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Biomechanical Fundamentals of Hand Standing and Somersaults: The Impact of Coaching Interference

Fundamentos biomecánicos de la bipedestación y los saltos mortales: el impacto de la interferencia del entrenamiento

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Abstract. Biomechanics is the leading sports science concerned with movement technique. This is particularly significant in gymnastics, where the performance styles of the top gymnasts serve as examples for others to emulate, we aimed to conduct this study to evaluate the biomechanical fundamentals of hand standing and somersaulting between the two groups with and without coach interferences. A comparative study was conducted in which 24 highly competitive national standard healthy male gymnasts were enrolled. The participants were divided into two equal groups each group consisting of 12 players. One group was interfered and additionally trained by a coach and another group served as control in which there was no additional interference of coach. The researchers filmed the performance via canon EOS 100D cameras, while the motion analysis was done using the Kinovea motion analysis program. For hand standing, balance time and postural execution was observed between two groups. For somersault, c-motion guidelines were used to attach markers to the joints and limbs of participants to observe the angle and angular velocity of joints. A total of 24 participants (12 in each group) were analysed. Results was found out that the angles of ankle, knee, hip and shoulder at toe off time was found statistically significant. The angular velocity at the time of initial contact and toe off between the two groups was statistically significant. The hand standing between two groups was found son significant. The study results revealed that the angles of participant under coach interferences were found effective in somersault. In light of the results, it is recommended that joint angles should be focused to acquire this technique more effectively.
Keywords: somersaults, hand standing, biomechanical fundamentals, coaching interference, gymnastic.

Resumen. La biomecánica es la ciencia deportiva líder que se ocupa de la técnica del movimiento. Esto es particularmente significativo en gimnasia, donde los estilos de desempeño de las mejores gimnastas sirven como ejemplos para que otros los emulen. Nuestro objetivo fue realizar este estudio para evaluar los fundamentos biomecánicos de la postura de manos y el salto mortal entre los dos grupos con y sin interferencias del entrenador. Se realizó un estudio comparativo en el que se inscribieron 24 gimnastas masculinos sanos de estándar nacional altamente competitivos. Los participantes se dividieron en dos grupos iguales, cada grupo constaba de 12 jugadores. Un grupo fue interferido y entrenado adicionalmente por un entrenador y otro grupo sirvió como control en el que no hubo interferencia adicional por parte del entrenador. Los investigadores filmaron la actuación con cámaras Canon EOS 100D, mientras que el análisis de movimiento se realizó utilizando el programa de análisis de movimiento Kinovea. Para la bipedestación manual, se observó el tiempo de equilibrio y la ejecución postural entre dos grupos. Para el salto mortal, se utilizaron pautas de movimiento en C para colocar marcadores en las articulaciones y extremidades de los participantes para observar el ángulo y la velocidad angular de las articulaciones. Se analizaron un total de 24 participantes (12 en cada grupo). Se descubrió que los ángulos del tobillo, la rodilla, la cadera y el hombro en el momento del despegue fueron estadísticamente significativos. La velocidad angular en el momento del contacto inicial y del despegue entre los dos grupos fue estadísticamente significativa. Se encontró que la mano que se encontraba entre dos grupos era significativa. Los resultados del estudio revelaron que los ángulos de los participantes bajo las interferencias del entrenador resultaron efectivos en el salto mortal. A la vista de los resultados, se recomienda enfocar los ángulos articulares para adquirir esta técnica de forma más efectiva.
Palabras clave: saltos mortales, parada de manos, fundamentos biomecánicos, interferencia de entrenamiento, gimnasia.

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Introduction

Gymnastics is one of the sports that require exceptional physical condition in terms of flexibility, muscle strength, and reaction speed, and neuromuscular coordination is one of its unique characteristics (Brewin & Kerwin, 2003; Kerwin & Hiley, 2003). The gymnastic somersault is one of the practical gymnastics skills that incorporate run-up, takeoff, flying, and landing phases (de Andrade et al., 2021). This is an essential skill for adolescent gymnasts who are just beginning to acquire more complex skills such as the twisted somersault, double somersault, etc. (Suga et al., 2021; Opala-Berdzik et al., 2021). Because learning and successfully using this approach not only provides the path for learning more complex techniques (Köklü et al., 2017), it can also lead to high scores and championships for this age group (Matos et al., 2020; Gharaat et al., 2020).

