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An Empirical Study on Movement Patterns and Functional Fitness Training for Dance Major Undergraduates

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Abstract

Background and Aim: This study investigates the effects of functional fitness training on movement patterns among undergraduate dance majors and evaluates its potential for injury prevention. The objectives include assessing improvements in core stability, flexibility, proprioception, and power development, and analyzing injury incidence rates following a structured functional training intervention.

Materials and Methods: A 12-week randomized controlled trial was conducted with 120 undergraduate dance majors (85 female, 35 male) aged 18-24 years from performing arts institutions. Participants were selected using stratified random sampling based on year level and dance specialization. The sample was divided equally into intervention (n=60) and control groups (n=60). Assessment tools included the Functional Movement Screen (FMS), Y-Balance Test, core endurance tests, range of motion measurements, and a comprehensive injury surveillance system. The intervention group underwent a progressive functional fitness training program (3 sessions/week, 60 minutes each) including core stability, limb strength, balance, coordination, and flexibility exercises, while the control group continued traditional dance conditioning.

Results: Statistical analysis using paired t-tests, ANOVA, and relative risk calculations revealed that the intervention group demonstrated significant improvements in core strength (increased by 38.6%, $p<0.001$), flexibility (flexion distance increased by 5.7cm, $p<0.01$), dynamic balance (Y-Balance Test composite score increased by 9.2%, $p<0.01$), and power (vertical jump height increased by 4.3cm, $p<0.01$) compared to controls. The functional training group experienced lower injury incidence (2.8 vs. 6.5 per 1000 training hours, $p<0.01$) with significant reductions in ankle sprains (56%), knee stress injuries (42%), and chronic back injuries (49%). FMS scores showed a strong negative correlation with injury rates ($r=-0.73$, $p<0.001$). Movement quality improved with enhanced hip joint range of motion (21.3%, $p<0.01$), spinal stability (15.7%, $p<0.001$), and reduced abnormal compensation patterns (18.4%, $p<0.001$). Professional technical assessment scores increased by 8.7% ($p<0.05$) in the intervention group.

Conclusion: The research demonstrates that functional fitness training effectively optimizes movement patterns in undergraduate dance students and substantially reduces the risk of injury. The comprehensive improvements across all measured physical parameters suggest that this training modality addresses the multifaceted demands of dance performance better than traditional methods. These findings strongly support the integration of functional training methodologies into dance curricula, representing an important advancement in evidence-based dance pedagogy and student well-being. Dance programs should consider restructuring their physical preparation components to incorporate functional fitness principles, aiming for enhanced performance outcomes and career longevity.

Keywords: Functional Fitness Training; Dance Major; Movement Patterns; Sports Injuries; Core Strength

Introduction

Dance education is facing a critical challenge: the persistence of high injury rates among undergraduate dance majors despite advances in training methodologies. Recent epidemiological studies by Bronner et al. (2023) reveal alarming statistics: 79% of undergraduate dance students experience at least one significant injury during their four-year program, with 43% suffering career-threatening injuries. These injuries not only disrupt academic progression but also potentially end promising careers before they begin. The economic impact is equally concerning, with dance-related injuries among students costing an estimated $247 million annually in medical expenses and lost training time (International Association for Dance Medicine and Science, 2024).

The fundamental problem stems from a critical disconnect between traditional dance training approaches and contemporary understanding of human movement science. While dance education has evolved aesthetically and technically, its physical preparation methodologies have not adequately incorporated evidence-based principles from exercise science and sports medicine. Traditional dance

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training emphasizes technique acquisition through repetition without sufficient attention to foundational movement patterns, creating a precarious foundation for complex choreographic demands. As Wu and Zhang (2023) observe, "Dance pedagogy has prioritized artistic expression and technical precision at the expense of biomechanical efficiency and injury prevention strategies."

This research addresses three critical gaps in current dance education practice. First, despite extensive research on injury prevention in sports, there remains limited empirical evidence on effective prevention strategies specifically tailored for dance undergraduates. Second, while functional training has demonstrated efficacy across athletic populations, its application to dance-specific movement patterns requires further investigation. Third, the relationship between movement pattern quality and injury risk among dance students has been inadequately explored, as noted by Chen and Liu (2024) in their comprehensive review of dance medicine literature.

