

WHAT DO ALL MARTIAL ARTS HAVE IN COMMON?

By Leith Darkin

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(BIOMECHANICAL PRINCIPALS)

HOW TO GENERATE FORCE & HOW TO COUNTER FORCE

WHAT IS A FORCE?

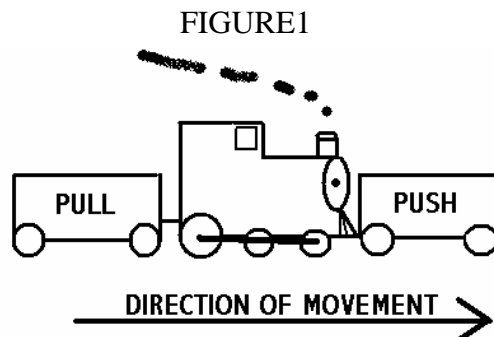
The greatest force the human body has to overcome is gravity. To do this our body has evolved with a skeletal system, which is our bodies support structure. This support structure allows us to resist the compressive force of gravity.

Attached to our bones are muscles, when our muscles contract they apply force (in the form of a pull) which brings the bones they are attached to together.

Our bones and our muscles are our bodies lever system for generating and applying force.

This lever system allows us to conquer gravity by standing upright and moving around freely in its presence. As well as generating force our bodies lever system allows us to stop another force, deflect a force and move out of the way of a force.

There are two types of force the human body is capable of producing, a **push** which is movement away from the body and a **pull** which is movement towards the body.



In figure 1 the train generates the force. By looking at the direction of movement and where the train is situated to the two carriages you can work out what type of force the train is applying to the two carriages. The same principle applies for human movement. Most striking techniques are created by a push as the desired outcome is to direct a force away from the body to cause impact, where as most grappling techniques are created by a pull as the desired out come is to keep your opponent in close to limit their striking capability. With grappling sports you will find that in allot of cases the push and pull work together to create angular motion, this enables us to take an opponent off balance, take them to the ground and manipulate joints.

There are two types of motion the human body is capable of producing from our lever system. “Angular motion” which is movement around an axis (rotation) and “Linear motion” which is movement in a straight line.

ANGULAR MOTION

An axis in the human body can be a joint between two bones in which case the movement (rotation around an axis) is created by the pull from the muscles attached to the bones either side of the joint.

Another axis in the human body is its centerline of gravity (figure 2).

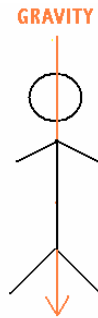


FIGURE 2

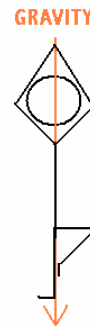


FIGURE 3

The body's centerline is our axis of rotation for movement such as a pirouette in dancing. (figure 3) In martial arts its the line of gravity that runs down the center of the body and through our supporting leg when attempting a round kick and is the same for spinning kicks.

In grappling type martial arts you'll find there is alot of angular motion used to take an opponent off balance and to manipulate joints. If you've done grappling type martial arts I'm sure you would have heard the term "push pull".

DIRECTION OF ROTATION

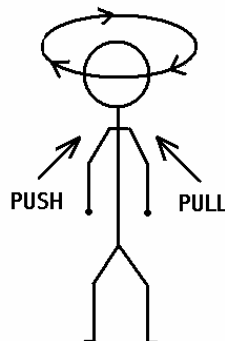


FIGURE 4

Looking at figure 4 a push has been applied to the left shoulder and a pull has been applied to the right shoulder, this in turn rotates the individual clockwise. The same principle applies when manipulating a joint, as a joint is an axis of rotation, a push and a pull applied to the limb attached to the joint will result in optimal force for joint manipulation.

Other forms of angular motion include a somersault, a fast bowlers arm action in cricket, and all isolation resistance-training exercises.

LINEAR MOTION

Linear motion is motion in a straight line created by compound (multi joint) movement in the form of either a push or a pull. When looking at the joint mechanics to produce motion in a straight line, you'll find that the individual joint movements are actually created by angular motion (rotation around an axis), however when these individual joint movements are activated in the right sequence, you have movement in a straight line.

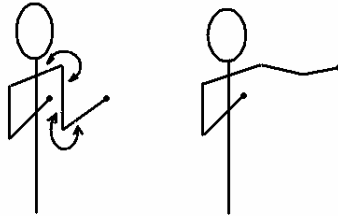


FIGURE 5

Figure 5 is a picture of an individual throwing a jab, the punch moves in a straight line (linear motion) however it is created from rotation at the shoulder and elbow joint. Other forms of linear motion are front kicks, front knees, running, swimming, jumping and all the resistance-training exercises mentioned in the strength article.

DIFFERENT LENGTHS OF LEVERS AND HOW THEY EFFECT FORCE APPLICATION

Why are kicks our most powerful strikes?

