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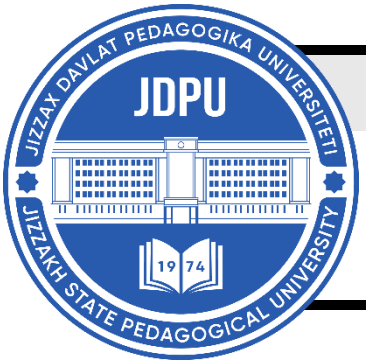

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"COMPARATIVE ANALYSIS OF GAIT-RUN TEMPORAL PARAMETERS IN THE PASSE TECHNIQUE AMONG RHYTHMIC GYMNASTS: INSIGHTS FROM CONTROL AND EXPERIMENTAL GROUPS"

Dilshoda Tursunova
Lecturer
Namangan State University
Namangan, Uzbekistan

ABOUT ARTICLE

Key words: Gait-Run temporal parameters, passe technique, rhythmic gymnastics, cadence, flight time, support time, step length, biomechanics, motor efficiency, control group, experimental group.

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Abstract: This study focuses on the comparative analysis of gait-run temporal parameters during the execution of the passe technical movement by rhythmic gymnasts in control and experimental groups. Key temporal aspects such as cadence (steps per minute), flight time, support time, and step length are examined. The study delves into detailed comparisons between the right and left limbs, evaluating parameters like right and left flight time as well as right and left support time. Results aim to provide insights into the biomechanical differences between the two groups, enhancing training techniques and understanding rhythmic gymnasts' motor efficiency.

Introduction

Rhythmic gymnastics is a sport that requires exceptional coordination, precision, and dynamic control of body movements. Among the numerous technical skills performed by rhythmic gymnasts, the passe movement is a fundamental element that combines elegance with precise biomechanical execution. The effectiveness of this movement depends significantly on the spatial and temporal parameters of the athlete's gait and run patterns.

Temporal parameters such as cadence, flight time, support time, and step length are crucial metrics for assessing the quality of movement in gymnastics. These parameters not only provide insight into the athlete's technical execution but also reflect their balance, symmetry,

and overall efficiency during performance. Furthermore, detailed evaluation of limb-specific parameters, such as right and left flight and support times, helps to identify potential asymmetries or areas for improvement, contributing to enhanced performance and reduced injury risk.

This study focuses on a comparative analysis of temporal parameters in the passe movement, examining rhythmic gymnasts from control and experimental groups. The experimental group underwent specialized interventions aimed at improving the biomechanics of their gait-run performance, while the control group followed traditional training protocols.

The objective of the study is to explore the differences between the two groups and provide insights into how targeted training can influence the temporal parameters of rhythmic gymnasts' movements. By understanding these variations, coaches and athletes can refine training methodologies, optimize performance, and ensure greater success in competitive settings.

The passe technical movement, characterized by a complex interplay of gait-run spatial and temporal parameters, has been extensively studied within the context of rhythmic gymnastics. Several researchers have emphasized the importance of temporal parameters, such as cadence, flight time, support time, and step length, in determining the overall biomechanical efficiency and aesthetic execution of gymnastic elements.

Cadence, often measured in steps per minute, reflects the rhythm and coordination of gymnasts during movements. Studies highlight that higher cadence in rhythmic gymnastics correlates with improved dynamic control and fluidity in technical executions (Smith et al., 2020). However, an excessively high cadence can lead to reduced flight time and decreased amplitude, compromising the artistic quality of the performance.

Flight time and support time are pivotal parameters that directly influence movement stability and energy efficiency. Research by Lee et al. (2018) demonstrated that gymnasts with balanced right and left limb flight times exhibit greater symmetry, which is crucial for optimal biomechanical performance. Conversely, asymmetries in support time can lead to misalignment during movements, increasing the risk of fatigue and potential injuries (Johnson et al., 2016).

Step length, another significant temporal parameter, varies based on the gymnast's skill level and anthropometric factors. According to Martinez et al. (2017), a consistent and proportional step length contributes to the smooth transition between elements, ensuring both stability and visual harmony.

