Title: A New Batting-model for the Twisting Model

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Introduction

Conventional batting models, double torso model, triple torso model or whatever, suggest that bat speed at impact is critical for gaining batted ball speed (BBS). The models imply that faster the bat speed faster the BBS is obtained. Therefore conventional equations for batted ball speed (BBS) are based on momentum of bat and ball only.

Whereas a model here I introduce titled "Twisting model" suggests that tensor (vector combination) produced by twisting in a body is critical for the BBS. The tensor produces stress to push a bat forward. Therefore equation for its BBS is based on momentum of bat, ball and force integral factor of the stress.

However on the contrary, it has been concluded that force integral factor with the body does not influence on BBS that is based on some test results.

On this study I introduce a new batting model which is based on the Twisting model that attribute momentum of bat, ball and force integral factor from the stress and the model does not contradict to the test results. Also I suggest a new approach for developing "baseball talent" from the Twisting model point of view.

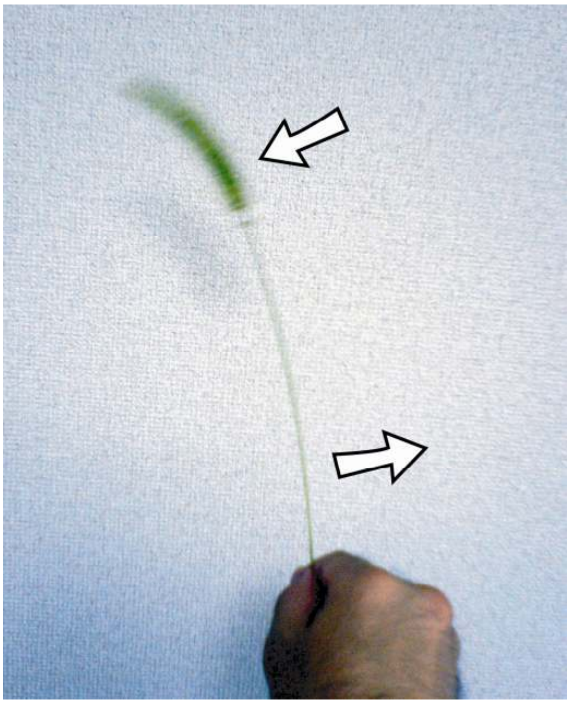
Ⅰ. Mechanism of power from the Twisting model

Before I introduce new Batting model based on the Twisting model, let me tell what the "Twisting Model" is.

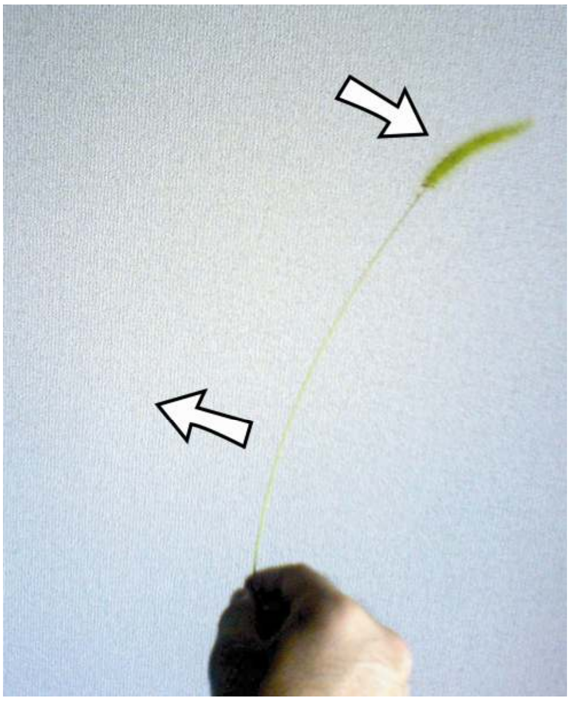
A. Mechanism of power from the Twisting Model

Particularly in baseball, the difference between talented and average athletes is more obvious than in other sports. For example a talented baseball athlete can pitch a fastball at over 150km/h while for an average baseball player that fastball speed is unattainable. It is believed that only talent given by the nature explains this ability. What is the crucial difference between the people who have and do not have this ability? I would like to introduce the “twisting model” and demonstrate how it explains this difference in the generation of power.

In pictures 1 and 2 (Picture1, Picture 2), I am bending bristle grass to observe how power is accumulated in the grass. To accumulate power by bending, 2 different vectors of opposite directions are used. We use our body in the same way when we play a variety of ball games. When hitting or throwing, power is generated by using upper-body (above hip joints) and lower-body (below hip joints) opposite force vectors with different timing . (Picture 3)

