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The Effect of Corrective Exercises on Some Biomechanical Variables and the Performance of the Hand Jump Skill in the Junior Category

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Abstract

The study aimed to highlight the importance of corrective exercises and to address the development and status of athletic activities. It also emphasized the significant role of human movement in the successful execution of various sports performances. Furthermore, the study explored the field of biomechanics and its relationship to optimal performance through motion analysis. The significance of this research lies in designing corrective exercises for a selected sample group with the intention of improving their performance, overcoming technical faults, and achieving better athletic results. The front handspring skill on the floor exercise mat is considered one of the most difficult techniques for athletes, due to its requirements for technical precision and motor coordination. During a particular phase of the skill, the body reaches a handstand position, necessitating accurate synchronization between the force exerted by the hands against the ground and the moment the body's center of gravity passes through the imaginary vertical axis.

Keywords: Artistic Gymnastics, Motion Analysis, Floor Exercises, Skill Performance, Biokinematic Variables.

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Introduction

The development in gymnastics and the achievement of creative and innovative performance, particularly on the floor exercise apparatus—which is one of the six primary apparatuses in artistic gymnastics—has not occurred randomly but through the application of the most advanced scientific methods. Movements performed on the floor serve as the foundation for all other apparatuses and are a central focus of sports events worldwide, aimed at achieving the highest levels of performance and attaining outstanding accomplishments. Technological advancements in mechanical analysis, in general, and in artistic gymnastics, in particular, play a critical role in enhancing the quality of skill performance, both in competitions and educational processes. Artistic gymnastics is characterized by the diversity of its performance, encompassing multiple apparatuses, including the floor exercise, which involves skills such as the front handspring. Achieving advanced skill performance in sports is an essential objective in the educational process, and researchers in this field continually seek innovative methods and tools to enhance performance. Sports apparatuses contribute significantly to improving technical execution and physical abilities, in accordance with the specific requirements of each sport. Since gymnastics performance is evaluated based on technical execution, the International Gymnastics Federation prescribes the proper form for skill execution, and any deviations result in deductions from the performance score.

This study aimed to diagnose errors in performing the front handspring for youth aged 8–13, identify the most significant biomechanical variables affecting its learning, and propose corrective exercises to optimize these variables.

Several researchers have addressed related topics. For instance, Rasha (2014) examined the effect of specialized physical exercises on selected biomechanical variables of the "Gazelle Jump" in rhythmic gymnastics, showing significant post-test improvements in speed and takeoff angle. Zina (2008) analyzed the relationship between biomechanical and physical-motor abilities in performing the back aerial somersault from a stationary position, finding significant correlations that affected performance. Abi Ramz (2005) investigated the effect of corrective exercises on kinematic variables of the spindle movement on the vault apparatus for youth, reporting meaningful improvements post-intervention. Ali (2002) studied the effect of educational exercises on the biomechanical variables of the front handspring, showing positive impacts for the experimental group. Mustafa (2019) examined the effect of specialized exercises using an innovative rotating support device on selected kinematic variables of the front handspring, demonstrating improvements for the experimental group. Sarmad (2021) explored the effect of a multi-stage innovative device on biomechanical variables in learning the Tkatchif skill on the

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horizontal bar, indicating positive effects on performance. Ibtehal (2021) assessed corrective exercises based on a model for handstand and cartwheel skills on the floor, reporting significant improvements in biomechanical indicators and skill performance.

Collectively, these studies emphasize the importance of designing corrective and specialized exercises according to mechanical principles, highlighting the positive role of progressive and sequenced application—covering preparatory, main, and final phases—in developing and enhancing gymnastic skills.

Methodology

The researcher employed the experimental method using the two equivalent groups design (control and experimental) with pre- and post-tests, as it was suitable for the research requirements. The research population was determined from artistic gymnastics players at the Specialized School for the academic year 2024–2025. The researcher used the purposive sampling method to select the sample, which initially consisted of 12 players. Out of them, 10 players were chosen, representing 83.33% of the original sample. These players were divided into two groups—control and experimental—comprising 5 players in each group. The reason for excluding the two players was due to injury.

Data Collection Tools

- Floor exercise mat.
- Foam mats.
- Measuring tape (6 meters).
- Ruler (1 meter).
- Video camera (1 unit), Sony, with a range of 30–1000 frames per second.
- Computer, HP.
- Laser discs (2 units), Prince brand.
- Tripod for the camera.
- Motion analysis software (Kinovea, version 0.8.27).
- Electronic scale.

