The Science of Taekwon-Do

Dale Copeland, 2020

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The Science of Taekwon-Do

An analysis of scientific principles used in Taekwon-Do.

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By Dale Copeland, 5th Dan

Offered as a thesis for 6th Dan grading.

With thanks to the **Taranaki Taekwon-Do** Club,
especially to instructor Master Neill Livingstone
for his dedication, enthusiasm and inspiration.

Puniho Press, New Zealand
ISBN 978-0-9941485-5-1

Science in Taekwon-Do

Science? Originally, 'science' meant 'knowledge'. All knowledge. So for the science of Taekwon-Do, you couldn't do better than read, and remember, and understand, General Choi's Encyclopaedia.

Here I'll look at the narrower modern sense found in schools. Nothing about Chemistry, except to advise that you eat well as your food is the source of energy and strength. And drink lots of water – you need it.

Physics. Not nuclear physics, except that it's the source of the energy in sunlight, and therefore the origin of all our food, our strength, life itself. Electricity only gets a passing mention for sending messages through nerves to muscles. Sound can be used as a weapon. We completely leave out most of the other topics found in Physics textbooks, from astronomy through optics, quantum mechanics, relativity and waves. It is mostly mechanics which concerns us here. Dynamic mechanics.

The Theory of Power *(Him Ui Wolli)*

In the words of General Choi Hong Hi:

'The beginning student may ask; "Where does one obtain the power to create the devastating results attributed to Taekwon-Do?" This power is attributed to the utilisation of a person's full potential through the mathematical application of Taekwon-Do techniques. The average person uses only 10 to 20 percent of his potential. Anyone, regardless of size, age, or sex who can condition himself to use 100 percent of his potential can also perform the same destructive techniques.

Though training will certainly result in a superb level of physical fitness, it will not necessarily result in the acquisition of extraordinary stamina or superhuman strength. More important, Taekwon-Do training will result in obtaining a high level of reaction force, concentration, equilibrium, breath control and speed; these are the factors that will result in a high degree of physical power.'

Reaction Force *(Bandong Ryok)*
Concentration *(Jip Joong)*
Equilibrium *((Kyun Hyung)*
Breath Control *(Hohup Jojul)*
Mass *(Zilyang)*
Speed *(Sokdo)*

With undiminished respect for General Choi's own words in the Encyclopedia, I choose to examine each of these aspects in terms of Newtonian physics.

$\boldsymbol{Power} = \frac{Energy}{Time}$ is measured in Joules per second, or Watts.

So to get great power, we must exert a large amount of energy in as small a time as possible

Energy comes in many forms, kinetic (moving) and potential (stored). As we are dealing with unarmed combat we will ignore the chemical potential energy of guns or flame-throwers, the electrical stored energy of tasers, the elastic energy of slingshots.

So for Taekwon-Do techniques we consider only the kinetic energy of moving body parts driven by muscles, and gravitational potential energy if we can aim techniques downwards, drop into them, or kick and punch on the downward part of flying.

The formula for **kinetic energy** (**E_k**) is **E_k** = $\frac{1}{2}$ m v^2 where **mass** (m) is moving at **speed** or velocity (v). Mass is measured in kilograms, and velocity in metres per second, giving energy **E_k** in Joules. If you want to increase the energy you could increase the mass of your fist (street fighters do this by holding a roll of coins in their hand as they punch). Making your fist 3 times heavier would multiply the energy of the punch by 3. But if you could increase the **speed** of the punch by 3 times, the energy would be **9** times greater, because of the v^2 term. It is often not realised that there is also another effect. If the distance between your resting hip and the target is fixed, then trebling the speed of your punch will divide the time taken to get there by 3, and also lessen the time that your fist is in contact, as the target is knocked back to the full extension of your arm. As the formula for power is energy divided by time, your power will be multiplied by up to 27 times if you can make your punch 3 times as fast. Practising to punch more quickly has **much** more effect than carrying a fistful of metal.

The **gravitational potential energy** is given by $\boldsymbol{Ep} = m\,g\,h$ where m is the mass which drops through a height of h metres, and the acceleration due to gravity is g. At sea level on earth the value of g is approximately 9.8 m/s^2.

Incidentally, many people confuse mass and **weight**, a fault in common usage. Weight is a **force**, measured in Newtons. Your weight is the force of the gravitational attraction between you and the mass of the Earth. $Weight = m\,g$ If your mass is 60 kg then your weight is almost 600 Newtons.