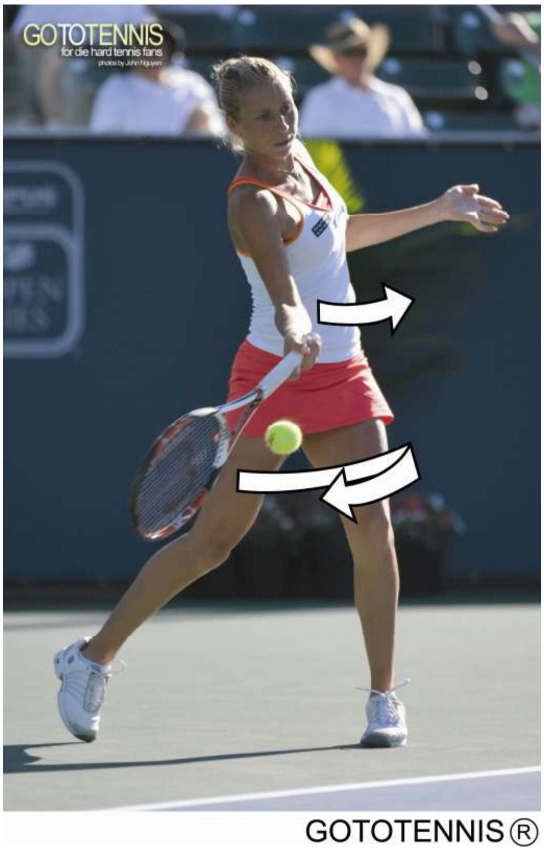


Picture 1



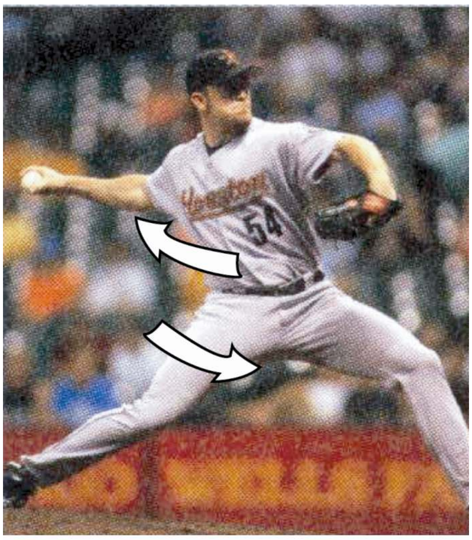
Picture 2

In picture 3 the tennis player is (Picture 3) using her upper-body and lower-body with different timing to generate opposite vectors to accumulate power for hitting. She starts her swing by moving her lower body first. In the lower body, the twisted power naturally twists back by stepping forward with the front leg followed by another twist in the upper-body. Through twisting a combination of vectors helps to accumulate/generate power in her body for hitting the ball.

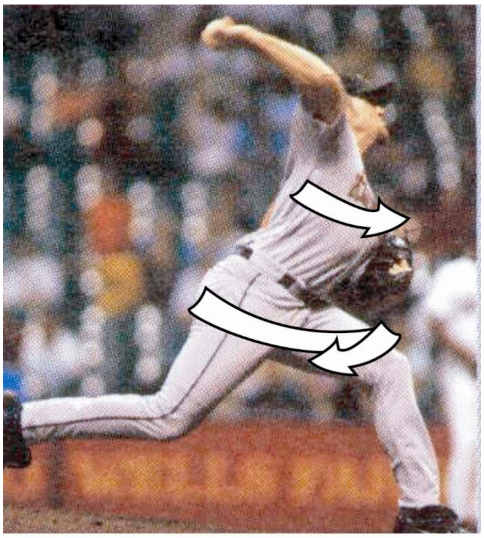


Picture 3

Pictures 4 and 5 show the pitching form of MLB player Brad Lidge as he throws a fastball. (Picture 4, Picture 5) He is also twisting his upper-body and lower-body in different timing. He twists his body, then steps (probably a little to the inside) to generate a twist-back in his lower-body that meets the upper-body at the right time to generate power (vector) for throwing. Since both the take-back and twist-back (after stepping forward), are centered on the hip joints, the more flexible the hip joints, the more power accumulation can be generated in the body.



Picture 4



Picture 5

Ken Griffey (Picture 6) is also producing power by twisting his upper-body and lower-body in different directions. He steps inside which causes strong twist-back in his lower-body. The only difference between Ken Griffey and the tennis player on Picture 3 is the angle of his wrists.

Picture 6

In this "Twisting model", because power is generated by "twisting" its profile can be described as wave, similar to how the energy in a spring can be described as wave like. Illustration 3 shows that two power waves, one which is the wave of upper-body and other which is the wave of lower-body meeting and interfering to generate a bigger wave.

On Twisting Model, this process is important. Twisting stress (potential energy) produced by lower body and upper-body is accumulated as a single/ bigger potential stress that throw/hit a ball forward. Often this same process has been described as "rotation" but I would like to differentiate between "rotation" and "twisting" (Illustration 4), because rotation can lead to negative results in the twisting model.

