The Scientific Approach to Hitting

By Coop DeRenne

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THE SCIENTIFIC APPROACH TO HITTING

RESEARCH EXPLORES THE MOST DIFFICULT SKILL IN SPORT

SECOND EDITION

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University of Hawaii—Manoa

Foreword by Tom House
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This book is dedicated to everyone who has ever swung a baseball bat. I especially dedicate this text to my baseball family: grandfather, Wilbur A. Cooper, 15 years with Pittsburgh Pirates, Detroit Tigers, and Chicago Cubs; father, Alfred L. DeRenne, 5 years as a minor league player with the Pittsburgh Pirates organization and 10 years as a professional scout; and son, Keoni B. DeRenne, former high school and collegiate All-American and USA National Team member and currently a professional minor league player.

A warm MAHALO to book cover designer, Donna Suehiro, University of Hawaii Auxiliary Enterprises. Also, special thanks to Melanie Ried for transcribing and editing the original manuscript. God Bless to you both!

Sincere thanks to friend and colleague Tom House for his continuous support.

In addition and most important, I thank our Heavenly Father, my Lord and Savior Jesus Christ, for without Christ in my life I could do nothing.

Furthermore, I thank my wonderful wife, Eunice, who is the best! God Bless you all!
Foreword

I want you readers to know that even if Coop DeRenne weren’t my friend, I would consider it an honor to write the foreword for *The Scientific Approach to Hitting*. Coop is a baseball man from a baseball family, a sports scientist, a researcher, and most importantly, a coach. His passion for hitting has always come through in the camps, clinics, and consultations he does around the baseball world.

In this book, Coop matches science-based 3-D information with experience-based field instruction. He identifies problems and provides solutions. Ultimately, he informs and instructs the science and the art of hitting as well as anyone in organized baseball.

*The Scientific Approach to Hitting* is a must read for parents, coaches, and athletes. It will help every player optimize the development of swing skills with genetic talent.

Nice going, Coop! You’ve hit a home run with this one!

Yours in baseball,

Tom House
Acknowledgments

1. All high school, college and professional players who were our research subjects during the last 25 years
2. Tom House (National Pitching Association), Tony Stellar, Alan Blitzblau, and Bob Keys, Bio-Kinetics, Inc., Sandy, Utah
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6. Glenn Fleisig and Dr. James Andrews of the American Sports Medicine Institute
7. Dr. Bill Harrison, Sport Vision Optometrist, Laguna Eye, Laguna Beach, CA
“The hand is quicker than the eye, but the camera doesn’t lie.”
-Tom House,
National Pitching Association

Millions of fans every year crowd into baseball parks to see their favorite team players. What’s the attraction? Competition—the ballpark is the battleground where athletes go to war: Reggie vs. Welch; Will Clark vs. Mitch Williams; and of course, the all-time confrontation, “King” Carl Hubbell vs. Ruth, Gehrig, Foxx, Simmons, and Cronin (5 K’s) in the 1934 All-Star Game. It is this confrontation that brings out the fans.

Baseball, though a team game, is essentially a one-on-one confrontation. The center stage is the pitcher-hitter contest. The pitcher stands on a hill, above the field, looking down from his throne. He is in control. There is no action until he begins. The hitter is the servant, waiting and waiting! The game revolves around this battle. Both are in no-man’s land—all alone.

This combat begins in practice, behind the scenes. The fans only know the battlefield, but the players and coaches realize the importance of complete preparation. With the advent of scientific training methods and high-tech equipment, today’s athlete is better prepared than his or her ancestors.

In order to compete in today’s amateur and professional arenas and to have the competitive edge, the modern day athlete must be trained from a “holistic” conditioning foundation. Hitters are no different. This holistic program for the hitter and hitting coach is the trinity interrelationship of SKILL MECHANICS, VISUAL DYNAMICS and EXERCISE SCIENCE. All three components work in tandem, for the pitcher and hitter as they either deliver the missile-pitch or strike a blow with the bat. This interrelationship is the central theme of this hitting text.

