

Mechanical Analysis of Free-Rolling Balls of Different Sizes on an Inclined Surface at Constant Circumferences

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ABSTRACT

The aim of the research is to identify the value of some mechanical variables before and after hitting the ground at a certain angle when the ball is rolled freely for each type of ball (basketball, handball, and football). The importance of the research stems from studying the variance in directions of the balls in their respective playing fields when rolled at a certain angle and rebounding at a different angle and this is when the circumference is fixed. adopted a method of tracking the movement of various types of balls (basketball, handball, and football) when they are in a free-rolling position in a constant environment. In ball competitions we find that the players can not accurately control inbound balls, especially a rebounding ball, and do not accurately predict or determine the distance of the ball's rebound in order to take the correct location to put down the ball or score it .

Keywords : kinematics Variable , Mechanical Analysis , Free-Rolling Balls.

التحليل الميكانيكي للكرات ذات التدرج الحر ذات الاحجام المختلفة على سطح مائل بمحيطات ثابتة

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الملخص

الهدف من البحث هو تحديد قيمة بعض المتغيرات الميكانيكية قبل وبعد ضرب الأرض بزواوية معينة عندما يتم لف الكرة بحرية لكل نوع من الكرة (كرة السلة ، كرة اليد ، وكرة القدم). تتبع أهمية البحث من

دراسة التباين في اتجاهات الكرات في حقول اللعب الخاصة بها عند تدرجها بزوايا معينة وارتداد بزوايا مختلفة وهذا هو عندما يتم إصلاح المحيط. اعتمدت طريقة لتتبع حركة أنواع مختلفة من الكرات (كرة السلة ، كرة اليد ، وكرة القدم) عندما تكون في وضع حر في بيئة ثابتة. في مسابقات الكرة ، نجد أن اللاعبين لا يمكنهم التحكم بدقة في الكرات الواردة ، وخاصة كرة الارتداد ، ولا يتنبأون بدقة أو تحديد مسافة انتعاش الكرة من أجل أخذ الموقع الصحيح لإسقاط الكرة أو تسجيلها .

الكلمات المفتاحية : المتغيرات الكينماتيكية ، التحليل الحركي ، الكرات المتدرجة الحرة.

Introduction

When we observe of the kinetic activities, we find that there are two things that draw the attention of the sports audience, namely the player and the ball, the later which represents the means to achieve the end. Any serious work must take into consideration the means as the basis for achieving its goal. The researchers attempt to investigate means of achieving the goals by kinetically tracking the ball (basketball, handball, and football) [1] when it is in a free-rolling steadily in the surrounding environment, the free rolling ball rolling of balls as the process of letting the ball roll on an inclined plane from the ground at a certain angle without this rolling process causing any driving force for the ball to roll. [2] We often see in the Olympic games, that some players and when they want to control a ball coming from a colleague or a rebound ball is that he does not accurately expect or determine the distance of the ball's rebound in order to take the correct location to put down the ball or target it. From here stems the importance of the research and it lies when the balls are rolled at a certain angle and rebound at another angle and this is when the circumference of balls are fixed and each ball tested according to its playing fields. [3]

We also know, according to Newton's third law, (action and reaction) that for every action there is a reaction equal in magnitude and opposite in direction [4] and this applies to solid bodies, i.e. when a force of (500) Newton's is applied with our arm on a wall (pushing a wall) This wall will respond to us this force by (500) Newton's in the opposite direction. So the problem addressed by the research stems from questioning if we apply this law on different types of balls by making them free fall from different heights, will these balls rebound to the same height they were dropped from? Will the modulus of

elasticity which equals (stress/ strain) [5] play a role in the balls behavior ? Do bouncing balls apply to the law of action and reaction?

The research aims to identify the following:

The value of some mechanical variables of the balls (basketball, handball, and football) before and after hitting the ground at a certain angle when each ball is rolled freely. Does the law of action and reaction have anything to do with balls rolling angle when the circumference is fixed?

Related Works

In the pursuit of peak athletic performance, biomechanics plays a crucial role by offering precise insights into motor abilities. This study, conducted from May 8 to May 10, 2018, with the Erbil Gymnastics Team at the Faculty of Physical Education's (Shahid Shakhwan) Gymnasium, aimed to identify mechanical factors related to frontal pike flips and open frontal air flips on gymnastic floor mats. The random sample of five gymnasts from the Kurdistan Region of Iraq underwent technical scientific observation through 120 frames per second videotaping. The primary experiment on May 10, 2018, at 11:00 am, recorded performances of front pike flips and open frontal aerial flips. Analysis of statistical parameters revealed significant variations in arithmetic means, emphasizing that the open frontal aerial flip demands more effort than the pike flip. This aligns with the research goal of mechanical comparison, suggesting a practical tip for gymnastics instructors: begin training with simpler skills like the pike flip and progressively introduce advanced programs for open frontal aerial flips, requiring more extended training sessions.[6]