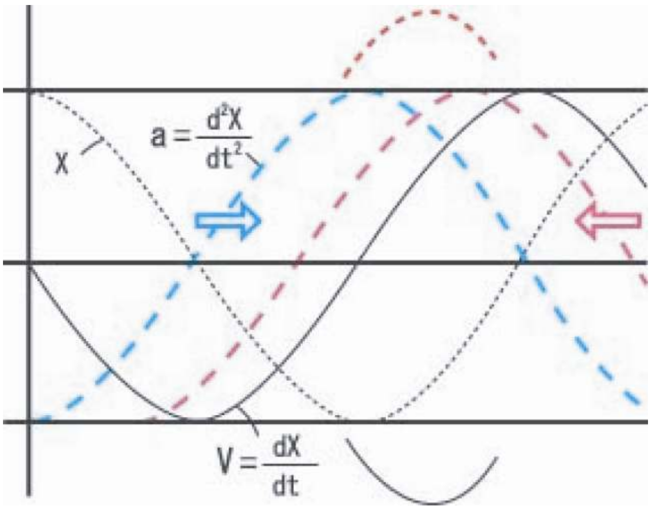


Illustration 3

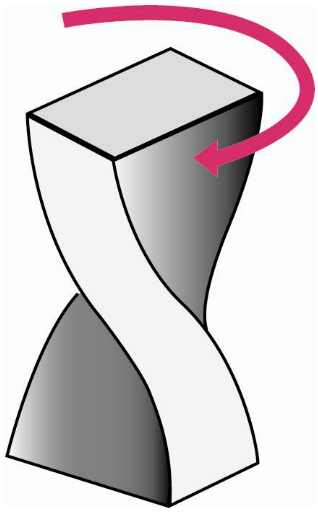


Illustration 4 (Kagakusuru Yakyu, 1984)

To test the "Twisting Model" the following observed movements from field study will be reviewed:

B. Inductive confirmation

To determine the validity of the Twisting Model the power produced by twisting combinations will be evaluated. The details are less important than determining whether the main power source for throwing, and hitting have the specific characteristic of a wave. If wave characteristics are observed, the Twisting Model will be inductively confirmed reliable.

1. Why timing is important.

In baseball timing is important for hitting and throwing. The importance of timing is explained because power is generated by two interfering waves. Timing generates maximum interference resulting in maximum power generation. If muscle was the main power source of hitting and throwing, a player's power profile would be steady and based only on strength.

2. Why a fastball from a side-hand pitch is slower than an overhand pitch.

Stress generated from an interfering wave for pitching would be a linear vector (Illustration 5). By throwing side hand rotational movement is introduced that generates centrifugal force and consumes the power (Illustration 6). In contrast an overhand pitch produces a minimum of rotation resulting in a minimal amount of power loss.

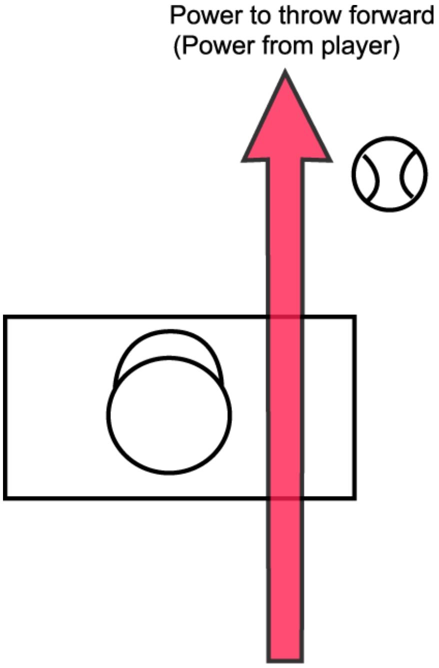


Illustration 5

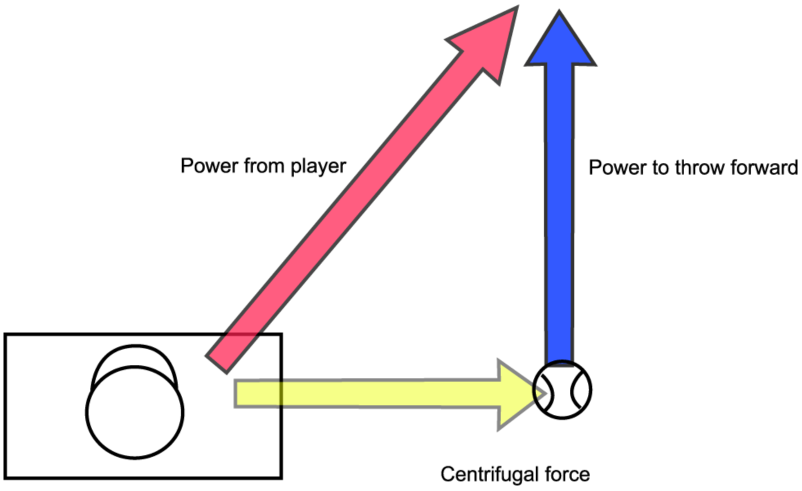


Illustration 6

3. Why you have to swing inside out (compact swing).

In the current baseball model introduced by "The Physics of Baseball" rotational movement is required to obtain bat speed at impact. However many batters believe that you should swing inside out to generate power. The Twisting Model explains that power is generated by minimizing rotation (Illustration 7). For example if a batter swings fast, he increases rotational movement and generates centrifugal force which increases as the square of the bat speed. The opposing forces reduce the power vector to hit forward (Illustration 8). Faster bat speeds increase kinetic energy through centrifugal force which also increases as the square of the bat speed, reducing power. This predicts that a faster bat swing (the more rotation is produced), results in wasted hitting power. This is the reason a compact swing is more efficient. With an inside out swing the maximum bat speed will be in front of the batter past the impact zone. (Illustration 7). Because there is a time gap between power (acceleration) and speed, which is the nature of the wave (Illustration 3), a batter cannot get bat speed and power (from the body) at the same time. Based on observations power is more critical than the bat speed. For this reason maximum bat speed should occur in front of the batter during the follow through motion.