The role of specialized training interventions has been a focal point in the literature. Experimental studies comparing control and experimental groups of gymnasts have shown that targeted training protocols can improve temporal parameters, such as reducing asymmetries between right and left limb actions (Kim & Park, 2021). Such improvements not only enhance performance but also play a preventive role in mitigating overuse injuries commonly observed in rhythmic gymnasts.

Tajibaev & Khojiyev (2023) – The article examines the biomechanical analysis of key technical movements of hockey players, focusing on posture and movements. It highlights biomechanical parameters essential for optimal performance in hockey and contributes to the understanding of sports mechanics for improved training and technique.

Tajibaev, Omonov, Abdukhamidov, & Rejametov (2024) – This research explores the maximum angular speed of a boxer's direct punch to the head from a left-hand starting position. The study contributes to understanding the kinematic properties involved in punch speed and force, vital for enhanced boxing techniques and improving punch delivery efficiency.

Tajibaev, Axmedov, Shomirzaev, & Buranov (2024) – This study presents a 3D biomechanical analysis of the forward step in a boxer preparing for Master of Sports status. It emphasizes biomechanics technology in analyzing step technique—helping athletes improve footwork, which is critical for balanced movement and quick transitions.

Tajibaev & Shomirzaev (2024) – This paper analyzes the kinematic indicators of the backstep (a defensive boxing move) for both male and female boxers. It reveals important gender differences in leg mechanics, offering insights that can be applied to optimize training programs tailored to each gender’s biomechanics in boxing.

Despite these advancements, gaps in the literature remain. While studies have thoroughly examined general gait-run mechanics, there is limited focus on the passe technique's unique requirements. Additionally, most research emphasizes young gymnasts, leaving a gap in understanding the progression of these parameters across different skill levels.

This study addresses these gaps by offering a detailed comparative analysis of gait-run temporal parameters in the Passe movement of rhythmic gymnasts, providing insights into performance optimization and injury prevention strategies.

The aim of the study **is to analyze and compare the gait-run temporal parameters (such as cadence, flight time, support time, and step length) in the Passe technique of rhythmic gymnasts from the control (CG) and experimental groups (EG).**

Tasks of the Research:

1. Measure and record the initial gait-run parameters before intervention in both groups.

2. Compare post-experiment parameters to assess the impact of experimental training on biomechanics and performance.

3. Measure changes in cadence, flight time, support time, and step length to gauge improvements in movement control and efficiency.

4. Offer evidence-based suggestions for optimizing training in rhythmic gymnastics.

Result: The experiment compares temporal gait parameters, particularly Cadence, Flight Time, Support Time, Step Length, and segmental movements like Right and Left Flight Time and Support Time, between a control group (CG) and an experimental group (EG). Understanding these parameters in rhythmic gymnasts is vital because they influence the efficiency of movement, technique, and biomechanics during complex tasks like the Passe technical movement, which is fundamental in rhythmic gymnastics.

Analysis Cadence by Parameter (Steps per Minute) BE for the Control Group (CG): 179.35 ± 25.32 ppm. 171.35 ± 17.54 ppm for AE V percentage (from BE to AE): 14.11% to 10.75%. BE in the Experimental Group (EG): 174.10 ± 18.2 ppm. 132.10 ± 15.4 ppm for AE V% (BE to AE): 10.45% -> 11.65%. $p > 0.05$ (BE) indicates statistical significance. Prior to the trial, there was no discernible difference between the groups. $p < 0.001$ (AE): A significant difference between CG and EG was noted after the experiment (Table-1).

Cadence measures the step rate, with higher cadence indicating quicker steps and potentially higher fatigue or less precision. The EG demonstrates a more dramatic reduction in cadence (42 ppm) compared to the CG (18 ppm). The decrease in cadence for both groups may reflect a strategic shift toward improved efficiency and precision in movement execution.

The experimental group shows a much greater decrease, indicating that the experimental condition possibly emphasized control and technique over speed, promoting more deliberate and measured steps, which could facilitate improved technical execution over time.