The theoretical framework for this study builds upon Cook's Functional Movement Systems theory (2023), which establishes clear relationships between movement pattern quality and injury risk. Cook's updated model now incorporates dance-specific adaptations, recognizing that "dancers represent a unique athletic population with distinctive movement demands requiring specialized assessment and intervention protocols" (Cook et al., 2024). This framework is complemented by Boyle's (2022) integrated approach to functional training, which emphasizes motor control development before progressive loading—a principle particularly relevant to dance, where aesthetic demands often overshadow biomechanical considerations.

Recent advances in functional training methodology offer promising applications to dance education. Yuan's (2023) "three-phase neuromuscular activation protocol" demonstrated significant improvements in elite gymnasts' performance quality while reducing injury rates by 42%. Similarly, Yin's (2022) "dual-pathway modulation theory" suggests that neurological adaptations precede and enhance technical skill acquisition, a finding with direct implications for dance pedagogy. These contemporary approaches align with Richardson and Jull's (2024) research on motor control retraining, which establishes that movement pattern optimization must precede high-level skill performance.

The significance of this research extends beyond injury prevention to address fundamental issues in dance education quality. In Thailand and across Southeast Asia, dance programs have experienced exponential growth, with enrollment increasing by 68% since 2020 (Asian Dance Education Association, 2024). This surge has created urgent needs for evidence-based training methodologies that support both artistic development and student well-being. As noted by the Thai Ministry of Higher Education (2023), "The sustainability of dance education depends on our ability to integrate cutting-edge movement science into traditional training paradigms."

This study investigates the effects of functional fitness training on movement patterns among undergraduate dance majors and evaluates its potential for injury prevention. By employing a randomized controlled trial design with comprehensive movement analysis, this research aims to provide empirical evidence for curriculum development in dance education. The findings will directly benefit dance students through enhanced training methodologies, dance educators through evidence-based pedagogical strategies, healthcare providers through improved preventive protocols, and institutional administrators through reduced injury-related costs and improved program outcomes. Ultimately, this research contributes to the advancement of dance education by bridging the gap between traditional practice and contemporary scientific understanding, supporting the development of dancers who can sustain long, healthy careers in their chosen art form.

Objectives

1) to evaluate the effects of functional physical training on key physical indicators such as core strength, flexibility, dynamic balance, and explosive power of dance students;

2) to analyze the effect of functional training on the improvement of the movement patterns of dance students through a three-dimensional motion capture system;

3) to compare the differences between functional physical training and traditional physical training in preventing sports injuries among dance students;

4) to provide scientific training methods and empirical support for the field of dance education and promote the scientific development of dance education.

Literature review

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The theoretical foundation for this research emerges from the integration of functional training principles with dance-specific movement demands. A comprehensive examination of both international and Chinese literature reveals several key theoretical frameworks that inform this study.

Cook's (2023) updated Functional Movement Systems theory provides the primary theoretical underpinning for this research. Cook conceptualizes human movement as an integrated kinetic chain where fundamental movement patterns form the foundation for all specialized skills. His recent work specifically addresses the unique challenges dancers face, noting that "technical virtuosity in dance cannot be sustained without robust fundamental movement patterns" (Cook, 2023). The Functional Movement Screen (FMS), developed by Cook and Burton (2021), has evolved to include dance-specific assessments that evaluate movement quality across multiple planes, identifying compensatory patterns that precede injury. Recent validation studies by Hoogenboom et al. (2024) confirm the predictive relationship between FMS scores and injury risk in collegiate dancers ($r=-0.73$, $p<0.001$), establishing a critical benchmark for this study's methodology.

Building on Cook's framework, Boyle's (2022) contemporary approach to functional training emphasizes four essential principles that directly address the movement challenges observed in dance populations. First, sport-specific functional training adapts conditioning protocols to the unique demands of each dance style, recognizing that ballet, contemporary, and traditional dance forms impose distinct biomechanical stresses. Second, movement pattern optimization prioritizes foundational competencies like squat, lunge, and hinge patterns before progressing to complex technical elements. Third, holistic kinetic chain training addresses the interdependence of muscle groups within movement systems, challenging the historically isolated approach to dance conditioning. Fourth, training diversity incorporates varied modalities to enhance neuromuscular control and movement adaptability. These principles provide the methodological foundation for the intervention designed in this study.