The gravitational potential energy delivered in a Taekwon-Do technique is usually only a small contribution to the kinetic energy, caused by the drop at the end of the knee spring, or 'sine wave'. Small, but not at all negligible. Boxers talk of the advantage of learning to 'drop your body mass' into a punch. And of course if you are executing a flying technique then your whole mass is falling and as you punch or kick downwards from the top of your leap, there is a considerable amount of gravitational potential energy added to the kinetic energy of your technique.

$$\boldsymbol{Pressure} = \frac{Force}{Area}$$

Concentration is a descriptive word for pressure, as a force is concentrated onto a small area. Think of a marble floor being chipped by a light person wearing stiletto heels, whereas a snow field is almost unmarked when people cross it in large snowshoes, even if they're much heavier. The force is your weight ($= m\,g$) and when the force is concentrated on the small area of the stiletto heels, it gives a huge pressure. Similarly a backfist strike will exert a greater pressure on the target than a backhand strike. A punch should be delivered through just two knuckles, not the whole forefist.

An experiment to try at home: stand on bathroom scales with both feet, then standing on one foot, then go up on tiptoe. The scales will show no difference as they are measuring your weight, which hasn't changed. But do the same while standing on the back of a willing friend lying face down on the floor (don't try this on a smaller or very thin person, and have your feet either side of the spine, or perhaps across the back of their upper leg). They will feel the difference, as the pressure will increase when you make the area of contact smaller.

As weight equals mass times the acceleration due to gravity, your weight will change if you change either your mass or gravity. Mass is easy to change – put on your boots or eat more, cut your toenails or starve. But gravity? I'm not going to suggest you go to the moon (with an acceleration due to gravity of only 16.6% of that on earth) or to Jupiter (2.5 times what it is here, or 250%) or even that you climb a mountain (at the top of Mt Everest the acceleration due to gravity only drops to 99.7% of what it is at sea level). There is an easier way (and it's fun too).

Next time you're in an elevator/lift, try running on the spot. When it's starting, and when it's slowing to stop. It's best if you're alone in the lift, because you'll probably burst out laughing; it's a strange feeling. If you're too embarrassed in company to start jogging, just keep the balls of your feet on the floor and lift your heels alternately. That feeling, of being very heavy or very light, is caused by the acceleration or deceleration of the lift being added to, or subtracted from, the acceleration due to gravity.

Back on the bathroom scales. Suddenly bend your knees: you might expect that you are lowering your body so the scales will feel more of a force as you drop. Try it, the scales will read lighter as you are dropping. Apparently, (this is not one to try at home) if you are in a lift and all the suspension cables break, as you and your cage both drop you will feel weightless .. there will be no force between you and the floor. As if you'd be noticing. Oh, and another misconception: if the lift suddenly falls you won't be left behind to hit your head on the ceiling. You and the lift will fall together.

The contributions of both energy and pressure to total power can be seen when chopping wood. Just letting the mass of the axe fall will not work, nor will trying to just push it through the log. Or having a blunt axe. For the greatest effect you lift the axe as high as you can, bring it down as fast as possible, using a sharp axe which has the smallest possible attack area. For the toughest logs you also raise as much of your own body weight as possible, and drop it as you strike.

Boxers and fairground sideshows have made many attempts to invent machines to show how hard you can punch, or hit something with a sledgehammer. Taekwon-do practitioners have, of course, got a reliable method: we break boards.

Reaction Force Newton's third law states 'To every action there is an equal and opposite reaction'.

We are accustomed to living with both the force of gravity and the forces of friction, so we haven't noticed them since we learned to walk. Most of us will never float in space, or even walk on slippery ice very often, so we have to imagine being free of friction. Watching someone learn to use roller skates is instructive. Trying to walk normally has the legs and feet just going back and forth like the blades of a pair of scissors. Push one forward and the other will move back, while the centre of mass of the body stays where it is. People soon learn to have the back foot on an angle so the wheels are pushing sideways on the floor and can't slide. We need the reaction force to make us move. Skates made with castor wheels which can turn in any direction sound like fun but would, I think, never be much more than a good illustration of Newton's laws of action as you wouldn't be able to do anything except keep going in the direction you were pushed. Or flail your legs around, or jump up and down, all while staying in the same spot.

In space, or on ice, if you throw something away, you will move off in the opposite direction. That's how rockets work. If you throw a punch while on a friction-free surface without pulling back your other arm, your body will slide away from the punch (your centre of mass will remain where it was). The punch can't be as powerful when it's coming from a retreating body. But if the other hand is pulled back hard at the same time, your body won't slide back. Even if you're standing still on a floor with friction, if you don't pull the other hand back hard, then the upper part of your body will sway back a little as your punch comes out. Stepping forward as you punch uses the reaction force of the floor against your foot to add more force to your punch. The reaction force of what you're standing on equals your weight if you're standing still. It equals your weight plus your force if you're pushing off for a jump or stepping for a punch. An unbalanced force gives an acceleration. Unbalanced force equals mass times acceleration. $F = ma$

Jumping seems to have four components: the flexing of the feet, the straightening of bent legs, the swing of the arms, and using the reaction force of the floor to push off.

From left: Alex Lovell IV, Jay Dicker III, Matt Irvine III.