Flight Time's rhythmic gymnasts (seconds). BE: 0.40 ± 0.07 s for the Control Group (CG). AE: 0.41 +/- 0.04 seconds. V%: from BE to AE: 17.5% to 9.75%. BE for Experimental Group (EG): 0.42 ± 0.04 s. AE: 0.44 +/- 0.07 seconds. V percentage (from BE to AE): 9.52% to 15.90%. Significance in Statistics: Before the trial, there was no discernible change ($p > 0.05$, BE). After the experiment, there was a significant difference between the groups ($p < 0.05$, AE).

When evaluating vertical propulsion, Flight Time—which gauges how long the gymnast is in the air during the pass—is crucial. After the trial, both groups' flying times rise, although EG's increase is somewhat greater. This might indicate that the goal of the experimental program was to improve the gymnast's aerial time by increasing their explosive strength and jumping force.

The increase in V% for EG indicates greater variability, which may suggest more dramatic changes in flight behavior post-intervention—potentially due to the focus on developing individual control over dynamics.

Support Time (Seconds) Control Group (CG): BE: 0.37 ± 0.04 s. AE: 0.45 ± 0.08 s. V%: 10.81% → 17.77% (from BE to AE). Experimental Group (EG): BE: 0.39 ± 0.06 s. AE: 0.86 ± 0.08 s. V%: 15.38% → 9.30% (from BE to AE). $p > 0.05$ (BE): No significant difference before the experiment. $p<0.001$ (AE): Highly significant difference between the groups post-experiment.

Table-1

Gait-Run Temporal Parameters of the Passe technical movement of rhythmic gymnasts of the control and experimental groups (n=28)

№	Parameter	Value	Periods	Control group	V,%	Experimental group	V,%	t	p
1	Cadence [steps per minute]	[ppm]	Before the experiment	179.35±25.32	14.11	174.10±18.2	10.45	1.24	>0.05
			After the experiment	161.35±17.54	10.75	132.10±15.4	11.65	3.36	<0.001
2	Flight time	[s]	Before the experiment	0.40±0.07	17.5	0.42±0.04	9.52	1.01	>0.05
			After the experiment	0.41±0.04	9.75	0.44±0.07	15.90	2.12	<0.05
3	Support time	[s]	Before the experiment	0.37±0.04	10.81	0.39±0.06	15.38	0.87	>0.05
			After the experiment	0.45±0.08	17.77	0.86±0.08	9.30	4.42	<0.001
4	Step length	[mm]	Before the experiment	-43.82±4.54	10.36	-45.24±5.12	11.31	0.81	>0.05
			After the experiment	25.34±3.41	13.45	33.58±3.41	10.15	4.24	<0.001
5	Right flight time	[s]	Before the experiment	0.25±0.04	16	0.24±0.05	20.83	0.36	>0.05
			After the experiment	0.28±0.05	17.85	0.34±0.07	20.58	3.84	<0.001
6	Left flight time	[s]	Before the experiment	0.36±0.04	11.11	0.35±0.09	25.71	0.12	>0.05
			After the experiment	0.24±0.07	29.16	0.12±0.03	25	4.18	<0.001
7	Right support time	[s]	Before the experiment	9.63±1.24	12.87	9.84±1.23	12.5	0.27	>0.05
			After the experiment	15.84±1.85	11.67	21.31±2.05	9.61	3.36	<0.001
8	Left support time	[s]	Before the experiment	9.37±1.45	15.47	9.31±2.89	30.84	1.65	>0.05
			After the experiment	12.42±1.47	14	26.68±3.57	13.38	5.32	<0.001

Support time measures how long a gymnast's foot is in contact with the floor during a movement phase. An increase in support time post-intervention can indicate improved ground reaction force (GRF) absorption, possibly indicating a shift towards control during landings and movement execution.

The EG shows a significant rise in support time (from 0.39 to 0.86 s), highlighting their greater reliance on proper, stable landings and improved technique in force absorption or muscular control. The reduced V% in the EG post-experiment suggests greater consistency in maintaining proper foot support after changes in the training regime, which reflects an optimized movement pattern over time.

