, training methodology.

Introduction

Rhythmic gymnastics integrates complex body difficulties with apparatus manipulation and expressive movement. The athlete must produce precise limb trajectories while preserving a controlled relationship between the centre of mass and the supporting foot. A balance that is visually impressive may nevertheless become unstable when the performer initiates a throw, changes gaze direction, rises onto the forefoot or prepares a subsequent pivot. Accordingly, the pedagogical problem is not simply to extend single-leg standing time, but to maintain the quality of technical action when sensory and mechanical conditions change.

Balance can be understood as the regulation of body orientation and equilibrium through interacting visual, vestibular and somatosensory information. It includes anticipatory adjustments before voluntary movement and compensatory responses following disturbance. In rhythmic gymnastics, balance also depends on task-specific constraints: amplitude of the free-leg position, trunk inclination, ankle plantar-flexion, tempo and visual attention toward the apparatus. Training specificity is therefore essential. A generic balance exercise may support foundational control without necessarily improving competition-relevant elements.

Calavalle and colleagues [1] identified enhanced medio-lateral postural control in experienced rhythmic gymnasts compared with athletes from other sports. Chen and colleagues [2] reported advantages in sensory organization when visual information was unreliable, while noting that advantages did not extend uniformly across all tested conditions. These findings suggest that technical expertise is associated with particular control strategies rather than a universal superiority in every balance task. Recent evidence has further emphasized the contribution of somatosensory and visual signals [3].

Training-related evidence is especially important. In a randomized study involving 44 young gymnasts, Cabrejas and colleagues [4] observed improvements in selected single-leg and gymnastics-specific outcomes after eight weeks of integrated functional core and plyometric training. A cross-sectional study of 126 gymnasts found that balance-related tests were associated with performance scores, although predictive relationships varied by developmental category [5]. More recently, Stojkovic and colleagues [6] developed a sport-specific balance assessment in a small pilot sample, highlighting the importance of apparatus-related and cognitive demands. Taken together, these studies justify an integrated training model, but do not establish that any single exercise sequence is optimal.

The aim of this article is to formulate an

Table 1. .Proposed eight-week progression (author-developed framework).

Stage	Weeks	Primary objectives	Illustrative task progression
Foundation	1–2	Foot–ankle control; trunk alignment; bilateral comparison	Flat-foot single-leg stance; slow relevé; arabesque entry and exit; static ball hold
Sensorimotor progression	3–5	Controlled perturbation; gaze changes; transitions	Head turns on stable support; supported pivot preparation; rhythmic stance changes; apparatus circles
Competition transfer	6–8	Postural precision under apparatus and musical demands	Balance-to-pivot links; apparatus throw-and-catch preparation; timed sequences; scored technical execution

evidence-informed methodological model for developing and monitoring sport-specific balance in young rhythmic gymnasts. The objectives are to identify relevant neuromotor components, structure an eight-week training progression, select feasible monitoring tests, and specify an empirical design capable of assessing the proposed model without conflating expected and observed outcomes.

Materials and Methods

Study design. This is a focused scientific-methodological review with intervention modelling, not an original trial involving human participants. Peer-reviewed articles were identified through targeted searches of scientific publishers and bibliographic resources, prioritizing research directly addressing rhythmic gymnastics, postural control, sensory integration, functional training and measurement. The evidence was interpreted narratively; no systematic-review claim, pooled meta-analysis or newly measured training effect is made. Particular weight was placed on source transparency, sport specificity, sample characteristics and limitations of the published designs.

The model distinguishes four complementary dimensions: (i) mechanical alignment and local ankle–foot control; (ii) proximal stabilization and coordinated hip–trunk activity; (iii) sensory reweighting when vision or support conditions change; and (iv) task-specific balance during apparatus manipulation, transitions and performance demands. Each dimension is trained progressively while avoiding substitutions in which extreme range of motion is mistaken for functional postural quality. Individual maturation, mobility and technical readiness should determine difficulty.

Proposed participants and experimental verification. A future prospective trial could recruit approximately 40–48 female rhythmic gymnasts aged 10–14 years with at least two years of training experience. This is a planning target, not an achieved sample or a formal power calculation. Following baseline assessment, gymnasts would be allocated to a usual-training control group or an intervention group, ideally through concealed randomization stratified by age and initial proficiency. Both groups would maintain comparable total training time, with the intervention replacing rather than adding to part of general coordination work. Assessor blinding should be used where feasible, and a sample-size calculation should precede recruitment.

Results and discussion

The proposed programme lasts eight weeks and includes three balance-focused blocks weekly, approximately 15–20 minutes each after warm-up. A block begins with two minutes of foot and trunk activation, continues through two or three primary stability tasks, and concludes with a short apparatus-integrated task. Quality is prioritized over maximum fatigue. Progression occurs only if the gymnast controls pelvic alignment, avoids repeated unplanned foot contacts and maintains technique across several correct repetitions. Coaches should provide rest or reduce difficulty when pain, dizziness or persistent instability occurs.

Exercise dosage should be responsive rather than rigid. Initially, two to three sets of 15–25 seconds may be used for static tasks, while technically demanding positions may require shorter holds and longer recovery. In later weeks, combinations of three to five actions may be repeated with sufficient rest to preserve precision. Narrowing the base of support, altering visual orientation and integrating apparatus are separate progression variables; increasing all simultaneously would obscure which challenge causes errors. Unstable equipment is optional and should not replace sport-specific practice on the standard surface.