Since the somersault technique is extremely fast and each phase of this movement occurs in a hundredth of a second, kinematic analysis and evaluation of this movement can identify important and effective factors in the correct implementation of this technique and could assist coaches in eliminating errors as quickly as possible (Yeadon & Hiley, 2018). Researchers in biomechanics have assisted in identifying the kinematic and kinetic aspects influencing the successful execution of this technique (Dos'Santos et al., 2018). McNitt-Gray (1993), who investigated the linear and angular kinematics of athletes who jumped from three different heights, reported that the extensor muscles of professional gymnasts use a greater force momentum at higher collision speeds than non-professional athletes to distribute the load at the moment the foot strikes the ground.

In gymnastics, perfecting the handstand is a well-recognized fundamental training component that is deemed crucial

from the outset of a young gymnast's career (Uzunov, 2008). In female and male artistic gymnastics, the handstand serves as a starting position or a static end of movement techniques employing the hands as body-apparatus interface (Hedbávn & Kalichová, 2013). The changing mechanical qualities of the various apparatus make posture correction more difficult and necessitate multiple experiences and precise muscle activation (Kochanowicz et al., 2017).

Quantitative examination of movement technique to promote the acquisition of motor skills is one of the key duties of sports biomechanics. Biomechanics is the leading sports science concerned with movement technique (Bartllet, 2009; Knudson, 2007). This is particularly significant in gymnastics, where the performance styles of the top gymnasts serve as examples for others to emulate. When complete descriptions of the talents are given, a coach is better able to direct the technical and physical training for these specific skills. Recording and/or measurement of various characteristics and a variety of accessible biomechanical techniques are applied in the scientific study of a movement technique of motor skills. Using many devices simultaneously, both the internal (muscle activation) and external (kinematics and kinetics) structure of the barbell snatch and bench press were understood (muscle activation and kinematics) (inter alia: force platform, electromyography, goniometers, and cameras) (Yeadon et al., 1990; Bartllet, 2009).

Achievement in the sport of gymnastics depends on the extent of the players' ability to perform the skills with high accuracy and at a distinguished technical level, taking into account the finest motor details, on the basis of which the referees directly evaluate the player's performance. This accurate performance cannot be achieved without taking into account the mechanical aspects of the skills performed, which necessitates the necessity of full commitment to all Mechanical aspects associated with gymnastics skills (Nyman,2020).

The rationale to conduct this study was that there was no data was available in this regard in our region and also this is the emerging topic that needs to be discussed. Therefore, we aimed to conduct this study to evaluate the biomechanical fundamentals of hand standing and somersaulting among the two groups with and without coach interferences.

In fact, biomechanics plays an important role in supporting sports training processes and raising the skill level of players. The field in sports has expanded and has become an integral part of any integrated sports training or education process (camops et al., 2022), Hence, this study differed in that it came to investigate the effect of the coach's directions on the skill performance of gymnasts from a biomechanical perspective, which is a perspective that gives numerical values of performance that truly and accurately reflect the effect of the coach's directions on the skill performance of his players in gymnastics.

From the foregoing, we point out that this study aimed to find out the impact of the coach's interventions on the performance of the skills of standing on the arms and somersaults in terms of the Biomechanical Fundamentals for gymnasts.

H1: There is a statistically significant effect of the coach's intervention on performing the skills of standing on the arms and somersaults, in terms of the Biomechanical Fundamentals for gymnasts at the time of detachment and attachment of toe from the ground.

Materials and Methods

Study participants

A total of 24 participants highly competitive national standard healthy male gymnasts were enrolled, Mean age, height and weight of participants was 12±4.2 years, 125±40.1cm and 48.5±12.5 g respectively, The participants were randomly assigned into two groups and each group consisted of 12 participants.

The study was approved the by the institutional ethics committee and informed consent was taken by the participants prior to the enrolment in the study. All individuals were evaluated under same laboratory circumstances.