As the hitter strides to the plate with his bat, he must carry these interrelationship prerequisites with him into warfare. All the fans see is the hitter’s walk to the plate, not realizing the amount of the exercise preparation (mechanical-visual-physical) that went into that turn at bat.
When the hitter steps to the plate, he has three goals in mind: First, to make accurate contact. Second, to arrive at contact on time. Third, the hitter tries to accelerate the bat as fast as possible while under bodily control for an increase in exit batted-ball velocity. Notice, coaches, in these hitting goals as the baseball is delivered, the hitter's visual-tracking skills commence as his body biomechanically moves, generating enough energy for the required amounts of strength and speed to swing the ballistic bat accurately. These three components—visual, biomechanics, and exercise science—are inseparable and have equal importance.

When a hitter achieves success, the three components are in unison, or in sync. During slumps, usually one or more of the components are missing like pieces of the puzzle—the picture is incomplete. All three-puzzle pieces must complement each other for the picture to have its identity. So it is with the hitter. If one component is missing, the swing breaks down, or doesn't function optimally. This text will demonstrate how the three components work in unison with practical field applications. In this process, we hope to improve hitting performances and eliminate prolonged slumps.

Today, we see the advent of scientific research and high-tech equipment influencing and enhancing numerous different kinds of sport performances all around the world—at the professional levels, as well as at the amateur levels. Baseball is now jumping on the bandwagon. Our holistic hitting program has its roots grounded in science. Using new and advanced research methods and high-tech equipment as our weaponry base, our hitter will have the leading edge.

The great hitting minds of the game—Ted Williams, Harry “The Hat” Walker, Charley Lau, Walt Hriniak, and many others—gave us their invaluable intuitive thinking. Each one has contributed to the game's valuable hitting information. We must always be thankful for these hitting gurus who have pioneered our offensive game. Now it is our turn at bat! We will use pure scientific research with high-tech equipment to explain the hitting process.

Now SCIENCE digs into the batter's box! It tells us that the bat is supersonic—it travels on the average of 1000 inches per second on the big league level. Science gives us data: bat speeds, exit batted-ball velocities, head movement, center of gravity measurements, body segment measurements, rotational information, and swing mechanical consistencies of successful hitters. Our scientific hardware, consisting of high-speed cameras and the computerized motion analysis system, gives us irrefutable data.

Can we really see the supersonic swing with our trained naked eyes? Maybe the best hitting instructors can, but why guess and give the million-dollar hitter the wrong information? Let's agree that as hitting coaches watch this ballistic action, they are standing at lengthy distances from the hitters and at difficult angles from the bench and trying to see the completed swing. Recognizing this
visual problem and knowing from the world of magic that “the hand (bat) is quicker than the eye,” permanent mounted high-speed video cameras placed at the correct angles could capture live uninhibited game swings. This data could unequivocally provide hitters and coaches with irrefutable hitting information not based on traditions or opinions.

In 1987 my partner Tom House, ex-pitching coach, Texas Rangers, and I formed a biomechanical company, a “think-tank,” in Laguna Hills, California called Bio-Kinetics, Inc. With two other partners, we purchased the best high-tech biomechanical equipment in the world. This equipment was used (and used today around the world) in 2008 by our Olympic teams in China.

The Texas Rangers provided us with major league access for our research. Arlington (Ameriquest Field) Stadium became an extension of our laboratory from California. We were able to collect live game hitting performances. We have spent the last twenty-three years analyzing these big league swings.

Now, for the first the first time in the history of the game, we can separate facts from theory. Our database is unique to the game and to the field of biomechanics. This text culminates these last twenty-three years of swing biomechanical research, and my past twenty-five years research work in exercise science. In addition, this text is an update and expanded from my first hitting book, High-Tech Hitting, written in the 1990s. The center theme in both books is research, searching for the truth. This text presents the current research in hitting, and presents the impact and interrelationships of four sciences (biomechanics, visual dynamics, exercise science and nutritional conditioning) on the “holistic” hitter.

-Dr. Coop DeRenne
SECTION 1

The Biomechanical Swing
"Hitting is a fluid sequential motion involving two movements working in tandem—straight forward or LINEAR and then angular or ROTATION."
- Coop DeRenne

Hitting is the single most difficult thing to do in life.” This is a quote from the great Hall of Fame Dodger manager, Tommy Lasorda. He rationalized that in life if a doctor, or an attorney or a teacher, etc., were successful only 30% of the time, like a successful major league hitter (.300), these professionals would be failures and likely out of business.