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Table 1: Description of the Research Sample (Control and Experimental Groups)

Variable	Mean (M)	(SD)	Skewness
Age (years)	10.63	0.937	0.047
Training age (years)	3.25	1.23	-0.168
Weight (kg)	30.75	4.79	0.899
Height (cm)	140.38	7.18	-1.67
Arm length (cm)	25.25	1.96	-0.952
Forearm length (cm)	24.25	2.53	0.123
Trunk length (cm)	43.38	0.827	0.483
Thigh length (cm)	37.88	3.64	0.468
Leg length (cm)	34.25	2.49	-0.305

Table 2: Equivalence of Control and Experimental Groups

Variables / Equivalence	Groups	Mean	SD	Levene's Test	F	Sig	df	t	Sig
Performance (s)	Control	2.88	0.545	0.062	0.810	0.250	0.306	0.816	0.438
	Experimental	3.13	0.415						
Vertical Inclination Angle (°)	Control	16.25	3.96	2.80	0.133	1.00	1.84	0.544	0.601
	Experimental	15.25	1.09						
Trunk Angle First Contact (°)	Control	55.00	3.24	0.105	0.754	2.75	2.22	1.24	0.251
	Experimental	52.25	3.77						
Thigh Angle First Contact (°)	Control	77.25	2.28	0.118	0.740	-1.25	1.30	0.962	0.364
	Experimental	78.50	1.80						
Hip Angle First Contact (°)	Control	132.25	2.28	1.62	0.238	1.50	2.38	0.630	0.546
	Experimental	130.75	4.82						
Linear Displacement of Hip (m)	Control	1.19	0.076	1.80	0.217	0.028	0.040	0.686	0.512
	Experimental	1.16	0.048						
Linear Hip Velocity (m/s)	Control	3.90	0.511	1.95	0.200	0.046	0.245	0.188	0.856
	Experimental	3.94	0.198						
Hip Angle First Contact for Arms (°)	Control	68.50	4.56	0.664	0.439	1.50	2.62	0.573	0.582
	Experimental	67.00	3.67						
Arm Contact Time (s)	Control	0.290	0.037	0.109	0.750	0.017	0.024	0.713	0.496
	Experimental	0.307	0.040						
Flight Time (s)	Control	0.160	0.022	0.079	0.786	0.015	0.015	1.04	0.328
	Experimental	0.175	0.025						
Body Tilt Angle (°)	Control	39.25	4.02	0.072	0.796	0.500	2.48	0.201	0.846
	Experimental	38.75	3.83						
Covered Angle (°)	Control	146.50	3.91	2.48	0.154	2.25	4.97	0.453	0.663
	Experimental	144.25	10.40						
Trunk Angular Velocity (°/s)	Control	297.23	55.22	1.74	0.223	-2.26	26.63	0.085	0.934
	Experimental	299.50	22.28						
Total Performance Time (s)	Control	0.776	0.074	1.57	0.245	0.002	0.036	0.056	0.957
	Experimental	0.774	0.032						

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Corrective Educational Units

After conducting personal interviews with a group of experts and specialists in teaching methods and based on their opinions and recommendations, the researcher prepared the corrective educational units and finalized them while considering the following:

- The total number of corrective educational units was eight (8), with one unit implemented per week.
- The total number of corrective exercises used to address the errors identified during the pre-tests for the research sample was thirty-two (32) exercises.
- The number of errors corrected in each corrective unit ranged from 1–2 errors, depending on the difficulty of the error.
- The number of corrective exercises per unit was five (5) exercises, depending on the type of error.
- The corrective exercises were implemented according to the sequence of the skill's sections (preparatory, main, and final).
- Corrective exercises were executed during the first half of the main section for 30 minutes out of the total 60 minutes allocated to the main section.
- The duration of each corrective unit was 30 minutes, including 10 minutes for explaining the errors and demonstrating the corrective exercises, and 20 minutes for applying the corrective exercises.
- The third corrective educational unit for the handstand skill was repeated due to the presence of some errors that were not adequately corrected.

Post-Test

The post-test was conducted on Saturday, 1/2/2025, starting at 3:30 PM and ending at 4:15 PM. Camera settings, dimensions, and speed, as well as the tasks of the assisting team, recording of attempts, the order of players, and performance evaluation, were all organized according to the same procedures and conditions used in the pre-test.

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Statistical Analysis

The Statistical Package for the Social Sciences (**SPSS**) program was used to extract:

- Mean (M).
- Standard deviation (SD).
- Skewness coefficient.
- Independent samples T-test.
- Levene's Test.
- Paired samples T-test.

