

ISSN: 2392-5442 ESSN : 2602-540X		<i>Sport system journal</i>
V/12 N/02 Year/2025		<i>International scientific journal published by: Ziane Achour –Djelfa- Algeria</i>
P 10 - 20		<i>Received: 2025-07-24 Accepted: 2025-08-25</i>

Analysis of a gymnastic technique performed in two ways to optimise the approach to basic exercises

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Abstract

The purpose of this study was to investigate the biomechanical differences between the two techniques. Methods: The analysis was conducted on two gymnasts from Iran. The data was processed by converting the film to a motion analysis program to extract data. Results: The movement times for the two techniques in the four quadrants of the skill were revealed. The high technique was longer for gymnast 1 (1.41 seconds) than for gymnast 2 (1.36 seconds). Gymnast 1 (21 degrees) had a lower hip joint angle compared to gymnast 2 (26 degrees). The angular velocities in the shoulder and hip joints were in favor of gymnast 1 (-209.55, -12.83, 298.01, 182.59 degrees/s, respectively) (1163.9, -454.6, -1739.6, 179.9 degrees/s, respectively). Conclusion: The high inverted circle technique is characterized by a brake at the beginning of the downstroke phase to facilitate rapid and controlled hip flexion, and a relatively large shoulder joint angle at the highest point of the ascent. Coaches and gymnasts should take these differences into account, as they contribute significantly to the success of the application.

Keywords: Adler; shoulder; hip; gymnasts.

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1. INTRODUCTION

Gymnastics has been an official event since the first Athens Olympic Games in 1896. Men's gymnastics consists of six events: floor exercise, pommel horse, ring vault, parallel bars, and horizontal bar. Artistic gymnastics is a sport that requires a well-trained body and physical strength, as well as originality and beauty in difficulty, advanced techniques, and movements. (Lim Gyu-chan, 2020) recently mentioned that this type of gymnastics has been attracting the attention of the audience by continuously developing its techniques and performing unique performances based on the athletes' unique techniques. As a result, new techniques, performance compositions, and connecting techniques continue to appear every year at international competitions.

Jahn divided the horizontal bar exercise techniques into techniques that focus on maintaining posture or holding power, such as bending the arms during rotational movements, and exercises that include climbing, rotating, and dismounting techniques, and said that they are composed of swings, twists, and flying movements without stopping (Wilson, 2007). Horizontal bar exercise is called the flower of gymnastics, and its technical elements consist of four elements: Group I elements, including long hang swings and turns, Group II elements, flight elements, Group III elements, including swings near the bar (in bar and Adler elements), and Group IV elements, dismounts (F.I.G, 2025). In particular, various techniques using swing movements are expressed in various technical forms by adding dynamism to techniques that remove one or both hands from the horizontal bar, perform various rotational movements, and then grab the bar again. In particular, the vault event has made great progress on the international stage, to the point of holding an Olympic gold medal, but it is the horizontal bar event that has been struggling. The main reason for this is thought to be the severe lack of research results on horizontal bar flight techniques.

In the past, the main performance composition of the horizontal bar event mainly consisted of complex hand movements, beating movements, and various connecting techniques utilizing the angular momentum obtained by approaching and rotating the bar. After that, as the elasticity of the horizontal bar and the average skills of the athletes improved, the main performance became aerial techniques in which both hands were released, an aerial movement was performed, and then the bar was caught again. The horizontal bar performance of Zonderland, who won the gold medal in the 2012 London Olympics, was

characterized by the consecutive execution of multiple aerial techniques. Performing three or more consecutive aerial techniques was a very shocking and surprising performance composition at the time. This case is evaluated as a performance that impressed the importance of aerial techniques in the horizontal bar event (youtube, 2016).

The inverted back-and-forth circle, also called the Adler (German for eagle), is an old element of artistic gymnastics performed mostly by men on the horizontal bar, but also by women on parallel bars of varying heights. In recent years, this element has become more important because it can be combined with other elements, especially with flying elements. This combination is important for earning aggregate points for a higher difficulty value for the series (Naundorf, 2010).