We do know that in all of human motor movement, hitting a baseball with all the “funny” spins and movements pitchers do it is the single most difficult skill in all of sport. We believe this is why on any baseball field and in any ballpark, hitting is discussed, theorized, and argued over more than any other baseball subject.

Picture or visualize if you can why hitting is so difficult. We are asking a normal untrained visual athlete while standing in the batter’s box to hit an incoming round ball that could be fast, or slow, or breaking across, down or in, while using a round bat trying to hit the ball “squarely.” On top of that, the hitter has the difficult task of trying to line up the two “sweet spots” on the ball (3/4”) and bat (approx. 5”) at the precise millisecond for a solid contact. Added to this is the fact that the hitter never sees the ball once it ballistically approaches the ball, therefore, he cannot guide the implement, and the hitter visually loses sight of the ball anywhere from 6-10 feet out from the plate. In other words, he never sees the bat and ball come together. Is it any wonder that hitting is so difficult?

Science to the Rescue

For thirty years, Ted Williams and Charley Lau have been disagreeing with one another over the mechanics of the swing. Therefore, around the country you have two primary hitting camps: Williams or Lau. Other hitting instructors have
gone off in different directions or tangents from these two basic theories and have emphasized different components of the swing. Yet, with all due respect to all other hitting coaches, Mr. Williams and Mr. Lau, because of their knowledge, their respect, and their high profile, have had their “theories or intuitive opinions” dominate the hitting intellectual market. Their influence still remains today.

In every ballpark, in every ball player’s home, hitting is discussed and analyzed. We can all picture the father swinging a broom handle, or a folded up newspaper while standing in front of his hallway wall-length mirror. In addition, we see the parent-coach staying late after practice in the dark imitating Hall of Famers’ Tony Gwynn’s or Wade Boggs’ swings. We also see top amateur hitting coaches hired at “baseball factory universities” everywhere dissecting the swing, as would a world-renowned surgeon. Yes, can’t you just see the professional hitting coach grabbing anything handy and diagnosing the swing to an inspiring young hitter in his office before practice?

Science is the great equalizer. Over the past twenty-five years, there has been more research produced in hitting and pitching motion analysis and in exercise science than during any other time period. Science produces facts. It solves problems and supplies us with answers. It is our choice to use science’s technology, research results, and suggestions. If we ignore scientific data, then we will be retarding hitting performances. It is your choice.

During the last twenty-five years, Bio-Kinetics, Inc. has collected live high-speed video swing and pitches from fixed mounted cameras in numerous major league ballparks, especially in Texas Rangers’ Ameriquest Field. As a result, a model swing and a pitching delivery have been created based on the commonalities of successful lifetime .300 hitters, 20 game winners, and the laws of motion and physics. This information is irrefutable.

Bio-Kinetics, Inc. has determined that there are four hitting absolutes integrated within the six common hitting components. The six hitting components are as follows: (1) stance, (2) load & stride, (3) launch, (4) approach, (5) contact, and (6) follow-through. Within these components lie the following four absolutes: (1) DYNAMIC BALANCE; (2) the KINETIC LINK; (3) BAT LAG; and (4) AXIS OF ROTATION.

In any movement, there is a beginning and an end. In other words, the swing is a SEQUENCE, from stance through contact to follow-through. No one component of the swing is more important than any other part. The important quality to remember about the swing is that it is a SEQUENCE, and each component contributes to the totality of the swing.
If they occur out of sequence, or if a player drifts, he will arrive too early, rotation will be late causing the body to partially rotate, which will result in loss of bat speed, exit batted-ball velocity, and power.

The swing basically has two movements: (1) linear or straightforward, and (2) angular or rotation. These movements flow in sequence. If they occur out of sequence, or if a coach emphasizes one movement over the other, then the swing is retarded.

**BIOMECHANICAL ANALYSIS SEQUENCE**

Photos from the American Sports Medicine Institute's biomechanical lab, Birmingham, Alabama. ASMI’s research teams have contributed to our hitting research since the 1980s.
Biomechanical Analysis Sequence:
Two high-speed cameras capture 2-dimensional live action movements. The computer’s hardware and software transform the 2-D video into a 3-dimensional animated computer image for biomechanical analysis.

