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A Biomechanical Analysis of The Gymnastics Cartwheel Using Dartfish Motion Analysis Software

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Introduction

A course long term project, A Biomechanical Analysis of The Gymnastics Cartwheel, was completed during lab portion of KIN 417 Analysis of Movement. This project required the comprehension and utilization of various biomechanical principles that were taught in the lecture course. The unique aspect of this project is the capability to scientifically analyze the performance of the gymnastics cartwheel using the Dartfish Motion Analysis Software. This software is the latest and most sophisticated computer video analysis software that is used by teachers, coaches, physical therapists and sports medicine specialists. It is used to detect errors in a person's movement, calculate angles, times, distances, velocities and provide feedback using the drawing tools and media book. Stephen F. Austin State University is among an elite group of universities in the United States that utilize this sophisticated software.

Abstract

The biomechanical analysis required videotaping two subjects performing the cartwheel to the best of their ability. Strict protocols were followed to ensure the analysis was accurate. In order to measure distances in the Dartfish program, an object of known length had to be recorded. Subjects were asked to hold a scaling rod for ten seconds before beginning their trials. Subjects recorded four trials each and all data was imported into the Dartfish program.
Average trials for both subjects were chosen to be analyzed extensively for strengths, weaknesses and most importantly the overall biomechanics of the cartwheel. The subjects' video was then broken down into separate frames to show the different phases of the cartwheel. The Dartfish drawing tools were used to illustrate the incorrect positions and form. An explanation was also offered to explain the illustrations and provide feedback on how the corrections were to be made. Basic physics and biomechanical principles were used to explain why the subject was struggling to complete the skill successfully; as well as explain why the corrections were beneficial. A DVD was created of each subject's analysis so the subjects could watch and apply the corrections to improve their cartwheel.

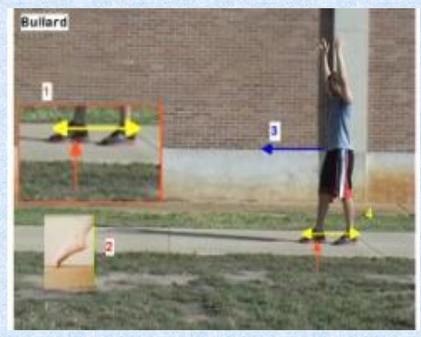
Methods

A videotape of the gymnastics cartwheel was created and imported into the Dartfish Motion Analysis computer program following strict instructions.

The performance was critically analyzed by utilizing the drawing tools. (See pictures) and conclusions were drawn using biomechanical principles and personal knowledge.

Results were provided to the performer by utilizing the drawing tools to illustrate errors and producing a DVD media book.

The performer is filmed holding a scaling rod for the computer program to accurate describe distance.



1. The orange arrow shows that the front foot is flat on the ground.
2. The correct stance requires the front foot be pointed with only the toes touching the ground.
3. The blue arrow: the performer's hips are in the correct position.
4. The feet are too close. A slightly wider stance will allow for a better push off the ground.

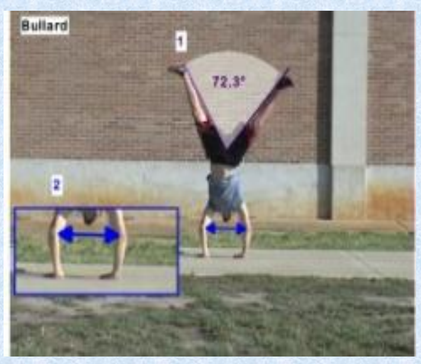
Biomechanical Principle (Conservation of Energy : The performer has more potential energy here than in the middle of the skill. When he begins the cartwheel the potential energy will turn into kinetic energy. At the end of the cartwheel, he will once again have potential energy.

1. The blue arrow shows that his back is not in line with the back leg.
2. The red arrow shows which direction his chest needs to move. This position will make the cartwheel short and more difficult to perform.
3. The green angle shows the angle at the waist. The correct angle should be an obtuse angle ranging from 115 to 130 degrees.

Biomechanical Principle (Moment of Inertia): In this phase of the cartwheel there should be slight knee and hip flexion. With this slight degree of flexion, there is a decrease of rotational inertia that allows the performer to maintain a straight line from his arms to his back leg. The performer has too much flexion at his hips causing him to have too much rotational inertia

1. The red horizontal lines shows that the performers knee is correctly bent over the front foot.

2. The blue arrow points to the right arm to show that it is bent as the performers hand reaches the ground. It should remain straight to support the body going into the cartwheel.

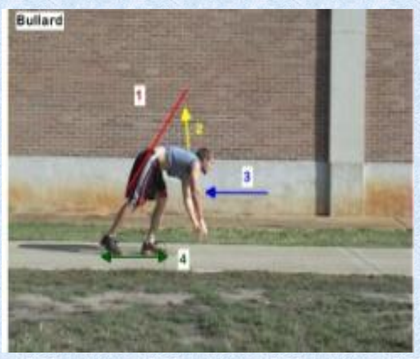


1. The purple angle indicates that an angle of 90 degrees was not maintained. A larger split allows for a more controlled and smooth lunge- out.
2. The picture of the arms indicates that they are still bent in the middle of the split making control difficult. A solid base of support is important.

Biomechanical Principle (Range of Motion): High levels of joint Range of Motion and Flexibility are important in performing gymnastics skills. In this particular phase of the cartwheel, good hip flexibility is needed for hip joint abduction of at least 90 degrees. The performer is lacking the ROM and flexibility as shown by the measured angle.

1. The red marker is once again showing that the foot is not pointed.
2. The yellow arrow is showing that the back leg is bent. In this position he is using the back leg as compensation
3. The angle that the hips make is too acute. This will make it harder to bring his chest up to finish the movement.

Biomechanical Principle (Levers): The body is acting as a first class lever. The left leg is the fulcrum, the back leg is the resistance arm and the chest and arms are the effort arm. The further away the effort arm is from the fulcrum: the easier it is to lift the load. Depicted above, the fulcrum (left leg) was placed too close to the arms and hands. This will make it more difficult and require more effort to lift up the upper body.



1. The red line shows that his back should be in line with his back leg.
2. The yellow arrow shows which direction the chest needs to travel to be in line with the back leg. The performer was slow with bringing his chest up out of the cartwheel and his back leg is to close to his front leg.
3. The blue line shows that his arms are not by the ears.
4. The spacing between the feet is too close resulting in less stability.

1. The performer correctly kept his arms by his ears and has a straight line from his arms to his back to the ground.

2. The red arrow is showing that he kept his hips square on the finish which is excellent because many people struggle with this part of the skill.

Summary

The Dartfish Motion Analysis Software enabled the investigator to more efficiently view the performers movements using a sound scientific basis . Evaluation and critique of the performer's movement using this software will provide the performer with more detailed feedback for improvement. A DVD media book was given to the performer as a resource for instruction and training to improve their gymnastics cartwheel.