Photo by Glenwyn Flynn III

Jay Dicker of Taranaki Taekwon-Do shows a two-direction kick as in the pattern Juche. Using just the wooden floor for launching. (For his grading to 3rd Dan he broke boards with the two kicks and also made a break with a turning kick added as the final part of that same jump.) Note: no use of Photoshop except fading the background. His opponents are both tall men.

When he was asked to attempt to use each of the four factors separately without the help of any of the other three, he found it difficult, and also ineffective. Just pushing off with his feet, or just using bent legs but with flat feet, or just swinging his arms. Each of these could lift him only a few centimetres. Running and jumping onto a mini-trampoline, but keeping his body rigid, could not lift him more than 60 cm. All four components are needed.

Equilibrium, or balance, is very important. The centre of mass of a standing adult depends on body proportions but is usually about 10cm below the navel, level with the top of the hip bones.

Fast body movement can be used to avoid an attack. Without moving your feet, you can sway to the side or back to avoid a blow, but if your centre of mass moves beyond your feet, you fall over. Stand with your side against a wall and try it. If you sway your upper body one way, your hips will try to move the opposite way.

Body dropping (*Mom nachugi*) will avoid an attack to your mid-section, but you need to be able to quickly get back up. Not many adults can easily and quickly sit on the floor then get up again without using their hands. It’s a skill worth working for.

The necessity of having the centre of mass over the feet is the reason why you have to lean away when performing a side piercing kick if you want to avoid losing balance and dropping the kicking leg, which would make you fall closer to the opponent.

There is more on balance and equilibrium on page 29.

The next photograph clearly shows the centre of mass directly over the supporting foot. Good balance allows a strong kick, then a rapid retraction to a strong guarding position, ready for whatever might come next.

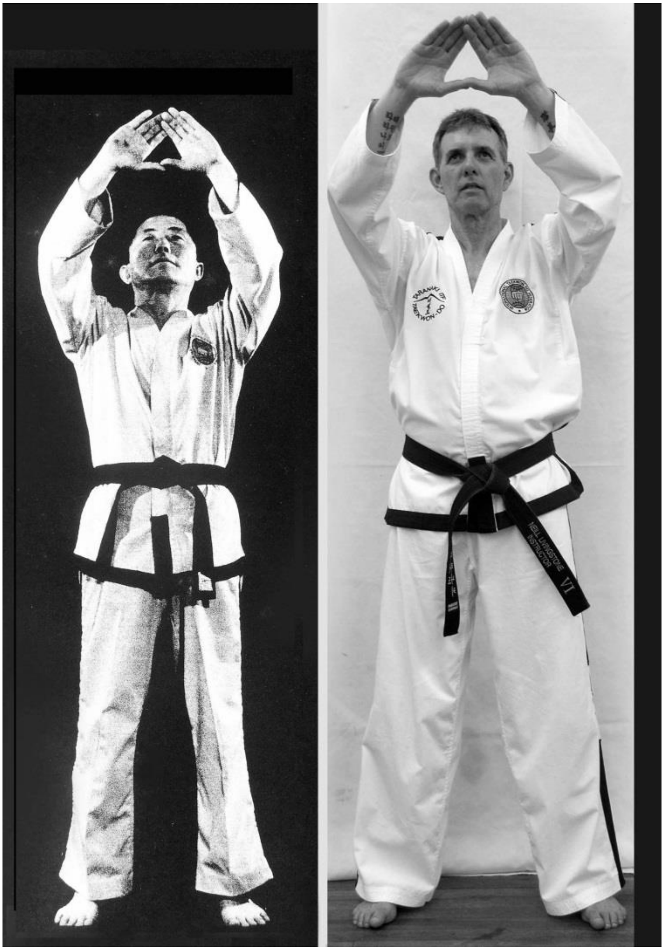
Sabum Kirsten Livingstone kicking through four boards at her grading for 5th Dan. She is now 6th Dan.

This photo of Kelly Lorth, 1st Dan, shows the benefits of having good flexibility as well as strength.

Stances: Measurements and Angles

General Choi's Encyclopedia gives the measurements of stances in terms of shoulder widths. For students with a similar build to the General, these measurements are ideal.

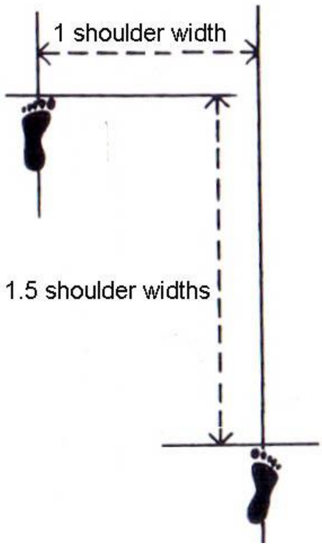
This comparison of photos is, as exactly as possible, to scale by the heights of General Choi Hong Hi and Master Neill Livingstone. Heights 5' and 6'1" or 153 and 186cm respectively.