As we specialize in gymnastics training, our field experience has enabled us to become increasingly familiar with the training requirements of modern artistic gymnastics, where the ultimate goal of perfect performance of technical skills and movements is sought by both the coach and athlete in this field by fine-tuning all the physical and mechanical properties of the movement.

Based on all of the above, the researcher conducted a biomechanical study of one of the requirements of the kinetic chain on the horizontal bar (the inverted circle back and forth) to develop the performance of gymnasts.

2. Method

2.1 Subjects

Two gymnasts from Iran in the this study were selected as male gymnasts who could perform Adler techniques simultaneously on the horizontal bar, and as gymnasts with national team experience or as excellent gymnasts. This study was an experimental study, there were two subjects, and the characteristics of the research subjects were collected as in (Table 1).

Table 1.Physical characteristics of the study subjects

variable	gymnast 1	gymnast 2
age	16	17
length	165	161
mass	67	65

2.2 Experimental Procedure

One-iphone pro 11 high-speed cameras were positioned toward the control point and the athletes' performance scenes were filmed at a shooting speed of 120 frames/s. The origin of the Cartesian coordinate was set to the middle point of the bar, the connection vector from the right end of the bar was set to the X-axis, the horizontal direction in which the body was projected was set to the Y-axis, and the vertical axis was set to the Z-axis. After sufficient warm-up, the experiment was conducted until the athletes successfully recovered the adler techniques twice each, and the athletes performed subsequent performances after recovering the bar. After filming, the movements that were judged to be good among the two successful performances were selected as the subject of analysis. The movements judged to be good at this time were selected by a researcher who holds a domestic gymnastics referee license in accordance with the scoring rules of the Gymnastics E-Referee Committee (F.I.G, 2025).

2.3 Data production

Using the kinovea image analysis program coefficients were calculated using the image coordinates and real space coordinates of the control points, and the 2D coordinate values of the human joint points were calculated using these. All figures [graphs] in this study were standardized to 100% for the time of the graph to help understand the analysis.

2.4 Skill stages

1. From the 1st to the 2nd first quarter.
2. From the 2nd to the 3rd second quarter
3. From the 3rd to the 4th third quarter.
4. From 4 to 5 fourth quarter.

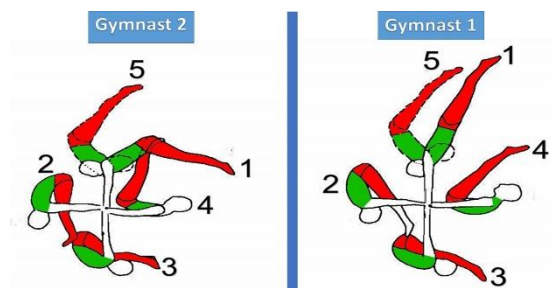


Fig. 1 The stages of skill for the first and second Gymnasts

3. Results and discussion

Table 2. Temporal results (s)

Quarters	Gymnast 1	Gymnast 2
1	0.58	0.5
2	0.26	0.2
3	0.24	0.27
4	0.35	0.39
Total	1.41	1.36

Table (2) shows by Comparison of Adler's movement time among gymnasts in the four quarters of the movement, high technique is longer for gymnast (1) , which is (1.41 second) than for gymnast (2), which is (1.36 second), although there are no significant differences between the gymnasts regarding In total times, however, the gymnast (1) spent a relatively longer time in the first quarter than the gymnast (2), as well as in the second quarter, while in the third and fourth quarters, gymnast (2) spent a relatively longer time than the second, due to the fact that gymnast (1) did an overextension In each of the shoulder joints and the thigh joints at the beginning of the fourth quarter in order to benefit from the energy that was stored in the horizontal bar and use it to climb over the horizontal bar, which requires an appropriate amount of transitional energy and rotational energy to perform the skill. These results agree with what was indicated by (Arampatzis,. & Brüggemann, 1999), where they indicated that in the first quarter of the skill, which is the preparation stage, in which the gymnast's body moves in the downward direction from the sloped position to the vertical suspension position under the crossbar, the gymnast collects as much energy as possible, and part of this energy is stored Also in the horizontal bar, and in the second quarter, which is the starting stage in which the gymnast body moves in the upper direction from the vertical suspension position below the crossbar until launching over the horizontal bar, the gymnast tries to preserve as much energy as possible, which is divided between transitional energy and rotational energy In the next stage, which is the stage of ascending to the top.