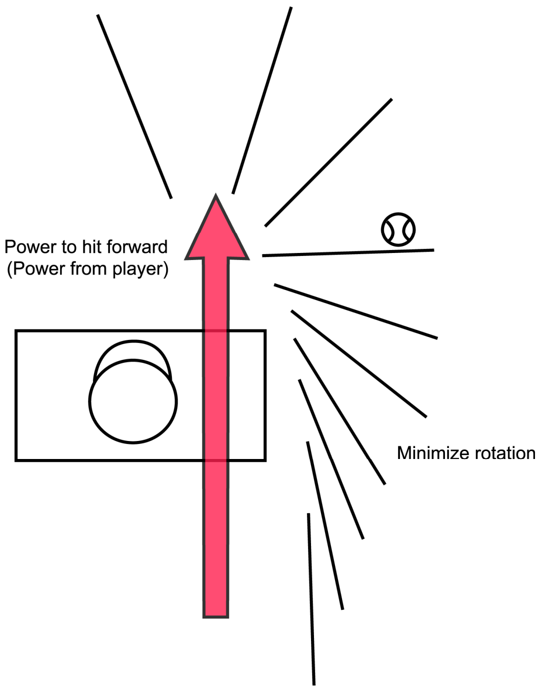


Illustration 7

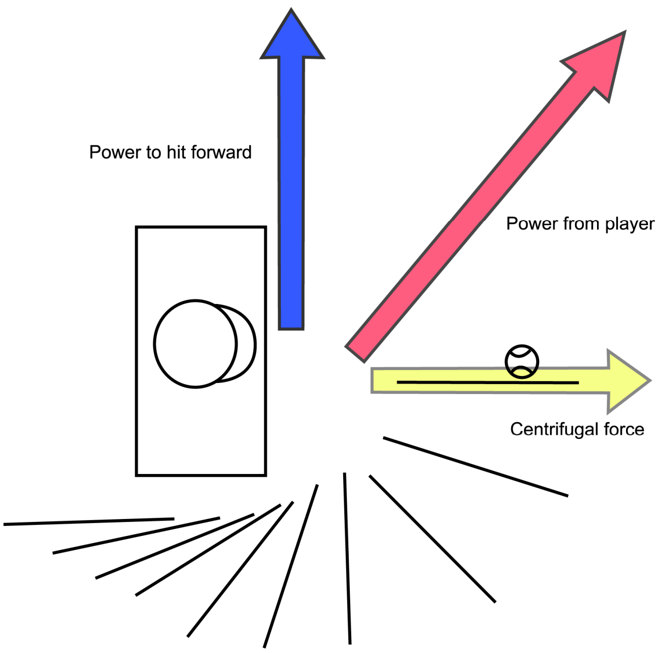


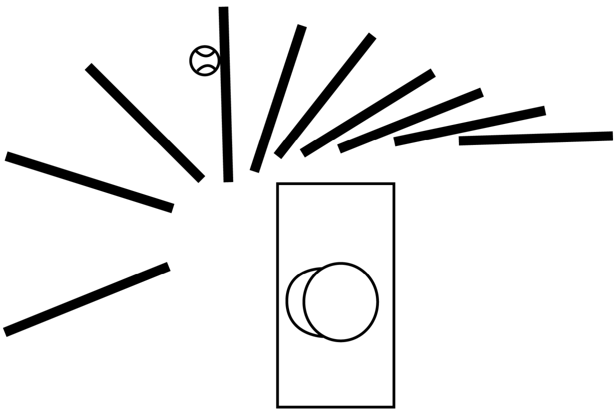
Illustration 8

Ⅱ.BBS equation of the Twisting model

Let me clarify difference between Twisting Model and conventional models by looking into equations for batted ball speed (BBS).

Conventional equations for batted ball speed (BBS) are based on momentum of bat and ball only. However on Twisting Model because stress produced in a body is predominant, BBS equation will be based on momentum of bat, ball and force integral factor of the stress from the body. (Illustration 9)

Please be noted that the equation is under assumption that initial momentum with ball, bat and force integral factor in the body are all transferred on ball and bat speed after the impact. Bat speed after the impact was eliminated by using coefficient of reflection "e" at the impact. And I took pitching direction as minus and hitting direction as plus.



$$MV + mv + \int Fdt \text{ (force integral factor)} = P \text{ (momentum)}$$

Illustration 9

(BBS equation of Twisting Model)

$$v' = \{(eM - m)/(m + M)\}v + \{(1 + e)M/(m + M)\}V + \{1/(m + M)\}\int Fdt$$

M : bat weight

V : Initial bat speed

m : ball weight

v : Initial ball speed

e : Coefficient of reflection

$\int Fdt$: Force integral factor

v' : batted ball speed

For more analysis, I simplified this model as below.(Illustration 10) Picture 7 (Picture 7) are of Ted Williams as reference.