Recent advancements by Chinese researchers have significantly expanded functional training applications to artistic disciplines. Yuan (2023) developed the "three-phase neuromuscular activation protocol" specifically for performers requiring precise movement control. This protocol progressively trains joint stability, kinetic chain synchronization, and performance-specific skill integration, showing remarkable efficacy in professional dancers with a 42% reduction in performance-related injuries over 16 weeks. Similarly, Yin's (2022) "dual-pathway modulation theory" demonstrates how neurological adaptations through functional training transfer directly to technical skill acquisition in dance, improving learning efficiency by 58% in controlled studies. These contributions establish a clear pathway from functional training interventions to enhanced dance performance.

The BRISS Functional Training Pyramid Model (Richardson et al., 2024) provides a structured implementation framework particularly relevant to dance education. This model progresses systematically from foundational movement screening to general physical preparation and finally to dance-specific skill development. Recent applications in conservatory settings have demonstrated significant improvements in technical proficiency scores (12.4%, $p<0.01$) while reducing injury rates by 37% over academic year-long implementations. This model addresses the critical need in dance education for a sequential developmental approach that prioritizes movement quality before technical complexity.

Research specific to dance populations confirms the efficacy of functional training approaches. A landmark randomized controlled trial by Bronner and Ojofeitimi (2021) demonstrated a 44% reduction in ankle injuries through neuromuscular training combining balance and eccentric control exercises. Meta-analysis by Hrysomallis (2023) established a strong correlation between dynamic balance capacity and rotational performance ($r=0.68$), directly linking foundational movement quality to dance-specific technical demands. Recent intervention studies with dance populations show promising outcomes: Hu (2023) reported significant improvements in stability and spin precision following 12-week balance interventions; Yang (2022) documented enhanced flexibility through proprioceptive neuromuscular facilitation techniques; and Zhang (2024) established the efficacy of core stability training for improved postural control in traditional dance forms.

Technological advances have further enhanced the assessment capabilities essential to this research. Motion capture systems, such as Yuan's (2023) inertial sensor-based platform, achieve body alignment precision ($\leq\pm1.5°$) with real-time EMG feedback, enabling objective measurement of movement pattern changes. Cost-effective alternatives developed by Gentile (2024) using smartphone video analysis with Kinovea software (error rates <15%) have democratized movement analysis, making sophisticated

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assessment accessible for educational settings. These technological tools provide objective measurement capabilities that strengthen the methodology employed in this study.

The integration of these theoretical frameworks, methodological approaches, and assessment technologies addresses a critical gap in dance education research. While functional training has demonstrated efficacy across athletic populations, its specific application to dance populations, particularly undergraduate dance majors, remains under-investigated. This study builds upon the established theoretical foundations to examine how structured functional training interventions can optimize movement patterns among dance students, potentially reducing injury risk while enhancing technical performance. By addressing this gap, the research contributes to the development of evidence-based teaching methodologies that support both artistic excellence and student well-being in dance education programs.

Methodology

1. Population and Sample Group

This study used a randomized controlled trial design with 120 undergraduate dance majors (85 female, 35 male) aged 18-24 years from Krirk University's Dance Department. Participants were selected using stratified random sampling based on year level (1st through 4th year) and dance specialization (ballet, contemporary, traditional Thai, and urban styles). Inclusion criteria required full-time enrollment, a minimum of 3 years of prior dance training, and being injury-free for 3 months. Exclusion criteria included recent orthopedic surgery, neurological conditions, and pregnancy. After stratification, participants were randomly assigned to experimental (n=60) or control groups (n=60) using computer-generated sequences, with no significant demographic differences between groups ($p>0.05$).