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Table. 3. Shoulder and hip joint angle (°)

Quarters	gymnast1		gymnast 2	
	Shoulder	hip	Shoulder	hip
1	76	21	62	26
2	47	26	27	20
3	32	62	26	49
4	151	120	113	45

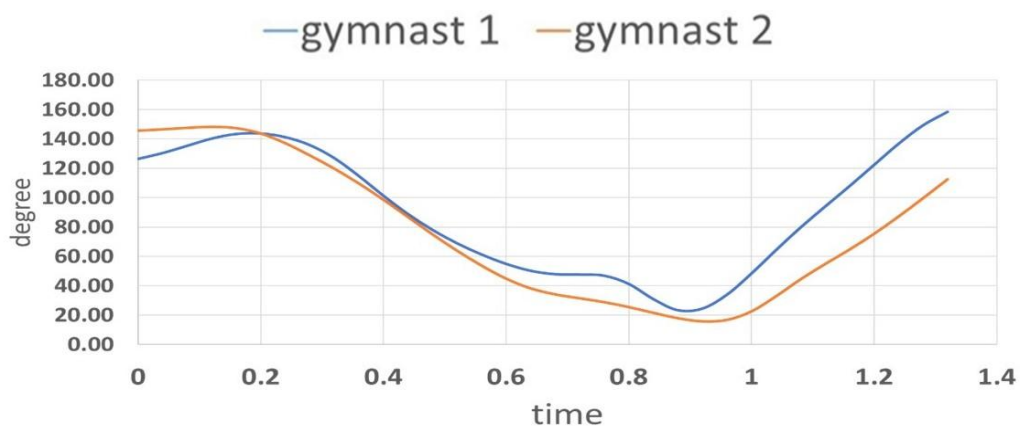


Fig.1. Shoulder angle for gymnasts 1 and 2

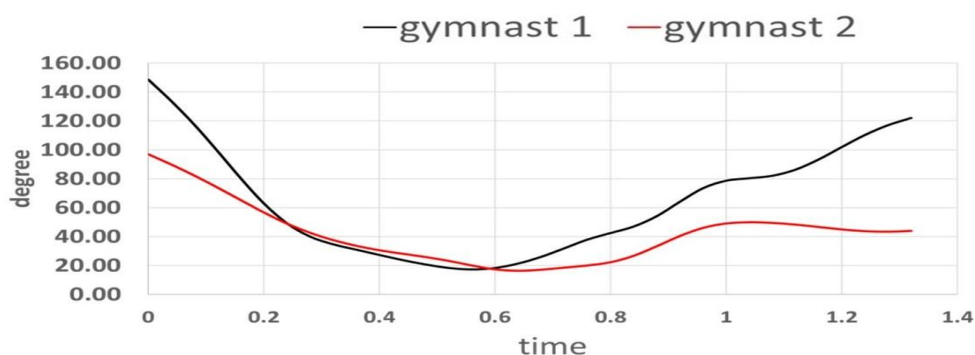


Fig.1. Hip angle for gymnasts 1 and 2

Table (3), and Figure (2, 3), show that the late fall technique requires the gymnast to restrain the landing in the first quadrant in order to facilitate flexion of the hip joint, by maintaining a relatively wide shoulder joint angle and consciously inhibiting forward rotation (Prassas ,1990). In addition to the most obvious and obvious difference with regard to the angle of the shoulder and hip where there are differences between the players, Which is related to the sharp decrease in the hip joint angle of the gymnast (1) and the block movement at the shoulder joint, which is manifested by a relatively sharp decrease in the first, second and third quarters. The researcher attributes the reason for this decrease to the approximation of parts of his body for the purpose of increasing the angular velocity, and increasing the angles of both the shoulder joint and the hip joint from the beginning of the last quarter of the study skill, due to the player extending all parts of his body away from the horizontal bar during the stage of the gymnast's body rising above the horizontal bar.