The purpose of the study was to determine how kinematic factors, especially those measured from 6 and 9 meters out, related to handball shooting skills during the flight phase. The researcher examined data from ten players using a descriptive technique and technical scientific observation using two video cameras running at 25 frames per second. ACD, Premier, and If Lima were among the software packages used in kinematic analysis. Significant differences were found for the left knee angle and the body center

of gravity's horizontal-vertical distance in favor of the 6-meter distance, and for the right shoulder inclination and hip angle in favor of the 9-meter distance. The remaining kinematic variables, however, did not show any discernible variations. The study suggests that during handball shooting drills, training should be concentrated on joint and body movement angles. Additionally, when performing high leaps in handball games, attention should be paid to both horizontal and vertical displacement.[7]

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The research explores the complexities of athletic movement processes in a variety of sports, highlighting the significance of comprehending components like anatomical, social, psychological, biological, and, most importantly, mechanical factors. Together, these components provide the theoretical framework that clarifies the interdependent effects on movement scales and results in the creation of optimal movement patterns that improve training and learning effectiveness. With an emphasis on weightlifting, the study discusses how lifting techniques are changing, especially with regard to the rise of the squat jerk in contrast to the split jerk. The study statistically analyzes the data and identifies variations in variables using a comparative analysis including the Nenava

weightlifting squad (H3, H4). The definitive results indicate that athletes with stronger upper bodies and less flexibility are more suited for the split jerk method, whereas athletes with stronger lower limbs, more upper body flexibility, and a faster descent speed beneath the bar are better suited for the squat jerk style.[9]

Material and Methods

The researchers used the descriptive approach for its suitability and the nature of the research. Basketballs, handballs, and footballs were chosen as tools, and each of these balls was pressurized according to sports regulations so that the mass of each ball becomes according to the rules of this game for each ball [6] .

Table 1. shows the values of the masses of these balls.

Balls	Legal mass of the ball (g)	Mass of used balls (g)
Basket ball	576 – 650	620
Hand ball	425 – 475	455
Foot ball	410 – 450	430

Evidence has been collected through scientific and technical observation and computer analysis.

Devices and Tools Used:

Device	Number	Device	Number
Basketball	1	Wooden scale (1 m)	1
Football	1	Measuring tape (5 m)	1
Wooden platform	1	Basket ball stadium	1
Wooden background (table)	2	Hand ball stadium	1
Video camera (SONY)	1	Foot ball stadium	1
Camera stand	1		
8 mm video tape	1		

The PILOT experiment was conducted on 3/25/2022 at exactly eleven o'clock in the indoor stadium of the College of Physical Education and Sports Sciences in order to determine and install the location of the

video camera in terms of the horizontal distance from the ball and the height of the center of the camera focus from the ground. The horizontal distance of the camera from the free-rolling position of the basketballs, handballs, and footballs, was (5.4 m) and the height of the center of the camera focus was (68 cm) from the ground.

The main experiment was conducted on 3/26/2022 at exactly eleven o'clock in the indoor stadium of the College of Physical Education and Sports Sciences, after the camera was fixed at the same distance and height in the pilot experiment. The free balls were rolled using a wooden bench, where the ball was rolled at an angle of inclination (24°). The ball was rolled here by releasing the ball. The rolling of each the three balls was repeated in three attempts. The best attempt was calculated according to the videography. Finally, the scale was photographed for the vertical position so that the researchers could know the real values , as we show in appendix (A) .

Kinematic variable extracted from free-rolling balls: as shown in rebounding angle. The difference between the angle of impact and the angle of rebound.

Programs Used in the Analysis:[10]

Special programs were used in the analysis by means of an electronic computer, as the analysis in general is a means of dividing the total movement into parts in order to extract the research variables, which are as follows:

I FILME Program:

It is a video player program through which we can segment the video movie into small video clips of MPEG format in which each movement is independent of the other movements to be analyzed.

Image Read 8

It is a sophisticated program from the Microsoft group that has the ability to cut the video movie and split it from beginning to end into 25 sequential individual images (1-25 images) / s, and then stored in the computer to be processed through another program.

AutoCAD 2000i: It is an engineering program widely used in the fields of architecture and in the mapping of buildings, and this program is used in the mathematical field in order to extract the values of your kinematics and kinetics. [١١]

Results:

The tables of the kinematics variables for the free rolling balls were presented in one table, in order to facilitate the reading of the results.