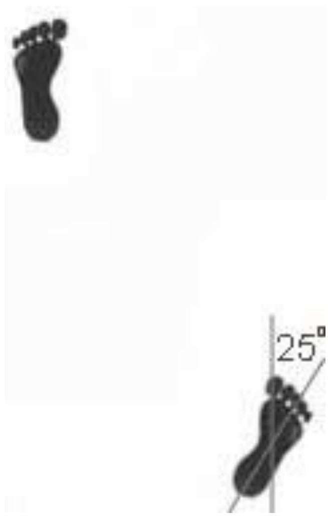


As you can see, there is a considerable difference in the lengths of all the long bones, but the shoulder widths are very similar.

If Master Livingstone makes his stances in terms of his shoulder width they are too short. He looks very upright, and covers such a small floor area that his stances are not strong or stable. I would like to suggest that stances measured in terms of femur length (the leg bone from knee to hip) would be a better measure to suggest to students. Or, another suggestion, as it seems that foot length is related to height, and from photos in the Encyclopedia as well as from measuring fellow club members, it seems that foot length might be a good measure, taking the Encyclopedia's "shoulder width" as equal to two foot-lengths.

This diagram of a Left Walking Stance was used in the Encyclopedia and has been copied widely. It seems to show tiny feet, too small for the purpose. (Also the rear foot should be turned by 25^0.)





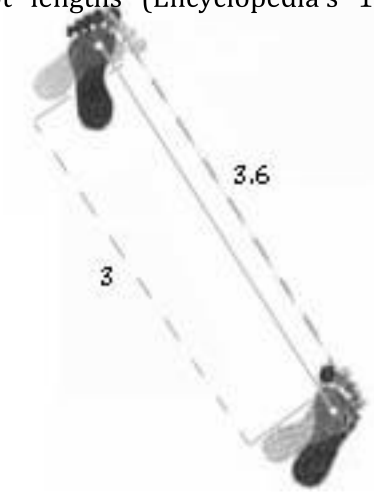
The second diagram is, as far as I could make it, to a more realistic scale while still following the General's ratio. Note that, no matter what unit of measure you use, the ratio of 2:3 remains the same.

This third diagram shows my suggestion of measuring stances in terms of foot length.

Left walking stance.
2 foot lengths wide, 3 foot lengths long.

Those who remember Pythagoras from high school geometry will know that this gives approx. 3.6 foot lengths as the distance between toes, or between the pivot points in the balls of the feet.

When you pivot from walking stance to sitting stance, as in the patterns Yoo-Sin and So-San, you can see that the measurement between inside edges of the feet is approximately 3 foot lengths (Encyclopedia's 1½ shoulder widths)



The General was a very clever man.

Angles, when given exactly in the Encyclopedia, should, of course, be followed. E.g. the 25^0 angle of the back foot in a walking stance and low stance, and the 15^0 angles of both feet in L-stance, fixed stance and vertical stance.

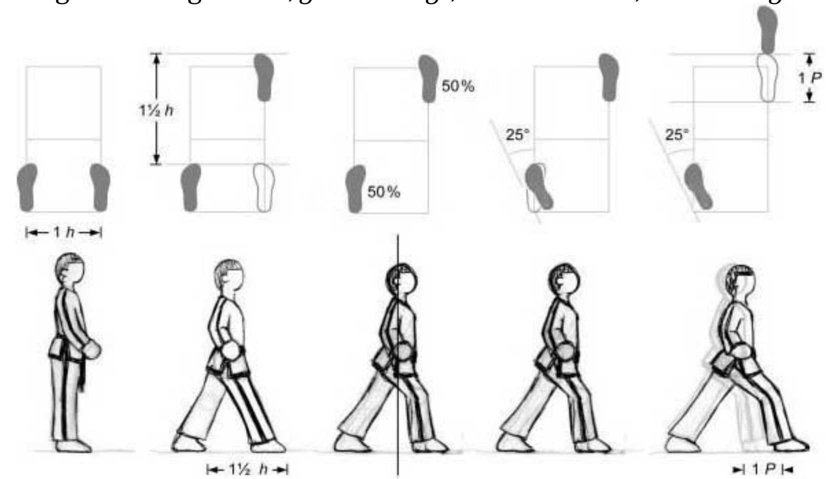
These diagrams show the progression: parallel stance to walking stance to low stance, with the rear heel pivoted inwards by 25^0, and a comparison of L-stance, fixed stance and vertical stance, where both heels are pivoted outwards by 15^0

(Note that I refer to the movement of the heel rather than the toe, because the pivot point is the ball of the foot.) Rear foot stance is similar to vertical stance, but with the front heel off the ground.