Table. 4 Angular velocities ($^{\circ}/\text{sec}$)

Quarters	gymnast1		gymnast 2	
	Shoulder	hip	Shoulder	hip
1	-209.55	1163.9	-238.36	-72.85
2	-12.83	-454.6	-90.56	83.56
3	298.01	-1739.6	272.88	5
4	182.59	179.9	370.57	59.12

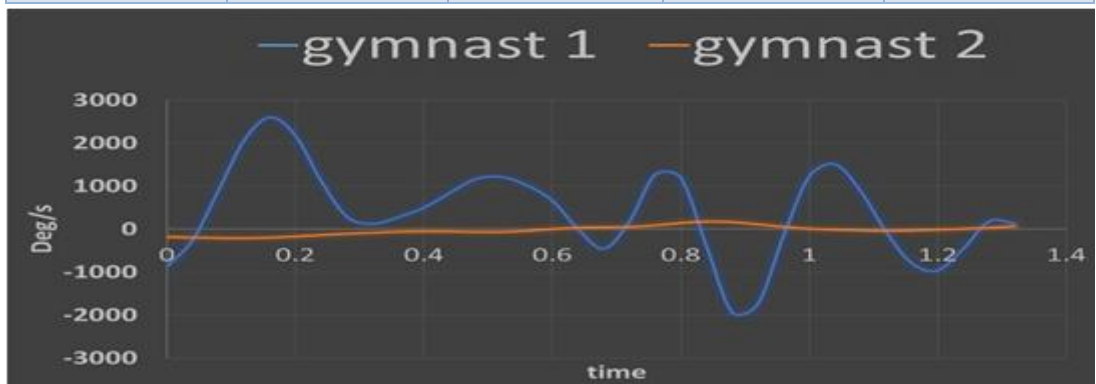


Fig .4. The shoulder angular velocity for gymnasts 1 and 2

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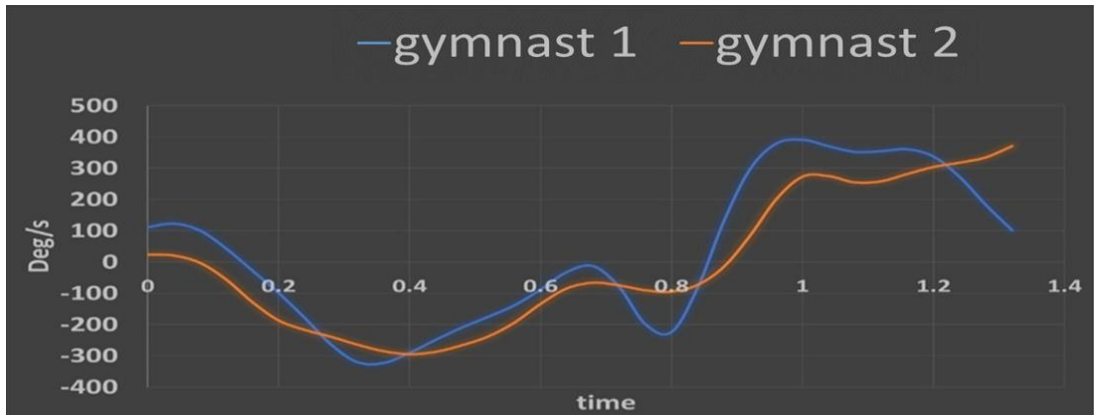