M_1 : bat weight

V_1 : bat speed

X_1 : bat position

M_2 : ball weight

V_2 : ball speed

X_2 : ball position

M_3 : bady weight

V_3 : bady speed

X_3 : bady position

L : length of spring

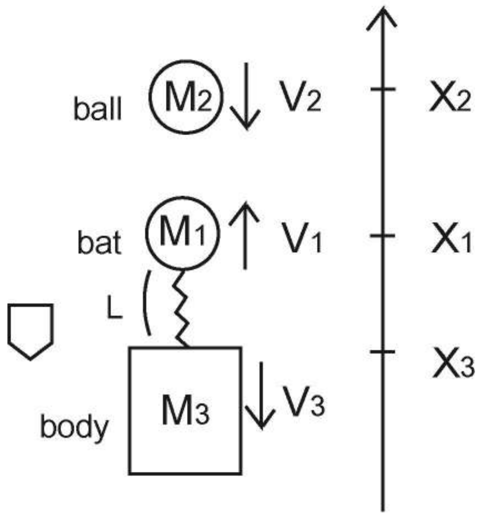
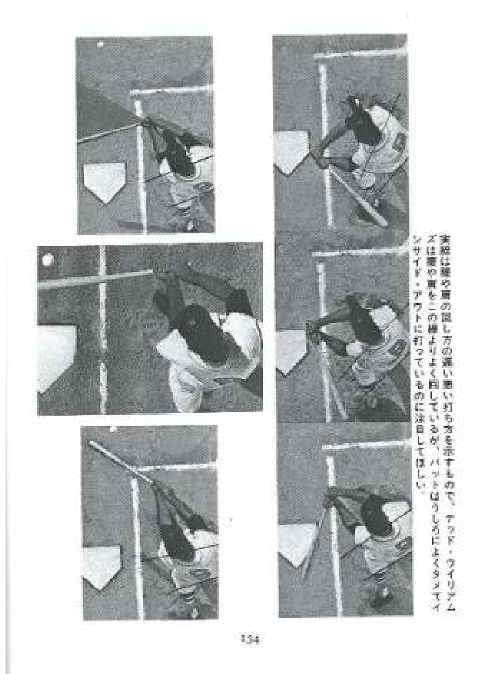


Illustration 10



Picture 7 (Kagakusuru Yakyu, 1984)

According to this model, naturally force integral factor is to show up as below.

A : Conservation of momentum

$$\begin{cases} M_1(dV_1/dt) = -k\Delta L & k: \text{spring constant} \\ M_2(dV_2/dt) = 0 \\ M_3(dV_3/dt) = k\Delta L \fallingdotseq 0 & (V_3 \fallingdotseq 0,\ \Delta L \fallingdotseq 0) \end{cases}$$

$$\Downarrow$$

$$d/dt(M_1V_1 + M_2V_2) = -k\Delta L$$

$$\Downarrow$$

$$d/dt(M_1V_1 + M_2V_2) + k\Delta L = 0$$

$$\Downarrow$$

$$M_1V_1 + M_2V_2 + \int k\Delta L dt = M_1V_1 + M_2V_2 + \int F dt = P \text{ (momentum)}$$

M_1 : bat weight

V_1 : bat speed

X_1 : bat position

M_2 : ball weight

V_2 : ball speed

X_2 : ball position

M_3 : body weight

V_3 : body speed

X_3 : body position

L : length of spring

Since the stress in the body is potential energy, "Conservation of kinetic-energy" law would be more adequate for BBS equation.

B : Conservation of kinetic-energy

$$\begin{cases} M_1(dV_1/\,dt) = -\,k\Delta L & k : \text{spring constant} \\ M_2(dV_2/\,dt) = 0 \\ M_3(dV_3/\,dt) = k\Delta L \end{cases}$$

$$\Downarrow$$

$$\begin{cases} M_1V_1(dV_1/\,dt) = -\,k\Delta L(dX_1/\,dt) \\ M_2V_2(dV_2/\,dt) = 0 \\ M_3V_3(dV_3/\,dt) = k\Delta L(dX_3/\,dt) \end{cases}$$

$$\Downarrow$$

$$\begin{cases} M_1(d(V_1^2/2)\,/\,dV_1)(dV_1/\,dt) = -\,k\Delta L(dX_1/\,dt) \\ M_2(d(V_2^2/2)\,/\,dV_2)(dV_2/\,dt) = 0 \\ M_3(d(V_3^2/2)\,/\,dV_3)(dV_3/\,dt) = k\Delta L(dX_3/\,dt) \end{cases}$$

$$\Downarrow$$

$$d/\,dt((MV_1^2/2) + (MV_2^2/2) + (MV_3^2/2)) = -\,k\Delta L(d(X_1 - X_3)/\,dt)$$