Study organization

This study used the experimental method Where the participants divided into two equal groups based on the evaluation of 4 specialized coaches for the level of the players and depending on their training age, when dividing the players into two groups, and to ensure the equality of the two groups, the specialists relied on skill tests, namely the handstand and the somersault. The participants conducted these tests and the specialists gave marks to each player. Then the players were divided into the two groups equally according to these marks. One group was interfered and additionally trained by a coach and another group served as control in which there was no additional interference of coach. Following a warm-up, the subject completed a 10-minute stretching routine. Each gymnast performed three attempts of hand standing and somersault acrobatics. For hand standing, balance time and postural execution was observed between two groups. For somersault, c-motion guidelines were used to attach markers to the joints and limbs of participants (van Sint Jan, 2007) and marks were done on the left and right wrist, elbow, shoulder, hip, knee, ankles, and forefoot to observe the angle and angular velocity at the initial contact to the ground and the time at which toes were separated from the ground during the toe off phase. . Two cameras were installed to observe the readings. The first camera was put on the right side of the athletes, while the second camera was placed on the left side. So that the camera axis was perpendicular to the sagittal plane upon which the athletes executed their technique. From the beginning of each athlete's take off until the conclusion of their landing, footage was captured. The test was conducted so that the athletes executed their somersaults consecutively and rested for approximately one minute between each performance.

Equipment and Tools

The researchers used 3 cameras (canon EOS 100D,) and (Kinovea 0.9.5) motion analysis software was used to reach the raw results of this study.

Statistical analysis

Mean and standard deviation (SD) were computed. T test was applied to observe the mean difference between two groups and p value <0.05 was considered to be statistically significant.

Results

After conducting statistical treatments, the researchers arrived at the results shown in the following tables, as Table 1 displays the mean and standard deviation of the angles of included joints for two groups at the two points of initial contact and separation of the toe from the ground during the take-off phase of the somersault and it was found out that the angles of ankle, knee, hip and shoulder at toe off time was found statistically significant. Angular velocities between two groups are presented in table 2 and it was observed that the angular velocity at the time of initial contact and toe off between the two groups was statistically significant. However, angular velocity of hip and shoulder at the tie of initial contact to the ground was significant. In hand standing, mean balance time and postural execution between the two groups was found non- significant.

Table 1.
Association of Angle of Joints between the Groups at Two Time Points

Angle (^{0})	Time of measurement	Group 1 (Coach interference)	Group 2 (Without additional coach interference)	P-Value
Ankle	Contact of toe with ground	118.3 (5.4)	110.1 (4.2)	0.085
	Separation of toe from the ground	142.4(7.1)	132.6(6.5)	0.021
Knee	Contact of toe with ground	152 (4.1)	149 (6.2)	0.558
	Separation of toe from the ground	167 (3.7)	160 (3.1)	0.035
Hip	Contact of toe with ground	135 (4.2)	128 (5.7)	0.107
	Separation of toe from the ground	181 (3.9)	152 (11.8)	0.001
Shoulder	Contact of toe with ground	58 (4.3)	68 (3.4)	0.321
	Separation of toe from the ground	115 (6.9)	133 (7.1)	0.021

Table 2.
Association of Angular Velocity of Joints between the Groups at Two Time Points

Angular velocity ($^{0/s}$)	Time of measurement	Group 1 (Coach interference)	Group 2 (Without additional coach interference)	P-Value
Ankle	Contact of toe with ground	701.6 (188.4)	375.9 (108.6)	0.032
	Separation of toe from the ground	1115.6 (421.5)	876.6 (6.5)	0.008
Knee	Contact of toe with ground	605.6 (235.7)	530.5 (240.8)	0.543
	Separation of toe from the ground	962.7 (435.6)	908.9 (312.4)	0.052
Hip	Contact of toe with ground	533.5 (212.8)	385 (134.9)	0.041
	Separation of toe from the ground	486.7 (201.8)	670.3 (267.8)	0.358
Shoulder	Contact of toe with ground	699.9 (478.8)	496.6 (203.6)	0.031
	Separation of toe from the ground	543.8 (312.5)	475.9 (197.9)	0.671

Discussion

The study was done to evaluate if there is A statistically significant effect of the coach's intervention on performing the skills of standing on the arms and somersaults, in terms of the Biomechanical Fundamentals for gymnasts.