2. Research Tools

Physical assessment instruments included the Functional Movement Screen (FMS) with high reliability (ICC=0.91), Y-Balance Test for dynamic balance, McGill protocol for core endurance, digital goniometer for range of motion, and Vertec device for power assessment. Movement patterns were captured using an 8-camera Vicon motion system (100 Hz) with 39 standardized markers during specified dance movements. A comprehensive injury surveillance system using REDCap software tracked all injuries, with certified athletic trainers documenting injury details, including location, type, mechanism, severity, and time loss from dance activity.

3. Tool Quality Assessment

All measurement tools underwent content validation by five experts (CVI>0.80) and reliability testing with 25 dancers not included in the main study. Inter-rater reliability (ICC>0.85), test-retest reliability (ICC>0.82), and internal consistency ($\alpha>0.80$) were established for all measures. Equipment was calibrated according to the manufacturer's specifications before each testing session.

4. Intervention Protocol

The experimental group completed a 12-week progressive functional fitness training program (three 60-minute sessions weekly) administered by certified specialists with a 1:10 instructor-student ratio. The program was periodized into three phases: Movement Pattern Foundation (weeks 1-4), Neuromuscular Control (weeks 5-8), and Dance-Specific Application (weeks 9-12). Each session included mobility preparation, neuromuscular activation, pattern training, dance integration, and recovery. The control group participated in traditional dance conditioning of equivalent duration, focusing on ballet-based exercises, center combinations, stretching, and technical drills.

5. Data Collection

Assessments were conducted at baseline (week 0) and post-intervention (week 13) under standardized laboratory conditions. Assessors were blinded to group allocation. Throughout the 12 weeks, exposure hours were tracked through attendance logs and self-reported practice times. Injury surveillance was continuous, with incidence rates calculated per 1000 dance participation hours.

6. Data Analysis

Statistical analysis used SPSS version 27.0 with significance at $\alpha=0.05$. Preprocessing of motion capture data included gap filling, filtering (6Hz cutoff), and segmentation. Analysis methods included descriptive statistics, Shapiro-Wilk normality tests, independent and paired t-tests, two-way repeated measures ANOVA, ANCOVA when appropriate, relative risk calculations for injury incidence, Pearson correlations, and effect size calculations using Cohen's d. Power analysis indicated 54 participants per group would provide 80% power to detect moderate effects ($d=0.5$), accounting for 10% attrition.

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Results

Analysis of the 12-week intervention revealed significant differences between experimental and control groups across all measured parameters. Table 1 presents baseline and post-intervention values for key physical fitness measures.

Table 1 Physical Fitness Measures Before and After Intervention

Parameter	Experimental Group (n=60)		Control Group (n=60)		Between-Group
	Pre-test	Post-test	Pre-test	Post-test	p-value
Core strength (sec)	58.4±12.7	80.9±15.2**	57.9±11.9	62.4±13.5*	<0.001
Flexibility (cm)	11.2±4.3	16.9±4.8**	11.5±4.1	12.8±4.5	<0.01
YBT composite (%)	84.6±6.8	92.4±5.9**	83.9±7.1	85.7±6.7	<0.01
Vertical jump (cm)	32.7±8.4	37.0±8.2**	33.1±7.9	34.2±8.1	<0.01
FMS score	14.2±2.3	17.8±1.9**	14.0±2.4	14.8±2.2	<0.001

*p<0.05, **p<0.01 for within-group pre-post comparison

Core strength in the experimental group increased by 38.6% compared to 7.8% in the control group ($p<0.001$). Similarly, flexibility improved by 5.7cm in the experimental group versus 1.3cm in the control group ($p<0.01$). Dynamic balance as measured by YBT composite scores showed a 9.2% improvement in the experimental group compared to 2.1% in the control group ($p<0.01$). Vertical jump height increased by 4.3cm in the experimental group versus 1.1cm in the control group ($p<0.01$).

Three-dimensional motion capture analysis revealed significant improvements in movement pattern quality in the experimental group. Hip joint range of motion increased by 21.3% in the experimental group compared to 4.6% in the control group ($p<0.01$). Spinal stability improved by 15.7% in the experimental group versus 3.5% in the control group ($p<0.001$). The prevalence of abnormal compensation patterns during technical movements decreased by 18.4% in the experimental group compared to 3.9% in the control group ($p<0.001$).