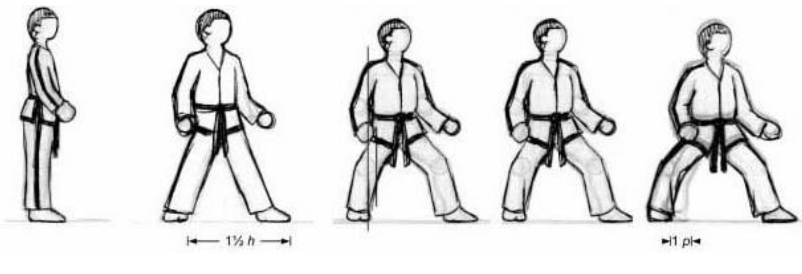
For most two-legged stances, the body weight is equal on both feet. 50% each. Except for L stance - 70% is on the back foot, 30% on the front. And Rear foot stance has 90% on the back foot.

With the kind permission of Fabián Fucci 5th Dan, of Instituto Internacional de Taekwondo, Ciudad de Buenos Aires in Argentina. I reproduce his useful diagrams for stances.
The measurement '*h*' stands for the shoulder width, or the width of a man. (Spanish for the man is '*el hombre'*). '*P*' for the length and '*p*' for the width of a foot. (Spanish for the foot is '*el pie'*).

This diagram shows progression from parallel stance, *narani sogi* to right walking stance, *gunnun sogi*, to low stance, *nachuo sogi*.



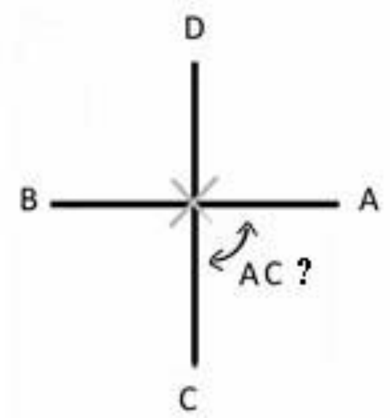
And this shows moving from parallel to right L-stance, *niunja sogi*, dropping body weight to 70% weight on the back foot and both heels pivoted out by 15^0. Then to fixed stance, *gojung sogi*, with 50% weight on each foot.

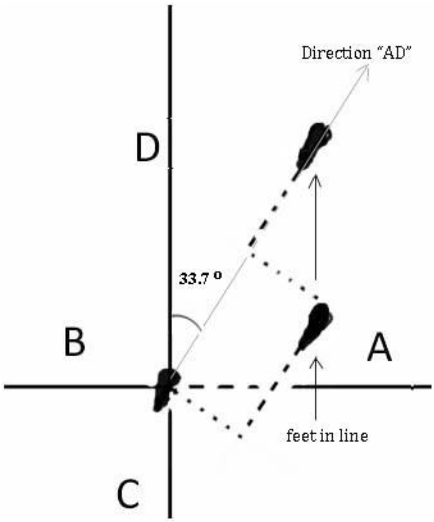


Directions We usually write D, the direction we face when starting a pattern, at the top of pattern diagrams.

In the Encyclopedia it is often reversed, with C at the top.

The directions A, B, C and D are exact, but when a direction is called AC we should not assume that it means exactly 45^0. It is somewhere between directions A and C.

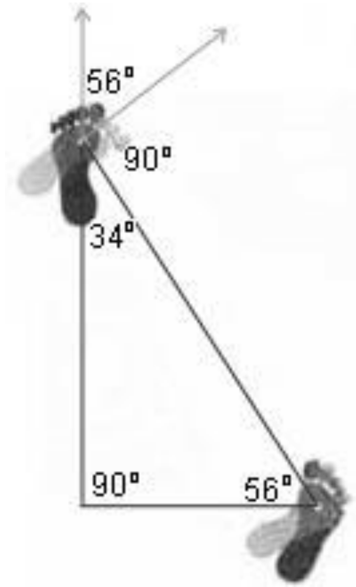


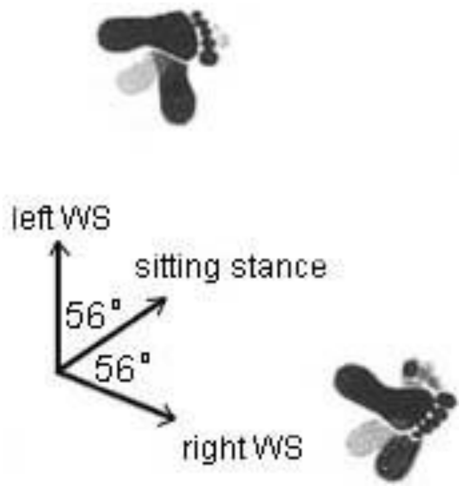


In patterns Do-San and Yul-Gok, when stepping out with a walking stance and a block, followed by a front snap kick and two punches in fast motion in another walking stance, the angle should be 33.7^0 (call it 34^0) as shown here (with directions as in movements 7-10 in Yul-Gok). This will bring both feet back onto line CD after the movement is repeated to the other side.