When looking at a round kick you have rotation around an axis (the bodies centerline) with a long lever. The length of a striking lever can be very important when it comes to generating force. The longer the lever the more distance it can travel. The more distance the lever travels the more speed it can gather along the way (providing there is sufficient strength from the muscles that are applying force to the lever) As speed is a sub quality of power, the more speed you can generate, the greater the power.

A good analogy of speed over distance is the top speed a drag car can produce over the quarter mile. Your top fuelers can reach speeds of 300 kmph, at half that distance (one eighth of a mile) they certainly weren't traveling at 300 kmph and if the race was over half a mile they would have reached speeds well over 300kmph.

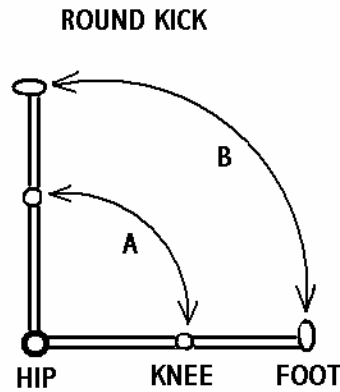


FIGURE 6

Figure 6 is a comparison of the distances that the knee (short lever) and the foot (long lever) travel over 90 degrees when attempting a round kick. As you can see distance B (the path the foot travels) is longer than distance A (the path the knee travels).

While long levers are great for generating power as they travel more distance than short levers and in turn pick up more speed along the way, short levers are better for deflecting and stopping a force. A short lever is closer to the bodies center of gravity so when it makes contact with another force your body is more stable. The further a lever moves away from the bodies center of gravity the weaker it becomes as it in turn has to contend with gravity it self. (figure 7)

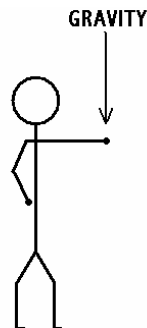


FIGURE 7

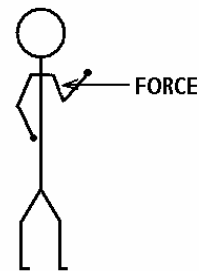


FIGURE 8

When deflecting a force close to the body with your elbow bent (figure 8), not only will you have a more stable deflection you will also elevate a lot of the sheering force on the shoulder joint which is present when deflecting or stopping a force with your arm straight. By alleviating sheering forces to the shoulder, you will decrease the likelihood of possible shoulder injuries.

When using a short lever to generate force you will find that because the distance traveled by the lever is short, the power potential is less compared to a long lever. Power for short levers is increased by using appropriate footwork to accelerate your bodies mass at your opponent, trunk movement and the contribution of the SSC. (See article on SSC).

Another important aspect on levers and their effect on force application (when generating a force) is the surface area of the lever on impact. For example we'll look at a punch and a single finger strike (Dim Mak). Both strikes are generated by the same lever and there for should deliver the same force. The main difference between the two strikes is the surface area of the hand that delivers the impact. The surface area of a punch is on average 5cm X 3cm which can deliver a crushing impact over a medium area, where the surface area of the tip of a single finger is only on average 1.5 cm in diameter which allows for a more penetrating impact over a small area. This is why elbows cut and knee strikes crush, both of these strikes are created by short levers however the surface area of the lever on impact is different in size.

OUR BODIES MASS AND HOW IT EFFECTS FORCE APPLICATION

Our bodies mass (weight) is an important factor when generating force, especially when we are accelerating our selves at our opponent. As $\text{force} = \text{Mass} \times \text{acceleration}$, the more mass we have and the faster we can move that mass the greater the impact of our force application. This also means that a lighter person traveling at a greater speed will generate a similar impact as a heavier person traveling at a slower speed.

This is important for two reasons.

- 1) Generating force to create maximum impact.
- 2) Choice of appropriate technique when defending against an opponent accelerating them selves at you (especially a heavier opponent)

FOOTWORK AND HOW IT EFFECTS FORCE APPLICATION

Figure 9 represents the difference that footwork can make when generating power with our round kick. A & B represents your feet in an orthodox fighting stance. If you propel your self on a 45-degree angle towards your opponent then your front foot B will now assume the position of C. Radius A B is the radius of the arc the leg travels while performing a stationary round kick. Radius A C is the radius of the arc the leg travels after the execution of a 45-degree lunge while performing a round kick. The arc that radius A C produces is greater than the arc that radius A B produces. By using the appropriate footwork to set up your kicks you can increase the distance the foot travels and in turn increase power output (the same footwork will also set up a SSC in the trunk).

