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History of Biomechanics

Code	**adi-vid-01165**
Title	History of Biomechanics
Subtitle	Part 2 - The Olympic Games in Mexico City (1968) and Analysis of the Long Jump World Record by Bob Beamon
Subject	APAS;Biomechanics;History;Performance Analysis
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Synopsis

In the last episode, the implementation of Biomechanics in the Olympic Games was discussed. The episode highlighted the use of cameras and other instruments to expand our vision and knowledge. The history of motion capture was traced back to the 1870s, with the work of Edward Mybridge, who invented a way to record quick movements. His work led to the birth of motion pictures and the first photographic analysis of physical motion.

Modern high-speed cameras can now record rapid motion with great clarity. Slow motion film is used in analyzing athletic performance. Dr. Gideon Ariel, a physical education expert, uses slow motion film as the first step in the scientific coaching of athletes. However, he found that even with slow motion film, it's hard to determine what is right and wrong in an athlete's movement.

Dr. Ariel turned to computers for aid in the analysis of movement. The computer can calculate the interrelationship of force, acceleration, and velocity in the athlete's movements. This data can pinpoint where athletic technique is hindering performance.

Dr. Ariel's computer analysis of Olympic discus thrower, Mac Wilkins, revealed that energy was being wasted on ground friction. Based on this analysis, Wilkins altered his throwing technique and set a new world record.

Dr. Ariel and Aaron started a company in Massachusetts to further develop this technology. They invented the automatic digitizer, which is a sonar digitizer that provides immediate coordinates.

The episode concluded with a discussion on how computers are being used to improve athletic performance. Dr. Ariel's company, Computerized Biomechanical Analysis, studies athletes' movements and uses computers to analyze their moves and project how well they ought to be able to perform.

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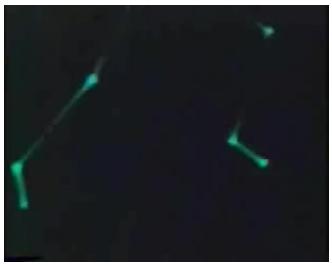
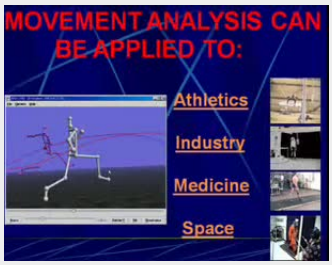
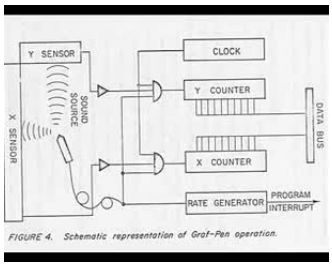
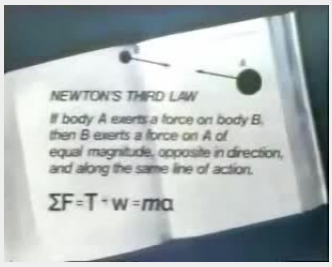
Audio transcription

Frame	#	Time	Spoken text
	0.	00:00:00	*Last episode was concluded with myself for the first time implemented Biomechanics in*
	1.	00:00:07	*Mexico City in the Olympic Games, where I film bad women among others and analyze the*
	2.	00:00:13	*log job to produce the first Biomechanical Analysis that was done in the Olympic Games*
	3.	00:00:20	*and from then on, it was continued.*
	4.	00:00:26	*The day is never before. Cameras and other instruments that see are radically expanding*