Movement: Coordination

Again, always remember that in any movement, you have PREPARATION, EXECUTION, and a COMPLETION—a sequence. A sequence is a fluid flow of muscle contractions called COORDINATION. Therefore, when breaking down the total swing into individual parts, never forget that no one part is more important than the whole. That is why when you use different hitting drills in practice, you should be careful to use each drill in the context within the whole swing. You cannot isolate drills and individual parts of the swing; if you do, then the swing becomes robotic.

Therefore, when you teach hitting mechanics, you must visualize the swing in its entirety. Then as you teach all the components of the swing try and create in your students’ minds that the total visualized swing, a fluid and sequential movement, consists of a coordinated series of muscle contractions. No one part of the swing is more important than another!
The Fluid Sequential Swing

<table>
<thead>
<tr>
<th>PREPARATION</th>
<th>EXECUTION</th>
<th>COMPLETION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stance or Set-up</td>
<td>Stride</td>
<td>Rotation</td>
</tr>
<tr>
<td>⇒ (Weight Shift)</td>
<td>⇒</td>
<td>⇒</td>
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</tbody>
</table>

The above flow chart basically describes the two movements that the body, hands and bat go through during the entire swing. These two movements are in sequence and work together in tandem. Again, the two movements in the swing sequence are as follows: straightforward then rotational.

Visualize the overall following picture of the swing. This is how the body moves through the swing:

1. **Stance**: The hitter maintains a balanced stance or weight (Center of Gravity) between the feet or a little weight shift to the backside.
2. **Load & Stride**: First, the moves his center of gravity back toward his back side/leg. This movement is slight, and performed as the hips move slight back. The hands and head should not move. Second, the hitter strides forward (or no stride), first shifting his lower body’s pelvis center of gravity), hips, and legs as his upper torso, shoulders and hands remain in place (closed), while the hands move slightly back (“walk-away-from-your-hands”). As the stride and weight shift are completed with the planting of the lead foot (balls of feet), and the hitter has decided to hit, the heel then goes down and rotation is initiated by the hips as the back foot pivots and heel lifts off the ground.

**ROTATIONAL SEQUENCE: hips-trunk-shoulders-hands-bat**

3. **Contact**: Full rotation is completed with the body in a balanced position.
4. **Follow-through**: After contact, the body remains balanced and fully rotated with the hands finishing naturally around the back. As long as the hands finish naturally and the head is down on bat-ball contact, the releasing of the top hand is optional.

**Semantics:**

There is a secondary problem that arises as “big league” information is handed down to the amateur ranks. Sometimes, as each guru analyzed the swing, he
introduced a new word or phrase in describing that emphasized part of the swing creating another problem. Now we have a problem in semantics. The new word or phrase introduced by Coach A might be exactly what Coach B is saying, but might be misinterpreted by another player or coach along the way. This creates confusion around the country.

What is needed is two-fold: (1) the Swing to be taught as a sequential movement with no one swing component more important than another; and (2) a hitting glossary must be constructed to introduce common ground hitting terminology in context, giving everyone a common foundation to work from.

Hitting Glossary

1. **Stance or Setup:** As a hitter steps into the batter’s box, he takes his stance or setup. His stance is unique to himself. The key is BALANCE. Hitters may look different in their setup or stance, but the weight (Center of Gravity—CG) should be equidistance between their feet. If the hitter loads the backside, then as he strides he must control the weight shift forward so the CG remains between the feet and not shifted onto the front leg.

2. **Balance or Dynamic Balance:** From the stance to the follow-through, balance or dynamic balance is the motion of the balance point (CG) through the swing. The CG must be central to the base of support starting at the stance, and continuing through the swing to the point of contact. In other words, the CG or weight is equidistance between the feet (body is said to be “balanced”) as the body moves through the swing.

3. **Load the Backside:** Before the stride there is a little movement-timing device by the hitters with either the hands, or hips (e.g., Mike Schmidt, Philadelphia), or a weight shift backward, called loading the backside (George Brett, K.C. Royals; George Bell, Chicago White Sox). This timing mechanism (rhythm) sets the body in motion, helps time the pitch and helps initiate the stride. During the preparation or setup, the loading mechanism must stabilize prior to the stride.

