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Original Article

An Analytical Study to Identify Some Kinetic Variables of Certain Stages of Performing the Double Salto Bwd Tucked on The Floor Apparatus

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Abstract

The Study is to identify some kinematic variables for certain stages of performing the two backward somersaults with a tuck on the floor exercise apparatus. The authorsused the descriptive method, employing video recording and biomechanical analysis, due to its suitability for the nature of the study. The sample was selected intentionally from the best gymnast in the Arab Republic of Egypt, who is a member of the national gymnastics team, performing the two backward somersaults with a tuck on the floor exercise apparatus. The main results of the study showed that the average horizontal force was 2016 Newtons with a standard deviation of 135 N, the average vertical force was 5555 Newtons with a standard deviation of about 32 N, the average resultant force was 5911 Newtons with a standard deviation of 43 N, and the average angle of force application was approximately 70 degrees with a standard deviation of 1.2 degrees.

Keywords: *Kinetic Variables, Gymnastics, Floor Exercises*

Introduction

The rapid development that the world is currently witnessing in various scientific and technological fields is the result of modern scientific research and inventions across different areas that serve humanity. Physical education is one of these fields that relies on scientific facts, principles, and modern methods to bring about significant progress in the global sports arena today, Physical education includes many curricula and sports activities, among which is gymnastics, characterized by the diversity and variety of skills performed on various apparatuses, each differing in nature from the others.

Gymnastics is considered a fertile field for dynamic analysis due to its multiple motor skills performed on all axes and levels. Its apparatuses are characterized by stability, which facilitates the analysis of its various skills. Biomechanical information is one of the best means to achieve the goal of movement, as it helps us discover the reasons for performance weaknesses and is considered an ideal way to find methods to enhance skill performance. (Abdel Wanes, 2015, p 3)

Each motor performance has a specific structure that distinguishes it from other motor performances, and this structure has its own characteristics that follow a specific arrangement of a set of motor procedures. These procedures are represented in accomplishing a specific motor task that has its own time span and dynamics. Kinematic characteristics are identified through a motion analysis program to analyse the skill performance of various skills and to understand the mechanical variables that govern the motor structure of each one, considering that any motor skill relies on a set of dynamic determinants that collectively form the motor structure of the skill. (Abdelaziz, 2000, p21)

The application of biomechanics laws to the human movement apparatus for gymnasts shows its importance in recognizing the precise rules of movement and the ability to assess it under various conditions, identifying errors in the movement path and correcting them, mastering performance, determining the result of the movement path, and establishing its compatibility when the goal aligns with the movement to be performed. (Hossam Eldin ,2014, p29)

Mohamed Ibrahim Shehata (2011) confirms that the primary goal of applying biomechanics in gymnastics is to improve the athlete's technical performance, with its second goal being injury prevention. Biomechanics can also contribute to improving training by identifying the physical and skill requirements needed, and it also enhances technical training in various ways by conducting a biomechanical analysis of actual performance that allows for identifying defects in technical performance, as well as determining training that resembles the practiced performance. (Shehata,2011, p24)

The skills involving aerial rotations accompanied by twists are considered complex technical requirements that necessitate time for teaching so that athletes can meet all the necessary conditions for performing them. (Riyad,2006, p137)

The floor exercise apparatus constitutes an essential pillar of gymnastics, as the skilful performance used in twisting movements on the floor exercise apparatus is the fundamental factor for performing similar skills on the other gymnastics apparatus. (Abdul Razak& Mahdi,2014, p3)

It is mentioned by Adel Abdel Basir (2008) that aerobic courses are the results of force impulses generated by the support of the hands and feet or both together. They are also considered a mixture of transitional movements, and this type of movement is performed from a standing position or from an approach. When performed from a standing position, it requires

a high level of motor ability from the player, in addition to the availability of muscular strength, flexibility, and coordination that enables the player to perform the movement from a stable position. When the movement is performed from an approach, it gives the player the opportunity to find the most suitable point for take-off while gaining the maximum amount of horizontal speed appropriate for the movement that the player will perform, which is then converted during the take-off to a height that facilitates the accomplishment of the required motor task. (Abdel Basir,2008, p14)

On the floor exercise apparatus is for the athlete to possess high physical abilities and motor sensitivity, including muscular strength due to its importance in executing the motor task resulting from the coordination of lower limb movements. Therefore, one of the challenges faced by the athlete during performance is the development of movement fluidity, as it is considered a fundamental criterion in assessing the level of motor performance. Movement fluidity means the optimal coordination between all parts of the body.

The practical importance of this study lies in its attempt to provide those working in the field of gymnastics coaching with knowledge and information that assist in teaching the skill of the double back somersaults by presenting and describing some of the kinematic characteristics of this skill, including displacements, velocities, angles of the shoulders and thighs, and the path of the body's center of gravity during performance. Thus, the research problem is summarized as a scientific attempt to study and conduct a kinematic analysis of the skill of double back somersaults to identify its most important characteristics and to attempt to explain some of the kinematic variables resulting from the athlete during the performance of this skill on the floor exercise apparatus.