Table 2: Shows the values of some kinematic variables for rolling free balls (basketball, handball, and football)

Balls	Kinematic Variables					
	Impact angle	Rebound angle	Difference between impact and rebound angle	Impact speed	Highest elevation after rebound	Rolling angle
Basketball	43°	41°	2°	1.139 m/s	0.324 m	24°
Handball	36°	27°	9°	1.179 m/s	0.268 m	24°
Football	31°	30°	1°	1.280 m/s	0.262 m	24°

From table 2 , we note that the balls rolling from an angle slope (24 degrees) hit the ground at different times and speeds. The researchers attribute the reason to the fact that the earth's gravity, the friction coefficient, and the modulus of elasticity of the ground with the ball at the moment of impact had a positive effect on the basketball in terms of the highest height after the impact. The positive effect was observed in the speed of the collision as well as in the angles of movement according to the law of gravity. We note that there are differences in all the other studied variables and the researchers attribute the reason to the difference in the elasticity modulus between the balls, which was reflected in the highest height after rebound and rebound speed as well as the difference between the angles and the value of the loss of the value of the angle according to Newton's law, for every action there is a reaction equal in magnitude and opposite in height, but not equal in speed or height of the rebound. The researchers believe that this is also reflected in the behavior of the tidal and the feeling of heat and cold for the human being, because the higher the temperature of the air, the higher the body temperature, but a moderate percentage that is proportional to the body scrub, so that the person remains alive, as well

as if the temperature is less than zero, then the human body He will be cold in a percentage that enables him to continue life for him , and this confirms our philosophy in this research that every action has a reaction that reflects in the direction, but it will not be equal to him in the amounts of the limits of this study.

Conclusions:

Through the presentation and discussion of the results, the researchers concluded the following:

- All balls rolling at an angle of (24°) did not rebound at the same angle of impact, but rather rebounded at an angle less than of (24°) .
- All the falling and rolling balls had a rebound velocity less than their impact velocity.
- For every action there is a reaction equal in magnitude and opposite in direction (but not equal in height in free-rolling balls).

References

- [1] Barbieri, F. A., Gobbi, L. T., Santiago, P. R., & Cunha, S. A. (2010). Performance comparisons of the kicking of stationary and rolling balls in a futsal context. *Sports Biomechanics*, 9(1), 1-15.
- [2] Pepple, J. (2010). Soccer, The left, & the farce of multiculturalism. AuthorHouse.
- [3] Cottey, R. A. (2002). The modelling of spin generation with particular emphasis on racket ball games (Doctoral dissertation, Loughborough University).
- [4] Brown, D. E., & Clement, J. (1987, July). Misconceptions concerning Newton's law of action and reaction: The underestimated importance of the third law. In *Proceedings of the Second International Seminar: A Misconceptions and Educational Strategies in Science and Mechanics* (Vol. 3, pp. 39-53).
- [5] Tabor, D. (1948). A simple theory of static and dynamic hardness. *Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences*, 192(1029), 247-274.
- [6] A. R. al- Bakri and B. chasm Mohammed, (2019) "Comparative Mechanical Analysis between Open and Curved Frontal Air flip on Gymnastics Floor Mat," *Al-Rafidain J. Sport Sci.*, vol. 22, no. 69, pp. 105–117, doi: 10.33899/rajsport.2019.163019.

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- [7] S. Fathallah,,(2012), “A comparative study of some kinematical variables for the flight phase of the hand boll between shooting from the (6m.) and the (9m.) line in handball,” *Al-Rafidain J. Sport Sci.*, vol. 18, no. 59, pp. 217–230, 2012, doi: 10.33899/rajsport.62652.
- [8] O. Ramiz, “Effect of the Swimming Pool on Some Bio-Kinematics Variables in the Frontal Summersault in Gymnastic,” *Al-Rafidain J. Sport Sci.*, vol. 13, no. 45, pp. 27–41, 2007, doi: 10.33899/rajsport.2007.6187.
- [9] aD .N.Al-Dulayme, “Comparative study of some kinematics variables of bar trajectory movement between spelt jerk and squite jerk styles,” *Al-Rafidain J. Sport Sci.*, vol. 11, no. 39, pp. 149–166, 2005, doi: 10.33899/rajsport.2005.6057.
- [10] Comparative Mechanical Analysis between Open and Curved Frontal Air flip on Gymnastics ,”*Al-Rafidain J. Sport Sci.*, vol. 22, no. 69, pp. 105–117, 2019, <https://doi.org/10.33899/rajsport.2019.163019>
- [11] <https://forums.autodesk.com/t5/autocad-forum/autocad-2000i/td-p/6671666>

Appendix (A)

Explains how to extract the kinematical variables to roll the free balls