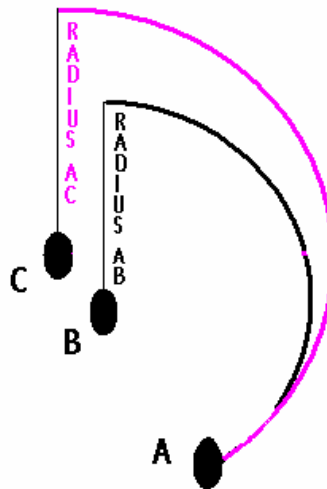


FIGURE 9

When looking at figure 7, footwork was used to create a larger arc for the foot to travel, which in turn helped us to increase our power output. The same footwork will help us make up the distance between our selves and our opponent, accelerate our bodies mass towards our opponent and set up a SSC. All these individual components are important if maximal power is to be achieved. However if the timing of our front foot landing on the ground (foot B assuming position C) and our striking foot making contact isn't right then maximal power won't be achieved. If our front foot (foot B assuming position C) makes contact with the ground before our striking foot makes contact then some of the power we have generated will dissipate through the ground. If our striking foot makes contact with our opponent before our front foot (foot B assuming position C) makes contact with the ground you will tend to bounce off our opponent (especially if your opponent is moving towards you and or has more mass and or force than you can generate). There will also be a loss of penetration as our body on impact is unstable without a supporting foot on the ground. For optimal power when accelerating yourself towards your opponent, your striking limb should make contact with your opponent at the same time as your other foot makes contact with the ground and is the same for all striking techniques.

HOW TO COUNTER THE FORCE YOUR OPPONENT HAS GENERATED

When countering force from your opponent you have three options,

- 1) Stop the force.
- 2) Deflect the force.
- 3) Move out of the way of the force.

STOPPING A FORCE

The most effective way to stop a push force is to make an impenetrable barrier, which will meet the angle of your opponents force head on. Boxers do this by bringing their forearms up to cover their face and bracing their hands firmly against the top of their forehead. Kick boxers and Thai boxers use the same principle when they check to stop a leg kick. Both of these techniques make use of short levers in close to the body and are best suited for stopping long levers on impact.

When stopping a pull force, such as an opponent pulling you towards them, you need to lower your center of gravity (this will be explained in the next section) and immediately apply a pulling force of your own. Its effectiveness will depend on your body mass, how low you position your center of gravity and how much force you are able to generate.

DEFLECTING A FORCE

Deflecting a force is changing the path of an oncoming force. Once again this is done most effectively with a short lever and is often accompanied with footwork to move your body out of the line of the oncoming force. Some martial arts use the force generated by their opponent to launch effective countering maneuvers after changing the path of their opponents force.

MOVING OUT IF THE WAY OF A FORCE

Moving out of the way of a force can be applied to any situation where an opponent is directing a force at you, however it is the best option when an opponent is accelerating themselves at you with more force than you can generate to stop them or effectively deflect and change the path of the oncoming force. A good analogy of this is the matador and the bull, the only option open to the matador is to side step and let the bull pass him by, the bull has more mass than the matador and is moving at a greater speed than the matador. Once again some martial arts will move out of the way of the oncoming force and use the force generated by their opponent to launch effective countering maneuvers.

CENTER OF GRAVITY

Previously we looked at our bodies centerline of gravity as an axis of rotation in human movement. Our actual center of gravity is our bodies center of mass. If we lay supine on a pyramid with the apex of the pyramid directly beneath our center of gravity, then evenly displaced our arms and legs, you would find that we would balance perfectly (figure 10). If we were to suspend our body by our wrists and ankles in the prone position, our center of gravity would be the point closest to the ground (figure 11).

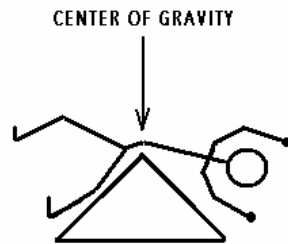


FIGURE 10

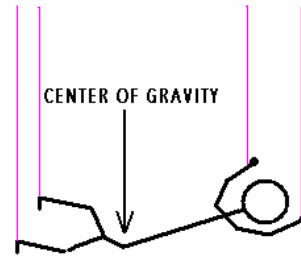


FIGURE 11

Grapplers use this principle (figure 11) to pin their opponents when in the cross body position. By raising their lower body (coming off their knees and onto the tips of their toes with their legs straight) they shift their center of gravity to their chest area which is then used to pin their opponents or to restrict their opponents breathing which in turn wears their opponents down (figure 12 & 13)

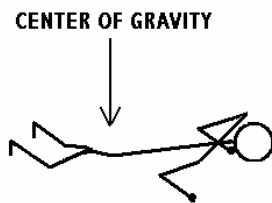


FIGURE 12

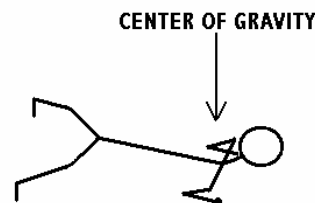


FIGURE 13

CENTER OF GRAVITY AND BALANCE

There are two important principles that effect balance, the height of your center of gravity and the width of your base of support. When standing tall with your legs straight and your feet together you are very unstable as your center of gravity is raised and your base of support is small. To make a stable stance you need to lower your center of gravity and increase your base of support. In Karate they use this principle well with a stance called a “horse riding stance” or a “double shoulder width stance”, although this isn’t a very mobile stance it is an extremely strong and stable stance (see figure 14).