The reason for this angle, for those who like to know these things, is that the right-angled triangle formed in a walking stance has sides in the ratios 2 : 3 And $\tan^{-1}(2/3)=33.7^0$

When pivoting from walking stance to sitting stance, the angle the body turns through is 56^0.



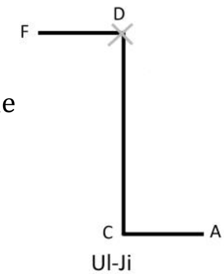


When pivoting between left and right walking stances, as in patterns Toi-Gye, Ul-Ji and So-San, the angle turned through is 112^0 (twice 56^0), as shown here.

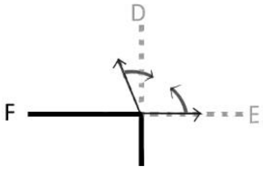
This knowledge is of use for getting an idea of the angle of some blocks.

Consider the <u>circular block</u>: in early patterns, all we know is that the block is delivered to an angle of somewhere between 0 and 90^0, e.g. in Won-Hyo from a walking stance towards C, the circular block is to CE or to CF. But in Ul-Ji when circular blocks are done from pivoting walking stances we have:

***39**. Move the right foot to E forming a right walking stance to E while executing a circular block to ED with the left inner forearm.*
***40**. Execute a circular block to DE with the right inner forearm while forming a left walking stance toward DF.*



The pattern diagram for Ul-Ji is given as:
With all directions shown, and the angles for the techniques,
we have:

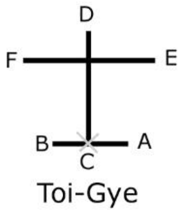


I hope it is apparent that for both the circular blocks to be in the direction ED (or DE), the angle of the circular block must be more than 22^0 ($112^0 - 90^0$)

You might wonder why I didn't use the similar movements from the pattern Toi-Gye as the example. The Encyclopedia gives:

***34.** Execute a circular block to AD with the left inner forearm while forming a right walking stance toward A, slipping right foot to A.*
***35.** Execute a circular block to CE with the right inner forearm while forming a left walking stance toward CE.*

This seems to be the only time that movements are described by the quadrant they occur in, rather than the directions they point to.



For movements 34, 35, 36 the left foot is planted firmly on the starting point as you pivot. I believe movement 35 would be better described by:

***35.** Execute a circular block to DA with the right inner forearm while forming a left walking stance toward DB.*

For measuring the angle of the double arc-hand block we should be able to be more precise.

In Ge-Baek and Sam-Il the (high) double arc-hand blocks from walking stances are listed as going to the diagonal, so the angle could be anywhere from, say, 10^0 to 80^0. But in So-San we pivot from a walking stance to D to a walking stance to BC (pivoting through an angle of 112^0 as we have seen) then the double arc-hand block (middle) is also listed as towards BC so the angle of the double arc-hand block would be less than 22^0 (112 – 90).

However further research shows that movement #34 in So-San was written in the 15-volume Encyclopedia as: *"Execute a middle block to **BD** with a double arc-hand while forming a left walking stance toward BC and looking through the hands."* In the Condensed Encyclopedia, and all later copies, this has been changed to *"… a middle block to **BC** …"*. An unfortunate change, as it makes the direction of the double arc-hand block almost straight ahead, a contradiction to the photographed movement in the original Encyclopedia. The purpose of the block is a strong push against an attacker approaching at an angle.

I believe we should change the wording in So-San back to:
***34**. Execute a middle block to **BD** with a double arc-hand while forming a left walking stance to BC and looking through the hands.*
***42**. Execute a middle block to **AD** with a double arc-hand while forming a left walking stance to AC and looking through the hands.*

We have an opportunity for another indicator for this angle: In Se-Jong we form a diagonal stance towards C, then a walking stance towards AC and the direction of the double arc-hand block is given as exactly towards C. This is a difficult angle to measure, as from diagonal stance it isn't possible to form an exact walking stance just by pivoting – the feet are too far apart. From asking several black belts to perform this movement and measuring the angle of the block, it seems to average around 30 degrees.

This angle seems to agree with the images in the Encyclopedia, and reinforces my view that the direction stated in movements 34 and 42 of So-San should be changed back to the originals.

If you'd like to know why or when I occupy myself with such pernickety problems, I've just spent a couple of nights in a tiny airbnb caravan parked behind an isolated cottage on an island in the Hebrides in Scotland, while the weather closed down and there was little to do but think. Now the cloud has lifted and I can go climb a craggy cliff.

Moving in walking stance - learning to walk again?
Not really. Practising a technique up and down the do-jang in walking stances is not like ordinary walking. And not only because of the longer and wider steps, and the 25^0 angle of the back foot.