$$= -\,k\Delta L(d(X_1 - X_3)/\,dt) = -\,k\Delta L(d(X_1 - X_3 - \Delta L)/\,dt)$$

$$= -\,k\Delta L(d\Delta L/\,dt) = -\,k(d(\Delta L^2/2)/\,dt)$$

$$\Downarrow$$

$$d/\,dt((MV_1^2/2) + (MV_2^2/2) + (MV_3^2/2) + (d(\Delta L^2/2))) = 0$$

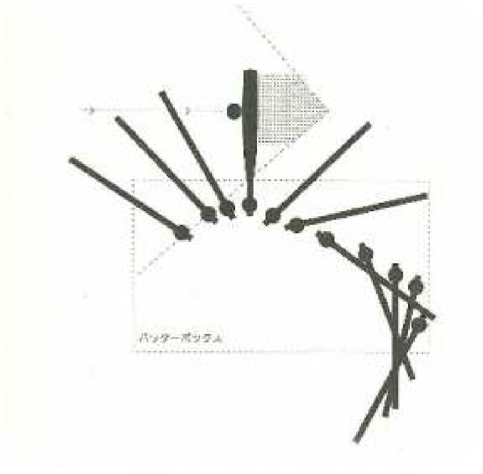
$$(V_3 = 0)$$

$$\Downarrow$$

$$(MV_1^2/2) + (MV_2^2/2) + (d(\Delta L^2/2)) = E$$

Whereas looking back into the conventional models, they are based on momentum of bat and ball only. (Illustration 11) As far as I understand all the models assume that power is transferred to bat speed by the time at the impact and force integral factor with the body does not work on the BBS.

Then why they ended up with conclusion that force integral factor does not work? In fact, as far as I understand, it is lead by objective test results.



$$MV + mv = P \text{ (momentum)}$$

Illustration 11

(BBS equation of Conventional Model)

$$v' = \{(eM - m)/(m + M)\}v + \{(1 + e)M/(m + M)\}V$$

Let me quote from the report "Models of baseball bats, Haward Brody, 1989" in which written that "...Grip firmness at impact time should not influence the post-impact velocity of the ball...". According to the report "Dynamics of the baseball-bat collision, Alan Nathan, 2000", it is mentioned that "...the momentum transferred to the ball is essentially complete by the time the elastic wave first arrives at the handle...". The tests were conducted objectively and their conclusions seem very adequate. Problem is that they dismiss the Twisting Model BBS equation as impossible.

For more analysis I simplified the conventional models as below. (Illustration 12)

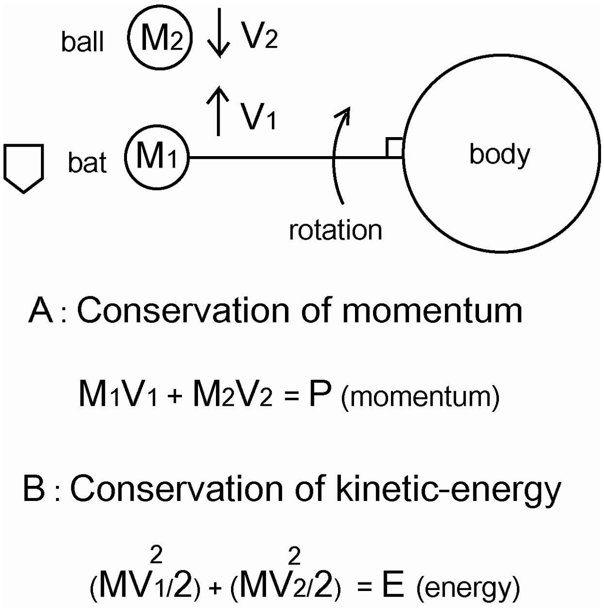


Illustration 12

Looking into this model, it assumes that contact is to occur on square to the body. Naturally kinetic energy on the body does not work. Therefore as far as test is conducted under this condition, any objective test will not show force integral factor or kinetic energy from the body. Since the tests seem done under this condition (Illustration 12), I do not think their conclusion can be applied on the Twisting Model. (Illustration 10)

III. Conclusion

For certain motions such as throwing or hitting, because it is assumed that a twisting combination of the hip joints generates power, the more flexible the joints, the more power generated by the player. This suggests that power is more closely linked to the make up of the body rather than from muscle power. This conclusion has many practical applications.

A. By introducing young players to proper exercises designed to improve hip joint flexibility, they can be raised to become powerful players. However exercising on hip joints themselves may not be effective for joints that are already flexible.