Fig. 5. The angular velocity of the hip for both gymnasts 1 and 2

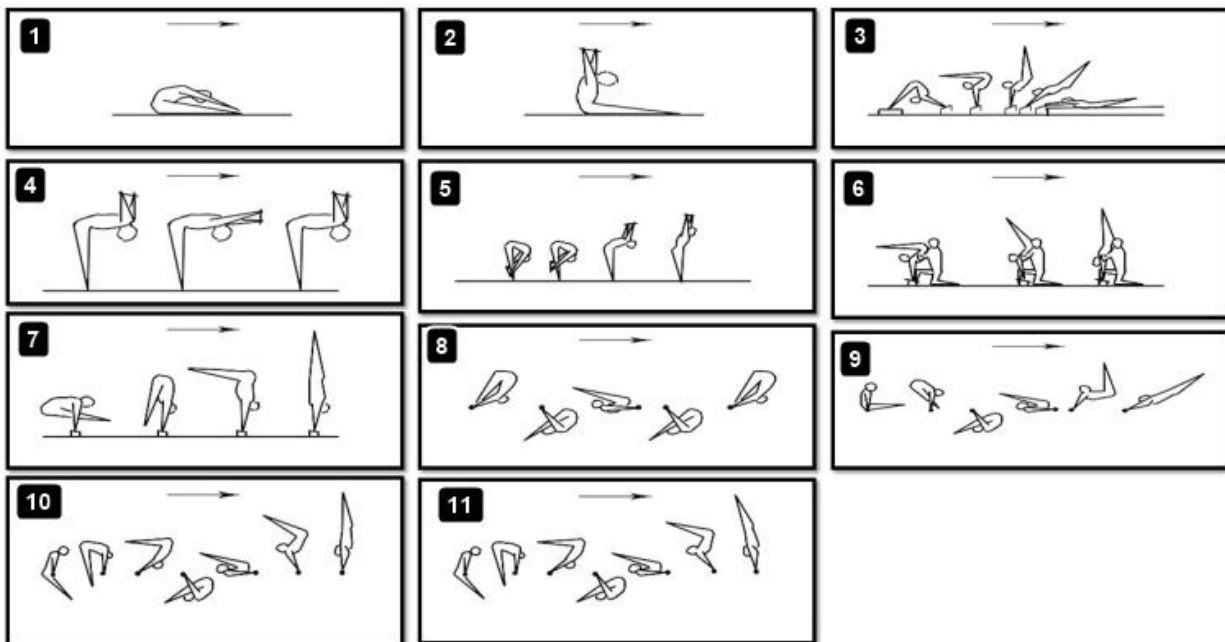
Table (4), and Figure (4,5) show that the angles of each of the shoulder joints and the hip joints decreased, and they reached their lowest value in the performance stages during the first, second, and third quarters of the skill under study, until the gymnast (1) increased the amount of grip in each of The shoulder joints and the thigh joints, which led to a decrease in the amounts of the angles of each of the shoulder joints and the thigh joints to their lowest value during the first, second, and third quarters. Earth's gravity, which leads to an increase in the angular velocity of the gymnast body's center of gravity, and thus an increase in the angular acceleration in preparation for the player's ascent above the horizontal bar. Therefore, the first gymnast, the high technique that requires greater demands than the low technique, flexes the hip and shoulder faster than the low technique. The results give us an answer as to why gymnasts use higher technique with greater demands. As the high mass of gymnasts is one of the reasons for choosing high or low technique. As the high technique avoids the player deductions in performance as (Naundorf, 2010) stated that additional research should include the calculation of joint energy and torque Applying this data to a simulation model can be used to improve locomotion.

Conclusion

The analysis revealed that the gymnasts used similar mechanical patterns, however, the inverted circuit execution was found to, in general, involve significant changes in body composition as a result of large hip and shoulder ranges of motion. However, the time factor, relative to the time of occurrence of these joint movements, was not consistent between the gymnasts, which led to different techniques. Although the angular velocity generally increased during the lower part of the movement and decreased at the upper part, the increases and decreases were not consistent between persons, although it can be shown that all performances were aesthetically pleasing, gymnast technique (1) resulted in a smaller loss of angular velocity in the weighted upper stage, and therefore, player's technique (1) is the recommended model with it.

Based on the analysis, we present a methodology for qualitative exercises of the inverted circuit skill in the high bar to improve the low bar technique in figure

Fig .6. Basic exercises





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Exercise explanation

1. Curved push-ups: Improve hip flexibility.
2. Using a stick: Improve shoulder flexibility.
3. Using a pull-up bar: Push off with fingertips using an inverted grip, then land on a mat.
4. Using a stick, bend forward with an inverted grip.
5. Using a stick, bend down, then rise.
6. Using a pull-up bar with the help of a trainer, bend down, then extend upward.
7. Handstand push-ups on a pull-up bar.
8. Bent curls on a low pull-up bar, right and left, repeating.
9. Climb onto a low pull-up bar, then raise your body up, then extend it, and lower it.
10. Perform the entire movement on a low pull-up bar.
11. Perform the movement on a high pull-up bar.

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