A curved line for the moving foot.
Stepping should be executed in a curved line as shown. This makes the body half-facing during the step, and so less vulnerable to attack.

The rigid back leg.

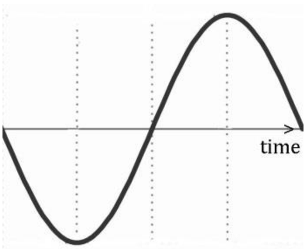
The General would, in his seminars, walk behind students and kick against the back of their knee with his foot if they were standing with the back leg bent. It should be locked and rigid.

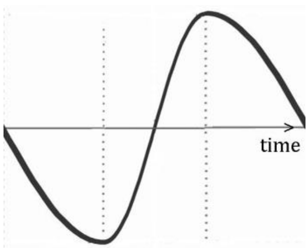
The heel of the back foot should, in almost all situations, be kept flat on the ground.

Sine wave or knee spring

One of the training secrets of Taekwon-Do is "To create a sine wave during the movement by utilizing the knee spring correctly."

A sine wave is a very exact mathematical graph which occurs often in physics … describing the sound wave of a pure note, and waves in the electromagnetic from gamma rays to long radio waves. Here is a small portion of the infinitely long graph of the pure sine function. As you can see, the wavelength can be divided into 4 equal time intervals.





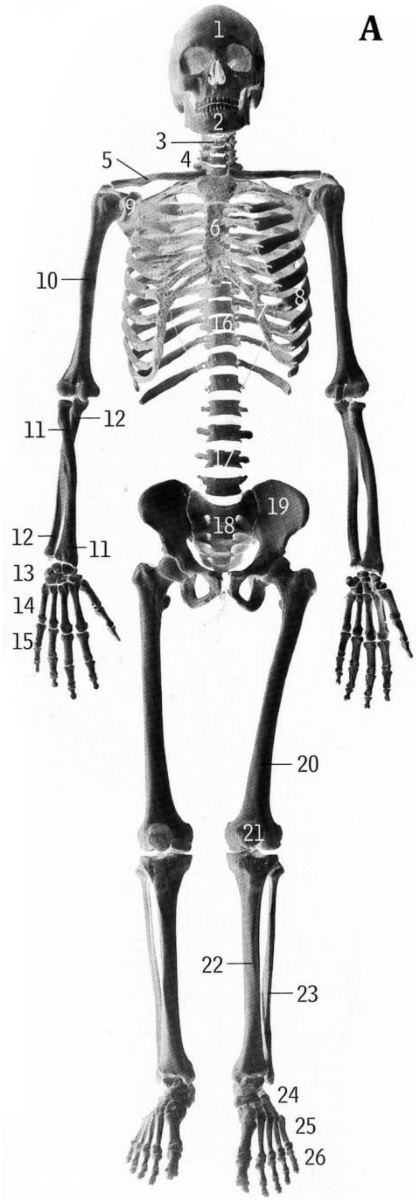
Alongside it is a curve which, I believe, better describes what the General meant, as he often referred to the motion as having THREE parts: down, up and down. I believe that 'knee spring' is a better term to use than 'sine wave', if for no other reason than that mathematicians get stroppy about the casual use of a name that has a very exact meaning and formula.

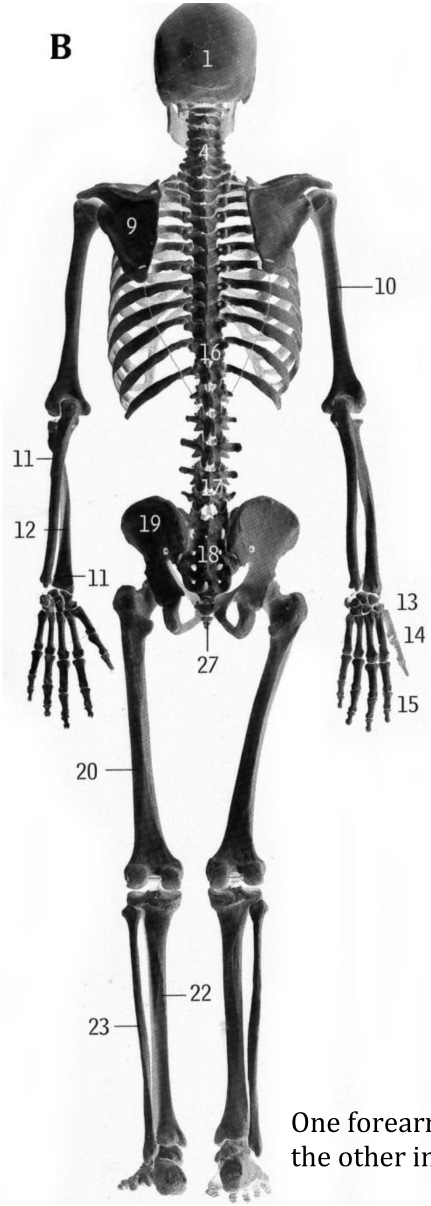
<u>Biology - biomechanics</u> ... how a bundle of bones can deliver the powerful techniques found in Taekwon-do.