4. **Center of Gravity (CG):** That point at which all the body’s mass seems to be concentrated; the balance point of a body. During the swing, the CG is the belly button.

5. **Weight Shift:** A directional movement of all the body’s CG. In the swing, the weight shift is a backward or forward movement of the waist (“lower half”—Walt Hriniak, former hitting coach, Chicago White Sox). All hitters weight shift when they stride. The key is to control this weight shift (CG) forward by stopping it after the stride as the lead foot plants down.
6. **Drifting, Sliding, Lunging, Top Half Lead**: If the CG or weight shift continues to move forward toward the pitcher after the stride, then the hitter is drifting or sliding or lunging. Hriniak calls this lunging a “top half lead.” Evidence of this lunging will be the sliding of the hips, upper torso, hands and bat forward as the lead foot plants in the stride. After completion of the stride, forward motion of the CG must stop prior to contact. The no-stride of some hitters still may reveal drifting problems, if the hips and CG continue to move forward as the weight is shifted onto and over the front lead leg.

7. **Approach, “Knob to the Ball, Hands to the Ball, Hands Inside the Ball,” Bat Lag**: All these terms describe the path of the bat from the launch position (hands start the bat movement) to contact. No matter where the ball is located—outside, down the middle, or inside, high or low—the bat knob or hands must go at the ball until the hands almost get fully extended. The bat route will be explained in detail in the next chapters.

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**BOX SCORE**

In summary, the swing movement sequence is as follows: (1) STANCE or SIT-UP (RHYTHM); into (2) WEIGHT SHIFT; then (3) ROTATION; ending with a (4) FOLLOW-THROUGH! The swing is a sequence of individual components. All components flow into one another. No one component is more important than the others. *THE WHOLE IS GREATER THAN THE SUM OF ITS PARTS!*
From a mechanical standpoint only, how should a hitter swing the bat? Science steps in and answers this question. The mechanics of the swing are based on the integration of the laws of motion and physics hidden in the six swing components.

Hitters and coaches recognize the following six swing components: (1) stance, (2) load & stride, (3) launch, (4) bat approach, (5) contact, and (6) follow-through. What is hidden within these components are the four biomechanical “ABSOLUTES.”

The four biomechanical absolutes of the swing that are integrated into the six swing components are as follows: (1) BALANCE, (2) KINETIC LINK, (3) BAT LAG, and (4) AXIS OF ROTATION. These absolutes comprise the ideal swing model.

Therefore, the four absolutes are based on the integration of the laws of physics and motion with the common dynamic performance ideals of successful hitters. We define a successful hitter as a .300 + lifetime career hitter or one close to .300 with power statistics, the indisputable BEST hitters, past or present. Some examples are: Ted Williams, Rod Carew, Roberto Clemente, Pete Rose, Stan Musial, Tony Gwynn, Don Mattingly, Will Clark, and of course, Wade Boggs.

It must be emphasized again that we must keep in mind that the four absolutes of the swing must be incorporated into the six swing components. Once a coach or hitter understands the connection between the absolutes and the six components of the swing, he will be able to make the correct mechanical, anatomical and visual adjustments.
The Four Absolutes

The following four absolutes are based not on human observation or intuitive reasoning which has been in vogue by the “old guard” traditionalists in the game since day one. Again, as we have mentioned, these absolutes are based on the integration of the laws of motion and the commonalities of successful hitters.

Hitters were recorded during live performances by high-speed video cameras. The collected information was then evaluated by analyzing each joint in the body in a frame-by-frame manner for every hitter through his successful swing. This digitized process can be interpreted by computer software. This high-tech evaluation process uses the most sophisticated video/computer motion analysis system in the world. In effect, we are taking the guesswork out of the naked eye, as the camera accurately records a ballistic swing traveling in excess of 900 inches per second.