Frame	#	Time	Spoken text
	5.	00:00:32	*the limits of our vision and knowledge, and altering forever our image of the world.*
	6.	00:00:39	*Through the specialized eyes of cameras come new dimensions of seeing, which our eyes alone*
	7.	00:00:51	*could never discern.*
	8.	00:00:56	*In a world of motion, there is infinite detail too fast for the unaided eye.*
	9.	00:01:02	*In the 1870s, an ingenious photographer, Edward Mybridge, invented a way to record movements*
	10.	00:01:10	*normally too quick to be seen.*
	11.	00:01:15	*A wager about the stride of a running horse brought Mybridge to the stock farm of a wealthy*
	12.	00:01:21	*Californian, with a battery of 24 cameras that were activated by threads stretched across*
	13.	00:01:30	*a track, Mybridge captured aspects of motion that had never been witnessed before.*
	14.	00:01:39	*Mybridge's patron had bet that all four legs of a running horse were sometimes simultaneously*
	15.	00:01:44	*off the ground.*
	16.	00:01:47	*Stop action photography proved him to be right.*
	17.	00:02:00	*By projecting his photographs in rapid succession, the first motion pictures were born.*
	18.	00:02:10	*Much more than just a technical curiosity, Mybridge's pioneering work was the first*
	19.	00:02:15	*photographic analysis of the dynamics of physical motion.*
	20.	00:02:30	*Today, modern high-speed cameras can record rapid motion with a clarity that Edward Mybridge*
	21.	00:02:43	*could only have dreamed of.*
	22.	00:02:45	*Slow motion film is now a commonplace tool in analyzing athletic performance.*
	23.	00:02:52	*For Dr. Gideon Ariel, a physical education expert and a former disk destroyer on the*
	24.	00:02:58	*Israeli Olympic team, slow motion film is just the first step in the scientific coaching*
	25.	00:03:05	*of athletes.*
	26.	00:03:09	*Coaches used to think that by looking on an athlete, they could tell what athlete does*
	27.	00:03:17	*right and what he does wrong.*
	28.	00:03:19	*Later on, they found out it's very complicated to start taking slow motion pictures.*
	29.	00:03:24	*But we find out, and coaches find out, that even looking on a slow motion film, you cannot*
	30.	00:03:30	*tell what is right and what is wrong.*
	31.	00:03:32	*The reason is that in any movement, it's not what we see with our eyes that make the*
	32.	00:03:39	*difference, but the derivatives of what the IC, which is displacement, velocities,*
	33.	00:03:45	*accelerations, forces, we cannot see acceleration, we cannot see velocity.*
	34.	00:03:50	*It might appear fast or might appear slow, but the relationship of one segment to the*
	35.	00:03:55	*other in the body, we cannot see with our eyes.*
	36.	00:03:58	*Dr. Ariel has turned to the computer for aid in the analysis of movement.*
	37.	00:04:04	*Slow motion film of an athlete is projected frame by frame under recording screen.*
	38.	00:04:16	*Each touch of a sonic pen transmits into the computer memory, the dynamically changing*