(Illustration 13) Such exercises would be effective on pelvis while the pelvis bones are not fully connected during growth period. (Illustration 14/ pelvis bones are separated in youth) According to my observation, once pelvis is fixed the flexibility of hip joints also seem to be almost fixed. Although further study is needed to confirm what kind types of exercise are safe and appropriate for young people from a medical point of view, Illustration 15 and Illustration 16 are examples of a potential exercises from Yoga. (Toga Anatomy, Leslie Kaminoff) They would produce inner twisting on hip joints and internal stress to the pelvis. (Illustration 15, Illustration 16)

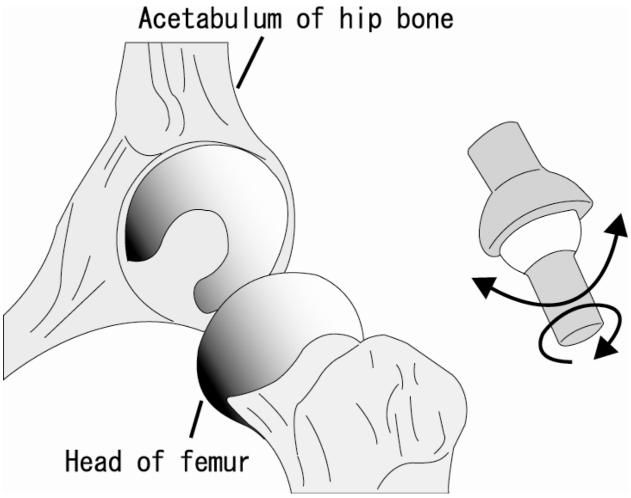


Illustration 13

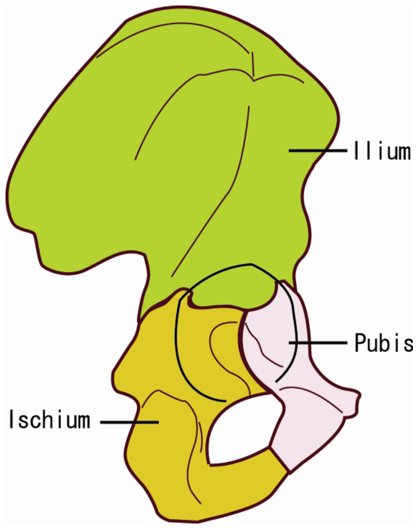


Illustration 14

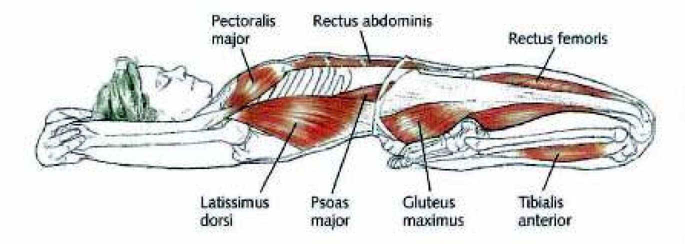


Illustration 15

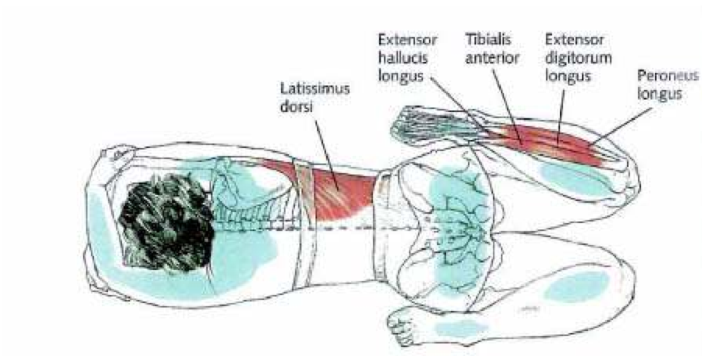


Illustration 16

Illustration 17 and Illustration 18 would be another potential exercises. (Illustration 17, Illustration 18) Please keep in mind that these exercises should be done under instruction of Yoga instructor to avoid accident.