**Dynamic Balance**

From the moment the great hitter sets up in his stance in the batter’s box to his follow-through, he remains balanced in motion. This state of moving balance is called **DYNAMIC BALANCE**, the first absolute. Dynamic balance is defined as the motion of the balance point (called the center of gravity) through the swing. The center of gravity (CG) is always central to the base of support for all great hitters. This means:

- The CG around the belly button area is equidistant between the feet starting in the stance and remains so through the six-swing components.

- The best hitters stop their weight shift stride as the front foot plants down in the stride. This means they hit against a firm blocking front side, and begin rotating as the heel of the front striding foot hits the ground.

- At contact and through the follow-through, the weight shift (position of CG) is neither on the front leg nor toward the back foot. The CG is between the feet for good balance.

Just before the stride, as a matter of style, hitters generally will prepare for the release of the pitch by wiggling their hips (Mike Schmidt), moving their hands (Carew), or drawing back their stride knee (Mattingly). This is called a
loading mechanism. This preparatory rhythm must stabilize prior to the stride. It is difficult to see this stabilization with the naked eye.

**Dynamic Balance:**

From their stance through the follow-through, good hitters are balanced. Their balance point, center of gravity (CG) at the belly button, is always between their feet.

1. Left: The balanced stance of Ted Williams;
2. Center: The dynamic balance of Pete Rose’s stride;
3. Right: The balance stance of Wade Boggs.

At contact, Tony Gwynn’s dynamic balance is equidistant between his feet. After ball-bat contact into the follow-through, Carney Lansford remains balanced.
CoopScoop: If the weight shift is emphasized during the stride by hitters and coaches, then the result is longer strides and more forward motion of the front side hip toward the pitcher after the stride foot plants. If the front hip continues to “drift” toward the pitcher after the stride foot plants, the CG will continue to drift causing excessive horizontal and vertical head movements characteristic of off-balance hitters at contact.

Why does this excessive head movement result? Visualize the head which is connected to the hips through the vertebral column. If the hips drift forward as the CG drifts, then the vertebral column attaching the hips and head will cause the head to move excessively. Being off-balanced at contact because of excessive drifting affects the eye-hand and the head-eye coordination of hitters.

We have heard big leaguers and coaches comment, “You must first go back (weight shift) to go forward.” Biomechanically, when you change direction, your timing is greatly affected. If you are a little early or late, it is difficult to adjust because you are changing the momentum of your entire body. This will result in excessive head and eye movements.
BOX SCORE

Good hitters are balanced through the swing. They have controlled their weight shift (CG) by stopping its forward movement as they swing against a firm front blocking side into immediate rotation. This places the hitter into the best visual position to track the on-coming pitch.

Poor contact hitters usually have shifted their hips and CG too far forward during their strides. As the hitter is over-striding into the contact position, he is unbalanced, making the visual tracking process more difficult.

Kinetic Link Principle

The second absolute, the KINETIC LINK, explains the process of generating high bat velocity so vitally needed with today’s abundance of hard throwers. The ideal Kinetic Link produces high bat velocity by the sequential transfer of energy from the strong and heavier body segments (legs and trunk) to the arms and finally to the bat.

This energy generation begins at the feet, the base of support. This energy is sequentially transferred through the legs, hips, trunk, shoulders, arms, hands, and lastly out into the bat as velocity. Energy increases through the “linked” body segments, so that maximum velocity is transferred to the bat.

The Kinetic Link, therefore, explains how a high bat velocity is produced. This is the importance of the Kinetic Link. For years, hitting coaches have emphasized the importance of quick hands to generate high bat velocities. Quick hands are important since they are the last link in the Kinetic Link. Yet, the critical concept to understand is that the velocity transferred into the bat comes from the rotating body segments sequentially transferring energy into the hands and bat.
How is the rotary Kinetic Link created while producing increased kinetic energy for a fast bat? This sequential transfer of energy from one body segment to another is initiated in the stride.

- Once the hitter decides to swing the bat, the striding front foot heel plants down and rotates approximately 45 degrees. As the heel plants down, the lead front hip begins to rotate the front leg. The front leg rotates and begins blocking to a full firm extension position. This action pulls the pelvis around the back hip, so both hips rotate together. This rotational action produces energy (torque) setting in motion the Kinetic Link process.

- As the front hip beings to rotate, the back hip rotates with a simultaneous lifting up of the back heel.