The skill in question occurs around the transverse axis that passes from one side of the body to the other, penetrating the lateral plane. This axis is imaginary, as happens when arching the torso backward or bending it forward, or it can be a temporary real axis that then transforms into an imaginary axis, as in the skill of double back somersaults on the floor exercise apparatus.

From here, the authorswants to identify the kinetic variables of the double backward somersault skill on the ground movement apparatus and the extent of the center of mass movement in tracing the motion path around the transverse axis around which the skill is performed. Therefore, the goal of the current study is to identify some kinetic variables of the body's center of gravity and the reactive force index during certain phases of performing the double back tucked somersault skill on the floor exercise apparatus.

Question of the Study

What are the Kinetic Variables of the Body's Center of Gravity and the reactive Force Index in Certain Phases of Performing the Double Back Tucked Somersault Skill on the Floor Exercise Apparatus?

Materials and Method

The authorsused the descriptive method, utilizing video recording and biomechanical analysis due to its suitability for the nature of the research.

Participants

The research participants was intentionally selected from the players of the Egyptian National Gymnastics Team registered with the Egyptian Gymnastics Federation. The main participants consisted of one player, while an additional one player from the same population, but outside the main participants, was chosen to conduct the pilot study.

The "research sample" consisted of several attempts to perform the previously mentioned skill on the floor exercise apparatus. The best 3 attempts were selected based on the judgment of experts, represented by international judges appointed by the Egyptian Gymnastics Federation. These attempts were then subjected to biomechanical analysis.

Procedures

Pilot Study

The authors conducted the initial pilot study on Saturday, July 22, 2023, a athlete from the same research population at the gymnastics hall of the Olympic Center for National Team Training. The sample was filmed performing several attempts of the skills under investigation on the floor exercise apparatus.

The objectives of the pilot study were to ensure the availability and functionality of all necessary equipment and tools for testing, to verify the suitability and readiness of the testing location for conducting the assessments, to Determine the optimal frame rate for recording performance and identify the appropriate positions for camera placement, and to Specify the required recording quality to perform biomechanical analysis of the skills under study.

Capturing videos for the Main Study

The filming took place on Thursday, July 27, 2023, at the gymnastics hall of the Olympic Center for National Team Training. Several successful attempts of performing the front double backflip on the floor exercise apparatus were filmed. The best three successful performances were selected based on technical execution, while considering the specific requirements and precautions of the movement analysis program. These performances were then subjected to biomechanical analysis to extract the most important biomechanical variables.

Several successful attempts were filmed for the performance of the double back tucked somersault skill on the floor exercise apparatus. The top three successful performances, in terms of technical execution, were selected for biomechanical analysis to extract key variables. The camera was positioned 4 meters away from the performance area and at a height of 1.10 meters above the ground. The authorsensured that the camera was perpendicular to the sagittal plane

of the motion and that the movement occurred in the center of the frame. Filming was conducted at 60 frames per second and a resolution of 1920x1080 pixels. A 4-point calibration cube measuring 1m x 1m was placed in the middle of the frame at the performance area for the skills under study.

Motion Analysis

The authorsconducted a two-dimensional motion analysis for the performance of the double front tucked somersault skill and the double back tucked somersault skill on the floor exercise apparatus. A 14-point reference model was used to represent the athlete's body parts during the skill execution phases. The authorsutilized Tracker Analysis 6.0 motion analysis software to analyze the filmed attempts and extract the key biomechanical variables under study.

Tools and devices

- Restameter for measuring length in centimeters.
- Medical scale for measuring weight in kilograms.
- Stopwatch.
- Gymnastics apparatus (floor exercise apparatus).
- Auxiliary devices (partitioned box - mats - jump ladder - wall bars).
- Components of the Motion Analysis Program.
- One SoCoo/C30 S High-Speed Camera (configured to a frequency of 60 frames/second, with a resolution of 1920x1080 pixels).
- One tripod stand equipped with a bubble level.
- HP Pavilion G6 laptop.
- Tracker Analysis 6.0 motion analysis software.
- A 4-point calibration cube measuring 1m x 1m.
- Statistical analysis software (SPSS v.20 and Microsoft Excel 2024).

Results and Discussion

Table (1) and figure (1) show that the vertical push was greater than the horizontal push. This is due to the increase in the body's center of mass to the highest possible point, benefiting from the speed gained during the approach and converting it into vertical speed during the flight phase. At this moment, the player is affected by gravity, pulling the body downward. When the center of mass reaches its maximum height, the vertical speed stops at zero, and the horizontal speed decreases due to air resistance. At this point, the body's rotation is at its lowest speed to achieve the ideal rotation. Vertical speed then increases again as the body descends toward the ground in the landing phase. This improvement helps in performing motor skills better and enhances the rotation around the body's transverse axis before landing, contributing to a balanced landing. If the vertical distance during the flight decreases, it may cause the player to

fail in performing the landing phase correctly, increasing the risk of injury on the floor exercise apparatus and leading to a deduction by the judging panel.