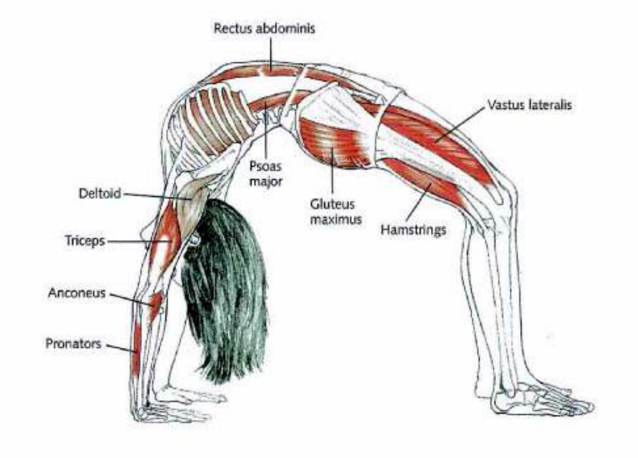


Illustration 17

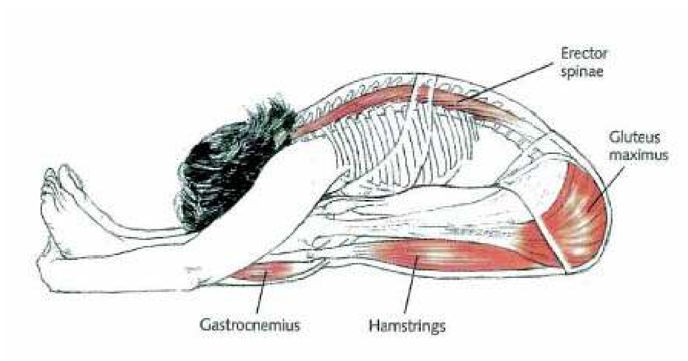
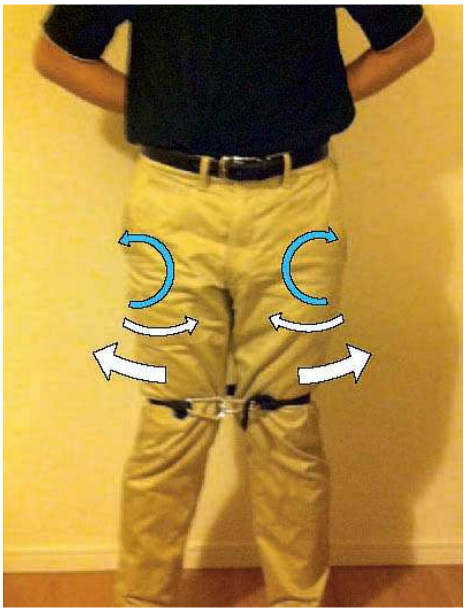
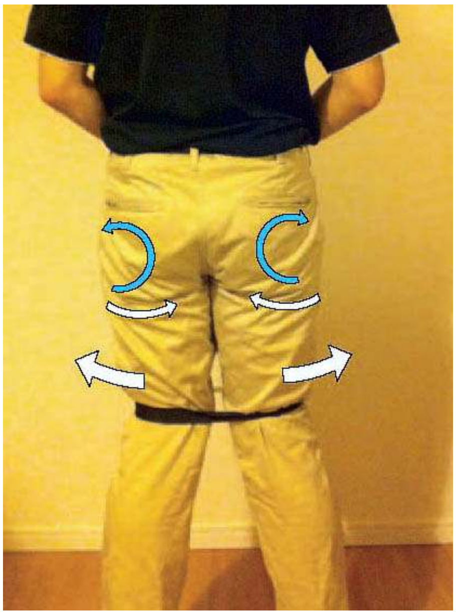


Illustration 18

Exercise using equipment would also help for producing internal stress to pelvis in which twisting stress is stored. Strapping above knees and pulling thighs aside produce moment around hip joints that pushes pelvis bones inside-out. (Picture 8, Picture 9)



Picture 8



Picture 9

Holding something elastic between thighs and pushing inside will also produce moment around hip joints, this time other direction that will also push pelvis bones from inside-out. (Picture 10, Picture 11)

Picture 10

Picture 11

If you think these are weird, never mind. Using gymnastic machine such as Picture 12 (Picture 12) or riding-horse machine (Picture 14) will produce the moment if properly used.

Picture 12

Picture 13

Problem is that they are not designed for producing momentum around hip joints. As for the machine of Picture 12, sitting position would produce less momentum. Leaning position would give more influence on pelvis bones than sitting position for producing bigger hip. (Picture 13)

Picture 13 (Artificial picture from Picture 12)

Mounting on saddle pinching with thighs will produce as same effect as Picture 10 and Picture 11. My personal preference is the horse riding machine. This might be good for kids chair at home for better posture.

Here is an old episode of Japanese baseball. A pitcher Inao who played in 50s and had over 200 wins was trained by old

Picture 14

fashioned Japanese boat. (Picture 14) When he was a kid, his father took him out for fishing every night and let him row. In retrospect he said that rowing the boat was great baseball training for make up his body.

I guess this is an example that redressal exercise helped for producing Baseball talent. Rowing such a boat would have produced inside-out momentum around hip joints that would help producing flexibility at the hip joints.

B. Understanding how the twisting combination works will help to eliminate cognitive gap between hitting and swinging that will bring out a player's best performance. For example, since the main power generated in the Twisting Model has the property of a wave, there is always a time gap between the power and the speed of the motion. For example when hitting a ball, to maximize power in the body the bat speed should be slower. On the contrary when bat speed is at its maximum, the power in the body is reduced. It is best to hit/throw when the power produced in the body is at its peak to minimize power loss. Therefore training to increase speed, whether it is bat speed, arm speed when pitching (driver speed at tee shot for golf, racket speed at impact etc..) is not the best way to obtain power.

C. It is commonly believed that a pitcher's arm is consumable. According to "The physics of baseball", every pitch, creates power stresses on the tendons and muscles of the arm until it is rendered unusable for pitching. The twisting model suggests that power is accumulated in the whole body in ideal, not only in the tendons and muscles of the arm. Power loss caused by aging could be caused by inflexibility of twisting movements around the hip joints. By maintaining twisting flexibility the power of athlete could be maintained, lengthening his career.

Acknowledment

This work is dedicated to Yutaka Murakami, author of the Kagakusuru Yakyu (Baseball Science). Special thanks to Sebido shuppan, GOTOTENNIS.com and Baseball magazine sha for permission of use of their beautiful pictures. Without them this paper would be far less convincing.

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