- This lifting up of the back heel allows room for the backside hip and leg to fully rotate.

- As the backside heel is raised, the rotation of the pelvis around the backside hip brings in the back knee. The back hip and knee are free to fully rotate because of the lifting of the back heel. The back knee is not a trigger. It does not initiate the backside rotation or help in the rotational process. *It is anatomically impossible for the backside knee to contribute to hip rotation.*

- The back foot position has the hitter on his toes with the shoelaces pointing down as the heel is being raised.

- Once the hips rotate, energy is transferred upward into the trunk and shoulders as they begin to rotate.

- Lastly, energy is transferred into the arms and finally into the hands resulting in a high bat velocity.
Hall of Famer Roberto Clemente:
This photo represents the Kinetic Link Principle. As Clemente rotates, he initiates a rotary force called torque. Torque produces rotational acceleration. As Clemente's lower body then upper body sequentially rotates, kinetic energy is created which is transferred upward starting from the ground into-feet-legs-hips-trunk-shoulders-arms-hands and into the bat. The kinetic energy results in bat velocity, batted-ball exit velocity, and ball-flight distance called in baseball vernacular POWER.

The Kinetic Link Principle:
The graph shows three curves: the hips, shoulders and the bat. The angle of the hips and shoulders are angular rotation as well as the bat angle through contact. The graph further shows that the hips begin their rotation first.

Hip rotation triggers the shoulder rotation, which occurs slightly after the hip rotation. The shoulder rotation reaches the higher angular velocity (a steeper slope) and proceeds higher than the hip rotation so it reaches a greater angle as well.

The shoulder rotation then triggers the bat rotation (arms swing rotation). The bat rotation is much steeper indicating the highest angular velocity. It also reaches the highest angle as it sweeps through the hitting zone to contact.

Therefore, the increasing steepness of the three curves and the time interval from one to another indicate the transfer of energy and the amplification of
energy from the hips to the shoulders and finally into the bat. This graph is the Kinetic Link of Wade Boggs—a line drive to centerfield.

![Kinetic Link Principle (hitting)](image)

This dynamic Kinetic Link sequence supports the importance of Ted Williams’ emphasis of hip rotation in the swing. The hands are secondary. The great “wrist hitter,” Henry Aaron, could not hit with power while sitting down in a chair using only arms—he weight shifted then he rotated.

**CoopScoop:** Dr. Robert Adair, Physics Professor, Yale University, confirms, “In particular, the contribution of the hands and wrists to the energy of the bat is almost negligible.” The hands are important for initiating the swing in the approach and to stabilize the bat as it becomes ballistic. Once the bat becomes ballistic, the muscles of the hands and forearms cannot contract fast enough to add additional energy to the bat. Therefore, the hands do not contribute as much to bat velocity as once believed.

**Bat Lag**
The third absolute is the **BAT LAG**. The hands and the bat are the last link in the Kinetic Link mechanism. The hands and the bat lag back last while the body

---

rotates during the swing. The lagging sequence is very important and can be described as follows:

- Hip rotation is initiated as the front foot HEEL plants down, while the trunk and shoulders remain closed and lag back with the hands.

- Once the hips rotate approximately mid-way, the trunk, chest, and shoulders begin to rotate in sequence while the hands still lag back.

- Finally, after trunk and shoulder rotation, the hands and bat begin to move toward the ball in the approach to contact.

The bat itself is the very last link to rotate. In its lag position, the bat is horizontal with the “club head” slightly higher or even with the knob of the bat. As the bat approaches contact, the path of the bat is first straight and horizontal, then rotational.

The bat lag position in the approach to contact is the result of the hitter taking the “knob or hands to the ball” on every pitch. The location of the pitch doesn’t matter, inside or outside, up or down.

The bat itself is the very last link to rotate. The bat route of all good hitters from their launch position (bat over back shoulder) begins a slight downward movement into the “slot area” (hands just inside the rear shoulder—see Lou Gehrig’s photos #1-2, Mattingly’s #3-5) and continues into the horizontal bat lag position. In its lag position, the bat is horizontal with the “club head” slightly higher or even with the knob of the bat. The bat route distance covered to this bat lag position is less than one-half of the distance to contact. In baseball vernacular, from the launch the hitter “drops the hands into the slot position.” Thus, the first movement of the bat is slightly downward into the horizontal bat lag position on all height pitches. Once the bat continues in the lag position, the hands/knob of the bat will move horizontally (teach: “Knob to the ball”) and end up in front of the rotating body with the barrel lagging straight back behind the rear shoulder.