Table 1. Kinetic characteristics of certain phases of performing the douple salto on the floor exercise apparatus

Trials	Time (sec.)	Braking time (sec.)	Force time (sec.)	Horizontal force (N)	Vertical force (N)	Resultant force (N)	Angle of Force (degree)	reactive Force Index
First	0.133	0.067	0.066	1862.725	5563.41	5866.96	71.48	19.22
Second	0.134	0.067	0.067	2070.381	5583.21	5954.72	69.65	19.299
Third	0.134	0.067	0.067	2116.046	5520.15	5911.83	69.02	19.32
The average				2016.384	5555.59	5911.17	70.05	19.28
Standard deviation				135.0169	32.25	43.88	1.27	0.054

It is also observed that the push angle reached 70 degrees, which is considered a good result and indicates an increase in the player's push strength. Additionally, we notice the high value of the rebound force index, which reached 19.27 degrees.

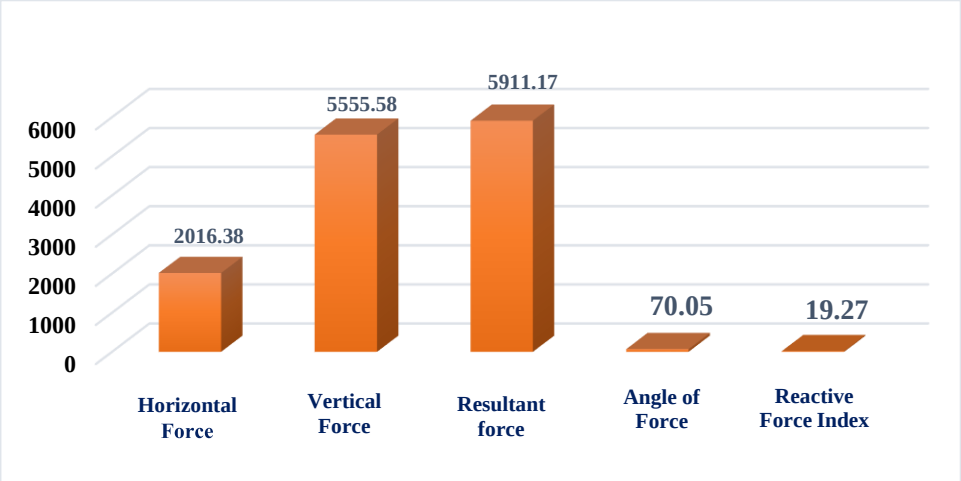

Figure 1. Kinematic characteristics of douple salto of the best trial

The authors believe that the greater the flight time and the higher the vertical distance, the better the player performs the skill, and the more difficult the skill becomes. This meets performance requirements, reducing performance deductions by the judging panel. The production of explosive power during the performance of the skill in gymnastics also depends on the player's knowledge of the correct technical execution of the skill and their ability to reach the automatic phase and maintain stability in movement. Mastering technical performance enhances the player's ability to use muscular force effectively, which contributes to improving

the ability to generate high explosive power. Therefore, the interaction between muscular strength and technical knowledge is a key element in achieving optimal performance in skills that require explosive power.

The results of this study are consistent with the findings of the studies by (Mohamed El-Shami, 2023).(Mohamed El-Bishlawi ,2021), Mahmoud Sorour,2019). (Ghidaa Abdel-Shakour , 2017) and the study by (Nico Nitzsche 2022) The push phase is one of the critical stages when performing the skills under study. This is because push is a vector quantity, and its direction is the same as the direction of the applied force. The physical dimension of push is like the physical dimension of momentum. The angle of push of the body's center of gravity is the angle formed between the horizontal direction and the direction of the applied force to push the center of gravity. This angle is used in the study of human movement and analysing how the force is distributed and its impact on the balance and movement of the body.

Conclusion

- The average horizontal force was 2016 Newtons with a standard deviation of 135 N.
- The average vertical force was 5555 Newtons with a standard deviation of approximately 32 N.
- The average resultant force value was 5911 Newtons with a standard deviation of 43 N.
- The average angle of force was approximately 70 degrees with a standard deviation of 1.2 degrees.
- The average rebound force index was 19.27 degrees with a standard deviation of approximately 0.05.

Recommendations

- It is necessary to use the data derived from the kinetic analysis of the skill in teaching by those responsible for it.
- Conduct similar research on other skills, which would save time and effort for both the athlete and the coach.
- It is essential to allocate a specific time in training programs for performing specialized exercises related to the nature and form of each skill, as it has a positive impact on improving performance levels.
- Attention should be given to kinetic analysis in studying and interpreting motor skills to achieve the best possible performance considering the specific performance conditions.
- It is crucial to provide a biomechanics lab in all educational and training institutions that focus on teaching and training the technical performance of various sports skills.

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