Results

Table 3: Pre- and Post-Test Differences in Performance Angles of the Handstand Skill for the Control Group

Variable / Control	Test	Mean (M)	SD	F-S	A-F	H-A	t	Sig
Vertical Inclination Angle (°)	Pre-test	16.20	3.96	4.40	2.97	1.33	3.32	.029
	Post-test	11.80	2.28					
Trunk Angle – First Motion (°)	Pre-test	55.00	3.24	2.20	10.06	4.50	.489	.650
	Post-test	52.80	7.63					
Thigh Angle – First Motion (°)	Pre-test	77.20	2.28	.400	4.04	1.81	.222	.836
	Post-test	76.80	2.59					
Hip Angle – First Motion (°)	Pre-test	132.20	2.28	2.60	7.67	3.43	.758	.491
	Post-test	129.60	7.09					
Hip Angle – First Motion for Arms (°)	Pre-test	68.60	4.56	-.600	4.77	2.14	.281	.793
	Post-test	69.20	8.26					
Body Tilt Angle Based On (°)	Pre-test	39.20	4.02	6.60	9.10	4.07	1.62	.180
	Post-test	32.60	6.07					
Angle Covered (°)	Pre-test	146.60	3.91	10.00	9.41	4.21	2.38	.076
	Post-test	136.60	7.23					

Table 4: Pre- and Post-Test Differences in Performance Angles of the Handstand Skill for the Experimental Group

Variables	Test	Mean	SD	Skewness	Kurtosis	Std. Error	t	Sig
Vertical Tilt Angle (°)	Pre	15.20	1.10	-0.400	5.22	2.34	0.171	0.872
	Post	15.60	5.03					
Trunk Angle, First Phase (°)	Pre	52.20	3.77	6.40	6.73	3.01	2.13	0.101
	Post	45.80	7.33					
Thigh Angle, First Phase (°)	Pre	78.60	1.82	4.60	2.70	1.21	3.81	0.019
	Post	74.00	3.54					
Hip Angle, First Phase (°)	Pre	130.80	4.82	11.00	6.00	2.68	4.10	0.015

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	Post	119.80	9.07					
Arm-Hip First Contact Angle (°)	Pre	67.00	3.67	-15.00	4.90	2.19	6.85	0.002
	Post	82.00	7.18					
Body Tilt Angle Based on Support (°)	Pre	38.80	3.83	14.60	5.13	2.29	6.37	0.003
	Post	24.20	1.48					

Table 5: Post-Test Differences in Study Variables for the Handstand Skill Angles

Variables / Post-Test	Groups	Mean	SD	F – S	H – M	t	Sig.
Vertical Inclination Angle (°)	Experimental	15.60	5.03	3.80	2.47	1.539	.162
	Control	11.80	2.28				
Trunk Angle – First Contact (°)	Experimental	45.80	7.33	-7.00	4.73	1.480	.177
	Control	52.80	7.63				
Thigh Angle – First Contact (°)	Experimental	74.00	3.54	-2.80	1.96	1.429	.191
	Control	76.80	2.59				
Hip Angle – First Contact (°)	Experimental	119.80	9.07	-9.80	5.15	1.904	.093
	Control	129.60	7.09				
Arm–Hip Angle – First Contact (°)	Experimental	82.00	7.18	12.80	4.89	2.616	.031
	Control	69.20	8.26				
Body Inclination Angle (°)	Experimental	24.20	1.48	-8.40	2.79	3.008	.017
	Control	32.60	6.07				
Total Inclination Angle (°)	Experimental	163.60	6.39	27.00	4.32	6.257	.000
	Control	136.60	7.23				

Discussion

The results of the statistical analysis reflect the presence of statistically significant differences in the post-test between the experimental group and the control group for the flight time variable, in favor of the experimental group in performing the handstand skill. No significant differences, however, were observed in the variables of hand contact time and total performance time. Flight time is directly associated with the push-off force exerted by the hands, which represents the decisive factor in providing the body with sufficient propulsion to execute the aerial somersault and achieve adequate height during the aerial phase. The greater this force, the longer the flight time, allowing the athlete additional time to optimize landing timing, reduce injury risk, and ensure smooth transitions between performance phases. It also provides the body with adequate time to prepare for the subsequent phase of the skill.

The researcher attributes this improvement to the fact that flight time is closely linked to the resultant speed generated during the push-off, particularly the vertical component of the push. A skilled athlete is able to convert a larger proportion of horizontal speed into vertical speed, which increases height and consequently flight time—the period the body remains airborne from leaving the ground until landing. This duration is influenced by several factors, including jump height

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(related to muscular strength) and coordination level during the aerial phase. From this perspective, the corrective exercises based on motion analysis played a significant role in adjusting performance angles and enhancing the ability to convert horizontal velocity into vertical velocity. This resulted in higher vertical speed at the expense of horizontal speed, achieved through precise motion analysis, identification of movement errors, and scientific correction aimed at increasing vertical velocity.