The injury surveillance data showed that the experimental group experienced significantly fewer injuries than the control group during the intervention period. The overall injury incidence rate was 2.8 injuries per 1000 hours of dance participation in the experimental group versus 6.5 per 1000 hours in the control group (risk ratio=0.43, 95% CI=0.28- 0.67, $p<0.01$). Specific reductions were observed in ankle sprains (56% reduction, $p<0.05$), excessive knee stress injuries (42% reduction, $p<0.05$), and chronic back injuries (49% reduction, $p<0.05$).

Correlation analysis revealed a significant negative relationship between FMS scores and injury incidence ($r=-0.73$, $p<0.001$), indicating that improved movement quality was strongly associated with reduced injury risk. This finding supports the theoretical relationship between movement pattern optimization and injury prevention posited in the literature.

The experimental group also demonstrated significant improvements in dance technical performance as evaluated by professional adjudicators using a standardized assessment rubric. Overall technical performance scores increased by 8.7% in the experimental group compared to 2.3% in the control group ($p<0.05$). The most substantial improvements were observed in alignment/posture (13.0% increase, $p<0.01$) and dynamic control (12.7% increase, $p<0.01$), suggesting that functional fitness training had particular benefits for these fundamental aspects of dance technique.

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These results demonstrate that functional fitness training significantly improved physical fitness parameters, movement pattern quality, and technical performance while reducing injury incidence among undergraduate dance students compared to traditional dance conditioning methods.

Discussion

This study found that functional fitness training significantly optimized movement patterns in undergraduate dance students and effectively reduced the risk of injury. The experimental group demonstrated substantial improvements in core strength (38.6%, $p<0.001$), flexibility (5.7cm increase, $p<0.01$), dynamic balance (9.2%, $p<0.01$), and power (4.3cm increase in vertical jump, $p<0.01$). These findings align with Boyle's (2022) concept of "holistic kinetic chain training," which views the body as an integrated system where any weakness or incoordination affects overall performance.

The strong negative correlation ($r=-0.73$) between improved FMS scores and decreased injury rates supports Cook & Burton's (2021) theory that optimizing basic movement patterns directly reduces injury risk. The experimental group experienced 56% fewer ankle injuries and 42% fewer knee stress injuries compared to the control group, similar to Bronner and Ojofeitimi's (2021) findings of a 44% reduction in ankle injuries through neuromuscular training. This consistency across studies suggests that functional training principles have broad applicability in dance education.

The improvement in technical performance (8.7%, $p<0.05$) in the experimental group challenges the misconception that supplementary physical training might interfere with technical acquisition. Instead, our results support Gentile's (2023) action-movement framework, which proposes that optimized movement patterns provide a more stable foundation for complex skills. The notable improvements in alignment/posture (13.0%) and dynamic control (12.7%) indicate that functional training enhances fundamental aspects of dance technique.

The enhanced hip range of motion (21.3%) and spinal stability (15.7%) confirm the effectiveness of Yuan's (2023) "three-phase neuromuscular activation protocol" in dance contexts. The reduction in compensation patterns (18.4%) validates the BRISS Functional Training Pyramid Model, which emphasizes sequential development from foundational movement to specific skills.

These findings suggest that dance education should consider reversing the traditional "technique-first" approach, instead prioritizing foundational movement patterns before complex technical elements. This may enhance both safety and skill acquisition, offering an evidence-based approach to curriculum development.

Study limitations include the single-institution sample, the relatively short 12-week intervention period, and incomplete control of participants' extracurricular activities. Future research should include multiple institutions and diverse dance styles, conduct longitudinal studies, investigate psychological factors, and integrate advanced motion capture technology.

In conclusion, this study provides evidence that functional fitness training optimizes movement patterns in dance students while reducing injury risk and enhancing technical performance. These findings support integrating evidence-based physical preparation methodologies into dance curricula to better address the multifaceted demands of dance performance and promote student well-being.

Conclusion

This 12-week randomized controlled experiment confirms that functional fitness training optimizes movement patterns in undergraduate dance majors and significantly reduces injury risk. The results showed that systematic functional training significantly improved key physical indicators such as core strength (increased by 38.6%, $p<0.001$), flexibility (improved by 5.7cm, $p<0.01$), dynamic balance (increased by 9.2%, $p<0.01$), and explosive power (vertical jump height increased by 4.3cm, $p<0.01$) in dance students.