Table 2. . Proposed multidimensional control battery (not empirical results).

Domain	Suggested measure	Interpretive precaution
Foundational static control	Single-leg stance, eyes open, 20 s; both legs	Record foot contacts and support-leg asymmetry
Sensory control	Standardized stance with gaze-direction changes	Avoid unsafe eyes-closed high-amplitude positions
Sport-specific execution	Arabesque or passé balance, filmed in two trials	Use identical technical criteria and camera position
Apparatus integration	Prescribed ball or hoop action during stance	Count loss of apparatus control separately from posture error
Inter-rater quality	Two judges score standardized recorded sequences	Assess inter-rater agreement before interpreting changes

Baseline and post-intervention testing should be completed under comparable footwear, warm-up, training-load and environmental conditions. Where possible, at least two familiarization trials should precede formal measurement. The principal outcome should be a predefined composite of technical balance execution, independently rated by two qualified judges using an explicit error rubric. Agreement may be expressed with an intraclass correlation coefficient; adjudication rules should be set before analysis. Force-platform centre-of-pressure measures can strengthen the assessment, but simple field tests should remain available for clubs without laboratory instruments.

The principal result is a four-component instructional framework aligning foundational postural control with rhythmic-gymnastics skills. The literature supports several design choices but provides different types of evidence. Calavalle et al. [1] document between-group postural characteristics, not the effect of a defined training programme. Chen et al. [2] suggest task-dependent sensory advantages and learning effects. Cabrejas et al. [4] provide direct intervention evidence, although improvements were identified in selected outcomes rather than universally across every balance condition. Therefore, a model that uses multiple complementary tests is more defensible than reliance on one static stance time.

In the study by Purenović-Ivanović et al. [5], balance variables explained a meaningful, but incomplete, proportion of variation in gymnastics performance scores: the authors reported explained variance of 35% in an advanced-level subgroup and 24% in the full sample. These are associations from the cited study and must not be interpreted as percentages of improvement attributable to the programme proposed here. Stojkovic et al. [6] reported high test–retest reliability for their newly developed specific balance test (ICC 0.96) in a pilot sample of 12 girls. That finding is promising for measurement development but requires external validation before routine generalization across age and competitive levels.

The proposed training model operationalizes these findings in a sequence of decision rules. Athletes first demonstrate stable alignment on the competition surface; next they maintain control through changes in gaze, body configuration and transition speed; finally they preserve the same technical criteria while handling apparatus and responding to musical structure. For each gymnast, progression is contingent on both balance duration and movement quality. This prevents apparent progress in holding time from masking excessive trunk compensation, unstable ankle mechanics or uncontrolled free-leg trajectories.

The distinctive feature of the proposed approach is its deliberate link between postural control and sport-specific task interference. A gymnast may hold an arabesque reliably when looking at a fixed point but lose stability while tracking a thrown ball. This difference reflects attentional, sensory and anticipatory demands and suggests that balance training should not end at isolated single-leg exercises. Apparatus handling is introduced after technical alignment is established, which preserves a clear progression from stable motor patterns to complex routines.

Safety and long-term athlete development are essential. Repeated high-load forefoot balances may increase local mechanical demands. A two-case electromyographic study by Rutkowska-Kucharska and colleagues [7] documented marked ankle-stabilizer activity during selected balances and advised caution when prescribing certain extreme positions to young gymnasts. Such evidence cannot determine injury rates or prove that a specific exercise caus-

es injury, but it reinforces the need for age-appropriate volume, varied support tasks and careful symptom monitoring. More recent work has also examined age-related postural asymmetries in rhythmic gymnasts [8], underlining the value of bilateral assessment.

Coaches should avoid interpreting an apparent reduction in sway as the sole marker of superior performance. The optimal control strategy may differ across quiet stance, pivots, large-amplitude balances and moving apparatus. For example, a controlled movement of the centre of mass may be required to initiate the next element; minimizing every displacement could actually impair fluid transitions. Qualitative execution ratings should therefore complement quantitative measures. Video analysis can help standardize observation even when motion-capture equipment is unavailable.

The approach has several limitations. The literature was selected through a focused narrative process rather than a preregistered systematic search. Included studies vary in age groups, competition levels, assessment instruments and methodological quality. The proposed sequence has not itself been experimentally tested, and its specific dosage should be considered a practical hypothesis rather than an established optimum. Future work must also distinguish changes resulting from maturation, ordinary technical practice, the balance intervention and familiarization with repeated tests. Multicentre replication and follow-up retention testing would improve generalizability.

Conclusion

Balance in rhythmic gymnastics is multidimensional and should be developed as an integrated technical-motor ability rather than reduced to duration of a single static stance. Published evidence supports attention to mediolateral control, sensory integration, trunk and lower-limb function and the interaction between balance and apparatus-specific execution. An eight-week, three-phase framework is proposed to connect these dimensions while maintaining individualized progression and age-appropriate loads. A standardized assessment battery combining bilateral static tests, rhythmic-gymnastics balances, apparatus-related tasks and expert scoring provides a reproducible basis for prospective validation. The framework is ready for pilot feasibility testing, but its effectiveness cannot be claimed until primary training data have been collected and analyzed.

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