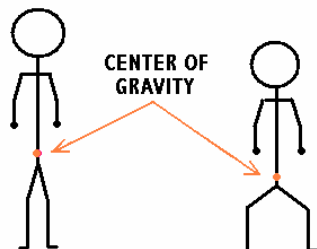


FIGURE 14

When looking at self-defence (especially from a grappling point of view), taking your opponent off balance and staying on balance at the same time is of most importance when escaping crabs and in some instances when avoiding strikes.

The principles of taking your opponent off balance are either to change the alignment of your opponents upper body mass in relation to their center of gravity (figure 15), to take your opponents legs out from underneath them (figure 16) or to rotate your opponent around an axis (figure 17).

Once you change the alignment of your opponents upper body mass in relation to their center of gravity, gravity it self will do the rest by keeping them off balance long enough for you to launch an offence, or by toppling your opponent to the ground.

When you take your opponents legs out from underneath them, gravity will send them crashing to the ground.

When rotating your opponent around an axis, you again have the opportunity to launch an offence before they regain their balance.

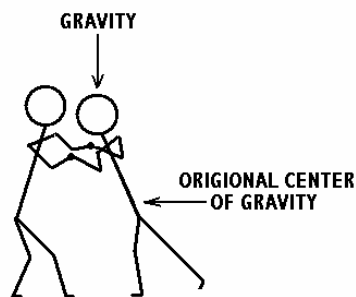


FIGURE 15

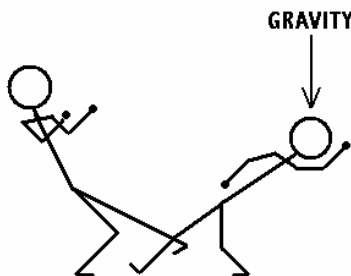


FIGURE 16

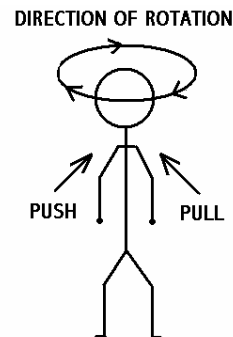


FIGURE 17

SUMMARY

- 1) There are two types of force the human body are capable of producing, a “push” and a “pull”.

PUSH



PULL



- 2) There is two types of movement the human body is capable of producing, “linear motion” which is movement in a straight line created by either a push or a pull and “angular motion” which is movement around an axis. Angular motion can be created by either a push or a pull, however in most cases, especially when applied to the human body, the push and pull work together to create angular motion.

LINEAR



ANGULAR



- 3) Most striking martial arts are based on push forces, as the desired outcome is to direct a force away from the body to cause impact.



- 4) Most grappling martial arts are based on pull forces as the desired outcome is to keep your opponent in close to limit their striking capability and push/pull forces working together which enables us to take an opponent off balance and or to the ground and manipulate joints.



- 5) Striking with long levers generate more force than short levers.



- 6) Deflections and blocks are more effective with short levers.

DEFLECTION

BLOCK



- 7) The surface area of your striking lever on impact will determine the distribution of the force and the penetration of the force.

KNEE STRIKE

FINGER STRIKE



- 8) When generating force, your bodies mass and your ability to accelerate your bodies mass at your opponent (with the appropriate footwork), will have an effect on the total force (power) you can generate.



- 9) When countering push forces generated by an opponent, you have three options “stop the force”, “deflect the force” or “move out of the way of the force”. When countering a pull force you need to lower your center of gravity and at least match the force that’s being applied by your opponent.

STOPPING A FORCE



DEFLECTING A FORCE



MOVING OUT OF THE WAY OF A FORCE



COUNTERING A PULL FORCE



- 10) The lower your center of gravity is and the wider your base of support is the more stable your stance is and the harder it is for your opponent to take you off balance.



- 11) To take an opponent off balance you need to either change the alignment of their upper body mass in relation to their center of gravity, rotate them around an axis or take their feet from under them.

CHANGING THE ALIGNMENT OF THE UPPER BODY MASS IN RELATION TO THE CENTER OF GRAVITY



ROTATING AN OPPONENT AROUND THEIR CENTER LINE OF GRAVITY



TAKING YOUR OPPONENTS FEET FROM UNDER THEM



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