The results showed a statistically significant effect at the level of significance of 0.05 for the influence of the coach on the performance of the players in the skills of standing on the arms and somersaults through the two points of performance and in terms of angles and angular velocities of the working joints, but this effect did not include all the variables of the study.

The counter movement is a subset of the initial phase, the purpose of which is to establish optimal conditions for the execution of the main phase. This is accomplished by pre-stretching the limb muscles. In biomechanics, this is known as the stretch-shortening cycle (Cronin et al., 2001; Krol & Mynarski 2010) and it increases the elastic energy of the muscles. Take off and flight are the primary phases, as they are when the primary task is completed. The primary duty involves body rotation about the free axis. The goal of the take-off is to give the necessary projection velocity to lift the body and the necessary angular momentum to accomplish a rotating motion.

Biomechanics is concerned with the forces that operate on the human body and the effects that these forces have, with muscle action taking precedence. Skeletal muscles are the principal movers and a biological system designed to generate mechanical force and induce movement (Król et al., 2016). In our study, average ankle angle during somersaulting was 142 degrees, knee angle was 152 degrees, hip angle was 135 degrees, and shoulder angle was 58 degrees at the point of foot separation from the ground during take-off and a significant mean difference between the participants with and without coach interferences was found. Irwin et al. (Irwin & Kerwin, 2009) reported contradicted to our findings as the joint angles at the moment of toe separation from the ground were 178° for the ankle, 180° for the knee, 170° for the thigh, and 145° for the shoulder. This disparity could be attributable to the different camera speeds. Excessive stretching of this joint might force athletes to bend too far forward and prevent the lower torso from opening sufficiently before take-off.

Moreover, the joint angles of the lower torso when detaching the toe from the ground were substantially greater

in participants with coach interferences than in those without coach interferences. Using the ankle's angular velocity at the time of attachment and detachment, we were able to determine the difference between the groups. Significant was determined to be the angular velocity of the hip and shoulder at the time of detachment. Using a kinetic motion analysis programme, a study (Al-Beshlawi, 2010) investigated the technique of the straight somersault in a series of sequential and single actions in 2010. Therefore, the time gained in this investigation is less than the time required to accomplish a single somersault's take-off, which was 1.04 seconds. In Al-Beshlawi's adult professional gymnasts with an average age of 19 years participated. As a result, the difference between the results of the present study and Al-Beshlawi's may be attributable to the difference between the participants of the two studies. In our investigation, the difference in mean balance time in hand standing was not determined to be statistically significant. In a study with similar results, there was found no positive effect of additional training on the maintenance of handstands by young gymnasts, opposing the notion that postural exercises complemented with augmented information prolong the maintenance of handstands by young gymnasts.

Thus, from the perspective of balance abilities, the present findings contradict previous reports indicating that movement practise supported by augmented feedback information (e.g., tactile advice or visual information) enhances the acquisition of sport-specific skills (Schmidt & Lee, 2005) and, in particular, handstand acquisition (Ghavami et al., 2012; Rohleder & Vogt, 2018). Frequently, computer simulation (Yeadon et al., 1990) is utilized to better comprehend the cause-and-effect linkages between biomechanical components. This is achieved by manipulating the major performance parameters in a systematic manner. The results of a simulation are dependent on the precision of the input data and the model's complexity. This first element is contingent on the type of measurement instruments.

Conclusion

In conclusion, the study results revealed that the angle of ankle, knee, hip and shoulder at the time of detachment of toe at the ground was significant between the groups with and without coach interferences and the angles of participant under coach interferences were found effective in somersault. However, the angular velocity at the time of detachment and attachment of ankle, hip and shoulder was found effective. It is recommended that close attention to the joint angles should be paid at the beginning and end of the take-off phase in order for players to acquire this technique more effectively. Further longitudinal studies with large sample size are needed in this context.

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