Remember coaches, instruct your hitters to take the knob to the ball (hands stay inside the ball) every time. This is the fastest route to the baseball. The end result will be a high bat velocity!

**CoopScoop:** The Bat Lag Absolute can be supported by Newton’s Second Law of Acceleration: \( A = F/M \). Acceleration of a body (bat) is directly proportional to the applied force; the greater the force applied to the bat, the greater its acceleration.
When the body transfers the bat from one plane to another (the launch position through the approach to contact) in a 90-degree arc, it contributes more applied force. Therefore, as the barrel of the bat is traveling from the launch to contact over a longer distance, it begins in the horizontal lag position and then goes angular and rotates in the 90-degree arc. Thus, the bat covers a longer distance to contact while it builds up acceleration and velocity.

Therefore, as the bat goes through the lag position, the knob of the bat (hands) leads the swing, creating a longer distance to contact. The bat will also have a higher acceleration and velocity resulting in less swing time, than when it is “casted” out barrel first in a sweeping fashion.

Coaches, therefore, always instruct your players to take the knob of the bat to the ball on every pitch. This action will result in a good bat lag position increasing the bat’s velocity and decreasing swing time to contact.

Here is the bat lag and computer stick figure graph of Don Mattingly.

**Bat Lag:**
The hands and bat are the last link in the Kinetic Link Process. The bat lags back in a horizontal “knob to the ball” approach.
The fourth and last absolute is the AXIS OF ROTATION. The axis of rotation is the imaginary vertical line around which the body rotates during the swing. If the hitter at contact is balanced and has fully rotated, he actually has swiveled around a “vertical pole” which is called his axis of rotation. This figurative vertical pole should pass through the head, the center of gravity (CG), and intersect the base of support equidistant between the feet.

The hitter in his stance sets the axis of rotation as he assumes a balanced position. If balance is maintained from the stance through the stride, rotation will begin at the right moment. Again, rotation begins when the front foot heel plants down and the front leg blocks at the end of the stride.

The objective during the axis of rotation is to maintain dynamic balance with as straight and upright body position as possible. This body position is critical for good swing mechanics. Therefore, the “coach-hitter teach” is for the hitter
to maintain his *up-right posture* throughout the swing. If the hitter is executing a good axis of rotation, the hitter’s CG will be equidistant between his feet (no excess leaning forward or backward), and there will be no side-to-side sagittal movement. In addition, the height of the pitch doesn’t matter to the body’s posture. Even on the low pitch, maintain a “tall” (upper body) and fairly straight posture for the proper axis.

If the hitter emphasizes the weight shift forward in the stride, the following will occur:

- The hitter’s long stride results in an excessive forward momentum that will prevent the initiation of rotation as the lead foot heel plants down.
- Late rotation will result in a partial rotation at contact.
- Partial rotation creates an unbalanced condition at contact, resulting in the lack of a stable axis hindering the eyes (the visual system) during the tracking process. Therefore, there will be more errors at contact. With a delayed and weak rotational Kinetic Link, the player will also have slower bat velocity and an increased swing time.

**Axis of Rotation:**

Axis of Rotation is the imaginary vertical line around which the body rotates during the swing. At contact, if the body is balanced, this imaginary vertical “pole” passes through the head and CG and intersects approximately equidistant between the feet.

Hall of Famer Ted Williams Displays a perfect Axis of Rotation absolute.
Detroit’s shortstop, Alan Trammell    Dave Winfield, Toronto

**Comparison of Vertical Head & CG motion:**

This graph compares the swings of Gwynn, Trammell and Incaviglia. Because of Incaviglia’s long 36” stride, his head drops 8” and his CG drops 7”. Therefore, Incaviglia is unbalanced at contact with excessive head movement that will result in more strikeouts than Trammell or Gwynn. Trammell’s head and CG motion are 2”, 0”, and Gwynn’s are 5” and 4” respectively.