The experimental group demonstrated significant improvements in movement pattern quality, including enhanced hip joint range of motion (21.3%, $p<0.01$), improved spinal stability (15.7%, $p<0.001$), and reduced abnormal compensation patterns in the lower limb mechanical chain (18.4%, $p<0.001$). These changes in fundamental movement patterns provided a stronger foundation for technical skill execution.

Functional fitness training effectively reduced the incidence of sports injuries among dance majors, with the experimental group experiencing 2.8 injuries per 1000 hours of dance participation compared to 6.5 injuries in the control group (risk ratio=0.43, $p<0.01$). The intervention showed particular effectiveness in reducing ankle sprains (56% reduction), knee stress injuries (42% reduction), and chronic back injuries

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(49% reduction). The significant negative correlation between FMS scores and injury incidence ($r=-0.73$, $p<0.001$) confirmed the importance of optimizing movement patterns in preventing dance injuries.

Beyond safety improvements, the experimental group also showed enhanced technical performance, with an 8.7% increase in professional assessment scores ($p<0.05$). While this improvement was statistically significant, it was somewhat lower than anticipated, possibly due to the relatively short intervention period and the complex nature of technical skill acquisition in dance.

These findings provide important empirical support for the field of dance education, indicating that integrating functional fitness training into dance curricula can effectively promote students' comprehensive development while reducing occupational risks. Based on these results, we recommend that dance education institutions introduce functional training concepts into curriculum design, establish assessment-training-reassessment cycles, and develop personalized training plans for different dance styles and individual characteristics.

Future research should explore the effects of functional training on specific technical requirements of different dance styles, extend observation periods to evaluate long-term training outcomes, and incorporate advanced motion capture technology and artificial intelligence analysis methods to better understand the mechanisms underlying movement pattern optimization and injury prevention, thus promoting the scientific advancement of dance education.

Recommendation

Based on the findings of this study, the following recommendations are proposed for dance education practice and future research:

Recommendations for Current Dance Education Practice

1. Curriculum Integration and Faculty Development

Incorporate functional fitness training into dance curricula with three weekly 60-minute sessions. Establish an "assessment-training-reassessment" model using FMS to evaluate movement patterns. Provide specialized training for dance faculty in functional movement principles. Create collaborative teams of dance educators and exercise specialists to design comprehensive training programs addressing the unique demands of dance.

2. Personalized Training and Injury Prevention

Develop style-specific functional training protocols for different dance forms. Create individualized training plans based on initial movement assessments. Establish injury surveillance systems to track and analyze injury patterns. Implement targeted preventive programs for common dance injuries affecting ankles, knees, and lower back. Educate students on self-management strategies and rehabilitation techniques.

3. Movement Pattern Optimization

Implement the BRISS functional training pyramid model to ensure fundamental movement patterns precede technical skill development. Focus on progressive development from stability and mobility to complex dance-specific movements. Use video analysis to provide objective feedback on movement patterns. Design training that systematically builds neuromuscular control through varied exercises challenging proprioception, balance, and coordination.

Recommendations for Future Research

1. Extended Investigation Scope

Conduct longitudinal studies examining long-term effects on career longevity and injury patterns. Compare different functional training methodologies across various dance styles. Investigate how individual factors influence training outcomes. Expand research to multiple institutions to enhance generalizability.

2. Advanced Analysis Methods

Utilize biomechanical analysis to identify specific movement changes that reduce injury risk. Examine neurological adaptations underlying improved movement control. Develop cost-effective motion analysis tools for dance settings. Investigate relationships between movement quality and artistic performance to address concerns about functional training's impact on aesthetics.

3. Implementation Science

Evaluate curriculum models that successfully integrate traditional dance pedagogy with movement science. Develop assessment tools specifically for dance-specific movement patterns. Study the economic

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impact of functional training on institutional resources, including injury-related cost savings. Identify barriers to implementing evidence-based training methods and strategies to overcome them.

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