Frame	#	Time	Spoken text
	39.	**00:04:21**	*positions of the athlete's joints and limbs.*
	40.	**00:04:32**	*Human movement is governed by the same laws of motion that apply to the entire physical*
	41.	**00:04:37**	*world, and from the visual information contained in the film, the computer can*
	42.	**00:04:42**	*rapidly calculate the interrelationship of force, acceleration and velocity in the*
	43.	**00:04:47**	*athlete's movements.*
	44.	**00:04:53**	*Computer-created images combined with a mass of numerical data can pinpoint where*
	45.	**00:04:58**	*athletic technique is hindering performance.*
	46.	**00:05:05**	*So what coaches in the past thought they can see with the eyes, we find out you cannot*
	47.	**00:05:10**	*do, you have to quantify, with the advent of computers we can provide the coaches with*
	48.	**00:05:15**	*much more objective, reliable information on how the body moves.*
	49.	**00:05:24**	*Dr. Ariel's computer analysis of Olympic discus thrower, Mac Wilkins, revealed that*
	50.	**00:05:30**	*useful energy which would affect his throw was being wasted on ground friction.*
	51.	**00:05:36**	*Additional force was being spent by not rigidly planting his forward leg at the moment of the throw.*
	52.	**00:05:50**	*Based on this analysis, Wilkins altered his throwing technique.*
	53.	**00:06:05**	*He threw the discus over 13 feet farther than he ever had before and set a new world record.*
	54.	**00:06:29**	*Biomechanics can be used in many applications in athletics, in industry,*
	55.	**00:06:34**	*in medicine and in space.*
	56.	**00:06:39**	*So Aaron, myself, decided to start a company in this little house in Belcher town,*
	57.	**00:06:44**	*Massachusetts Middle University.*
	58.	**00:06:47**	*And the first thing I had to invent the automatic digitizer, which is a sonar digitizer that*
	59.	**00:06:53**	*when you push against the screen, you get immediately the coordinate.*
	60.	**00:06:57**	*That's very, very important in our kitchen.*
	61.	**00:06:59**	*We built the first digitizer.*
	62.	**00:07:01**	*This was the first one in the world, connected with a terminal to a telephone line to the University of*
	63.	**00:07:11**	*On the CBS Morning News, exactly 13 minutes before the hour.*
	64.	**00:07:16**	*In this age of instant replays and electronic wizardry, it should come as no surprise.*
	65.	**00:07:22**	*The sports fans, the computers, are now being used to make mediocre athletes less mediocre*
	66.	**00:07:28**	*and to make superstars more super.*
	67.	**00:07:31**	*But what is surprising is just how many ways a computer can be used in the sports world.*
	68.	**00:07:40**	*In any sport, whether you're throwing something or hitting something, kicking something,*
	69.	**00:07:47**	*or trying to outlive, outrun, or out jump somebody,*

Frame	#	Time	Spoken text
	70.	00:07:54	*there are certain laws to be obeyed.*
	71.	00:07:56	*Not those laws laid down by Avenue Double Bay or Pete Rosell.*
	72.	00:08:01	*But those laid down a long time ago by Sir Isaac Newton.*
	73.	00:08:05	*They're on the basic laws of physics, expressed in equations having to do with mass and weight,*
	74.	00:08:10	*speed and acceleration, force and torque.*
	75.	00:08:13	*Most athletic coaches are not into Newtonian equations, but Gideon Ariel is.*
	76.	00:08:19	*Ariel's company, computerized biomechanical analysis, studies the way athletes do what they do,*
	77.	00:08:25	*and what the help of computers analyzes their moves, projects how well they ought to be able to do,*
	78.	00:08:30	*and what they might do differently to realize their potential.*
	79.	00:08:33	*Olympic champion, Mac Wilkins, the discus thrower, was one athlete Ariel worked with.*
	80.	00:08:39	*Ariel, a former Israeli Olympic shot putter himself, took slow motion movies of Wilkins doing his stuff last March.*
	81.	00:08:46	*Then, frame by frame, he fed into the computer, the movement and position of certain joints.*
	82.	00:08:52	*Those were read out as coordinates on a graph.*
	83.	00:08:54	*With certain known factors such as Wilkins weight and size, the length of his limbs, the mass of those joints,*
	84.	00:09:00	*the computer was able to come up with the thousands of calculations necessary for Ariel to tell Wilkins how he could do better.*
	85.	00:09:07	*Mind you, he was doing pretty well as it was.*
	86.	00:09:09	*He was throwing the discus 218 feet, and the world record was 226 feet.*
	87.	00:09:14	*But Ariel's analysis indicated by doing certain things differently, he could do better than that.*
	88.	00:09:20	*He's more lifting up than actually pulling the discus, so one of the comments that we told him,*
	89.	00:09:27	*we didn't have to go to Mac and say, you will result in forces at 75 degrees,*
	90.	00:09:31	*but we told him, Mac, try to pull the discus at that location and bring your chest as much as possible forward rather than upward.*
	91.	00:09:41	*Wilkins pulled, as Ariel suggested, and kept both feet on the ground, as he suggested.*
	92.	00:09:46	*And not only did he go on to win the Olympic gold medal, but in the first official throw he made after getting Ariel's advice,*
	93.	00:09:52	*he threw 232 feet, shattering the old world record.*
	94.	00:09:57	*Ariel says one reason the East...*

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