This outcome aligns with what Samir Mosallat (2000) indicated: analyzing motion through recording and quantitatively identifying influential variables—such as launch speed, height, and angle—is the most effective method to address variables that coaches or athletes seek to improve in performance (Mosallat, 2000, p. 233). Moreover, identifying movement errors helped athletes use their muscles correctly to increase elevation and control during flight, which was clearly reflected in the post-test results, showing a positive effect on flight time. Wajih Mahjoub (2001) also confirms that motion analysis "is used to solve problems related to learning and training, by diagnosing movements, balancing their components, timing, and force, and differentiating between correct and incorrect movements. This supports skill development and technical understanding, providing coaches with a model of ideal movement to guide appropriate training methods to learners and avoid movement errors" (Mahjoub, 2001, p. 15). Applying advanced motion analysis programs enabled precise identification and scientific correction of movement errors, which the results clearly demonstrated.

Regarding hand contact time, the researcher notes that it is a critical factor in improving the handstand skill, as it reflects the effectiveness of the push force generated upon hand-ground contact. The shorter this time while maintaining sufficient force, the better the technical performance and movement efficiency. However, the results showed no statistically significant differences between the groups, indicating that the corrective exercises were not sufficiently targeted to improve this variable, or that other factors such as individual technique or muscular balance influenced it. This is consistent with Loui Ganmal Al-Samid'i (2007), who stated that "the mechanical effect of force on the body over a short time equals the product of the force and the specific time instant, demonstrating that the relationship between push and contact time is closely linked to the performance angles adopted during the push-off and flight phases. Specifically, the transition from running to hand-ground contact requires greater force in a shorter time to maintain momentum without losing speed" (Al-Samid'i, 2007, p. 93). Despite numerical differences favoring the experimental group, these differences did not reach statistical significance, likely because the push variable is influenced by both force and time, which were relatively similar across groups. Both coach and researcher worked on developing physical components and skill abilities to achieve optimal performance.

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This aligns with Adel Abdel Basir (1999), who noted that "the type of sport aiming for elite performance determines the nature of physical and skill components, and there is a close relationship between the development of physical components and skill abilities" (Basir, 1999, p. 91), which is reflected in the nature of the exercises used in this study.

Regarding total performance time, results also indicated no statistically significant differences, despite temporal differences favoring the experimental group. This reflects that contact time plays a central role in determining overall performance quality and movement success, which is affected by factors such as muscular strength, motor balance, and coordination between performance phases. Haider Nawar (2012) emphasized that "movement time is influenced by how force is applied; periods in which force is not applied according to goal requirements lead to discontinuous and non-fluid performance, especially between the preparatory and main skill phases" (Al-Amiri & Haider Nawar, 2012, p. 39). The researcher notes that total performance time is influenced by body inclination, push force, and launch angle, and that the corrective exercises did not specifically target this variable but rather focused on improving motor control and muscular coordination. Improvements in this variable may also relate to general adaptation from training or differences in individual commitment within groups. This is supported by Talha Hossam Eldin (2003), who indicated that "the amount of push force generated during takeoff depends on muscular strength, joint extension speed, and coordination, with the vertical component of push achieved through sudden and simultaneous extension of working joints" (Hossam Eldin, 2003, p. 136). From this standpoint, improving total performance time requires continuous training incorporating advanced techniques to control timing during flight and landing, allowing athletes better opportunities to adjust launch angles and flight time, thereby enhancing overall skill performance.

Overall, the results are logical and reflect the effect of corrective exercises and motion analysis on developing technical and motor performance for this complex skill.

Conclusions

1. The adoption of corrective exercises based on motion analysis has a positive effect on the hip angle at the moment of initial hand contact in the handstand skill, indicating an improvement in arm positioning at the beginning of the movement, which positively reflects on overall body balance during performance.
2. Corrective exercises informed by motion analysis have a positive impact on the body tilt angle during the support phase of the handstand skill, suggesting an improved ability to maintain balance and distribute body mass properly during skill execution.

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3. Corrective exercises guided by motion analysis show a positive effect on the final vertical tilt angle in the handstand skill, reflecting an improvement in the final body posture—a key indicator for evaluating technical performance quality.
4. Corrective exercises based on motion analysis positively influence flight time in the handstand skill, reflecting development in explosive strength and neuromuscular coordination.
5. Corrective exercises derived from motion analysis positively affect the overall performance score of the handstand skill.

Recommendations

1. The researcher recommends the use of biomechanical analysis as a permanent diagnostic tool for evaluating athletes' technical performance, due to the precise data it provides, which contributes to scientifically guided training.
2. It is recommended to involve gymnastics coaches in development courses focused on quantitative analysis using video and mechanical analysis software.
3. Emphasis should be placed on developing body and hip tilt angles during technical training, as these angles have a direct effect on stability, balance, and fluidity during flight and support phases.
4. Researchers and coaches should consider relevant body measurements (e.g., height, trunk length, leg length, arm length) when designing corrective exercises, as these measurements are critical for correcting movement trajectories in many sports skills.

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