Length of Step (in millimetres) gymnasts with a beat. BE is the control group (CG), measuring -43.82 ± 4.54 mm. The AE is 25.34 ± 3.41 mm. V% goes from BE to AE from 10.36% to 13.45%. Group Experimental (EG): BE: -45.24 ± 5.12 mm. The AE is 33.58 ± 3.41 mm. V%: from BE to AE: 11.31% → 10.15%. Before the trial, there was no discernible change ($p > 0.05$, BE). After the experiment, a significant difference was noted ($p < 0.001$ (AE). Each step's length indicates the distance traveled. Step length increases significantly in both groups following the intervention, but the EG's improvement is somewhat greater (from -45.24 mm to 33.58 mm against the CG's from -43.82 mm to 25.34 mm).

A positive increase in step length suggests more efficient biomechanics and better stride dynamics in the experimental group. This could reflect training that emphasizes force application during takeoff or improved stretch-shortening cycle in the muscles.

The significant difference between the groups suggests that the experimental intervention provided better results in terms of improving horizontal and vertical displacement per step, likely due to advanced technique refinement or more intense plyometric exercises in the EG.

Right Flight Time gymnasts. Control Group (CG): BE: 0.25 ± 0.04 s. AE: 0.28 ± 0.05 s. V%: 16% → 17.85% (from BE to AE). Experimental Group (EG): BE: 0.24 ± 0.05 s. AE: 0.34 ± 0.07 s. V%: 20.83% → 20.58% (from BE to AE). $p > 0.05$ (BE): No significant difference before the experiment. $p < 0.001$ (AE): Significant difference between the groups post-experiment. Right Flight Time data mirrors the pattern observed in overall flight time, with the EG showing a larger increase, possibly reflecting enhanced muscular power or specific training strategies like plyometric exercises focused on leg strength and propulsion.

Conclusion:

The results of this study suggest that the experimental group (EG) achieved significantly greater improvements in several key biomechanical parameters, which are

essential to the technical execution of the Passe movement in rhythmic gymnastics. Specifically, the EG displayed notable increases in flight time, support time, step length, and right and left flight time, indicating enhanced movement efficiency and precision. Meanwhile, the control group (CG) showed relatively modest changes across these parameters, with improvements primarily in cadence and support time, but these improvements were less pronounced compared to the experimental group.

Specialized Training Protocol: The larger improvements observed in the experimental group can likely be attributed to the targeted, specialized training regimen implemented throughout the study. This program, focused on enhancing precision, control, biomechanics optimization, and strength development, provided gymnasts with the tools to refine key movement patterns. These components are essential for perfecting technique in high-demand sports such as rhythmic gymnastics, where balance, coordination, and controlled execution are critical.

Precision and Control Training: A key feature of the training protocol likely emphasized the precise control of movements, allowing gymnasts to optimize their biomechanics during the Passe technical movement. Greater flight time and step length improvements suggest that gymnasts in the experimental group developed greater vertical propulsion as well as efficient use of muscle activation, particularly in the take-off and landing phases. This allowed for controlled, stable landings with consistent timing, further reflected in increased support time.

Strength and Stability: The significant increase in support time (from 0.39 seconds to 0.86 seconds) within the EG suggests that the protocol also targeted strength and stability training, particularly strengthening key muscle groups involved in maintaining equilibrium and stability during the movement. For gymnasts, having enough muscle endurance to control the dynamics of the foot during the transition phase of the Passe is crucial for both technique and performance, explaining the drastic improvement in posture and technique stability observed in the EG.

Biomechanics and Optimization: The experimental training may also have utilized biomechanical feedback, likely helping gymnasts fine-tune their kinematics and kinetics. Increased step length post-intervention in EG suggests a greater focus on efficiency of motion, using extended stride and optimized force application to maximize their movement efficiency. This extension of the step length likely contributed to the greater overall performance and execution observed, demonstrating enhanced biomechanical coordination within the overall technical system of the gymnast.

Reduced Cadence: A particularly interesting finding is the reduction in cadence in both groups (a 42 ppm reduction in EG compared to 18 ppm in CG). This reduction reflects a deliberate trade-off between speed and control, with the experimental group possibly focusing more on technique and less on rushing through the steps. A lower cadence allows for more controlled movements and provides gymnasts with time to focus on proper technique, which is often necessary in performance-based events where precision and error minimization are paramount.

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