The adult human body has 206 bones. We are born with 270 but the extras gradually fuse together until our mid-twenties, as our bodies grow.

This collection of bones is a beautiful thing, but how does it WORK?

The bones are tied together by ligaments - long, stringy collagen fibres that create bands of tough, fibrous connective tissue. Ligaments are slightly elastic, so they can be stretched and gradually lengthen, increasing flexibility. But if stretched too much, ligaments can become overstretched and compromise the integrity of the joint they are supposed to be stabilizing — so begin stretching with caution. The term double-jointed actually refers to people who have highly elastic ligaments, which allow them to move their joints into more extreme positions than most people.





Human skeleton
A from the front
B from behind

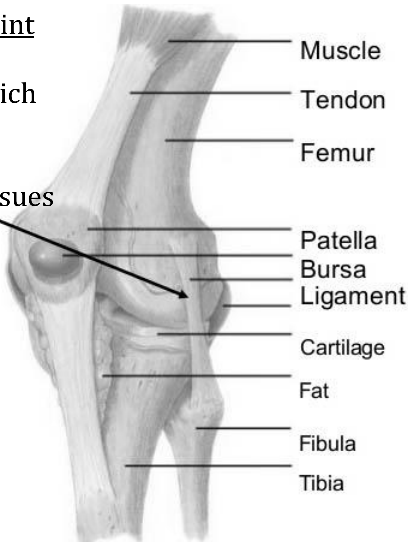
1. Skull
2. Mandible
3. Hyoid bone
4. Cervical vertebrae
5. Clavicle
6. Sternum
7. Costal cartilages
8. Ribs
9. Scapula
10. Humerus
11. Radius
12. Ulna
13. Carpal bones
14. Metacarpal bones
15. Phalanges of fingers
16. Thoracic vertebrae
17. Lumbar vertebrae
18. Sacrum
19. Hip bone
20. Femur
21. Patella
22. Tibia
23. Fibula
24. Tarsal bone
25. Metatarsal bones
26. Phalanges of toes
27. Coccyx

One forearm is in the position of supination, the other in pronation (thumb inwards).

Voluntary Muscles

When skeletal muscles contract, bones move. But how do muscles make your bones move? A voluntary muscle (one that you can decide to use) usually works across a joint. It is attached to both the bones on either side of the joint by strong cords called tendons - tough bands of connective tissue that connect a muscle to a bone. Tendons are similar to ligaments, except that ligaments join bones to each other.

The Knee Joint

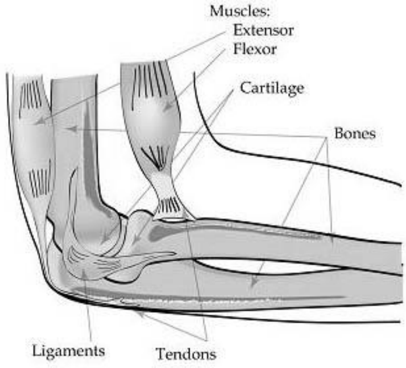


Tendons are connective tissues which attach bones and muscles,
to allow bones to move.
Ligaments are tough connective tissues that attach bones to bones.

Muscles move the body by contracting against the skeleton. When muscles contract, they get shorter. By contracting, muscles pull on bones and allow the body to move.

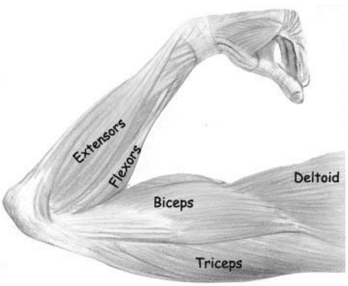
Muscles can only contract.

They cannot actively extend, though they can move or relax back into the non-contracted neutral position. Therefore, to move bones in opposite directions, pairs of muscles must work in opposition. Each muscle in the pair works against the other to move bones at the joints of the body. The muscle that contracts to cause a joint to bend is called the **flexor**. The muscle that contracts to cause the joint to straighten is called the **extensor**. When one muscle is contracted, the other muscle from the pair is always relaxed.



For example, the biceps and triceps muscles work together to allow you to bend and straighten your elbow. When you want to bend your elbow, your biceps muscle contracts and, at the same time, the triceps muscle relaxes. The biceps is the flexor, and the triceps is the extensor of your elbow joint.

Other muscles that work together are the quadriceps and hamstrings used to bend and straighten the knee, and the pectorals and trapezius used to move the arms and shoulders forward and backward.

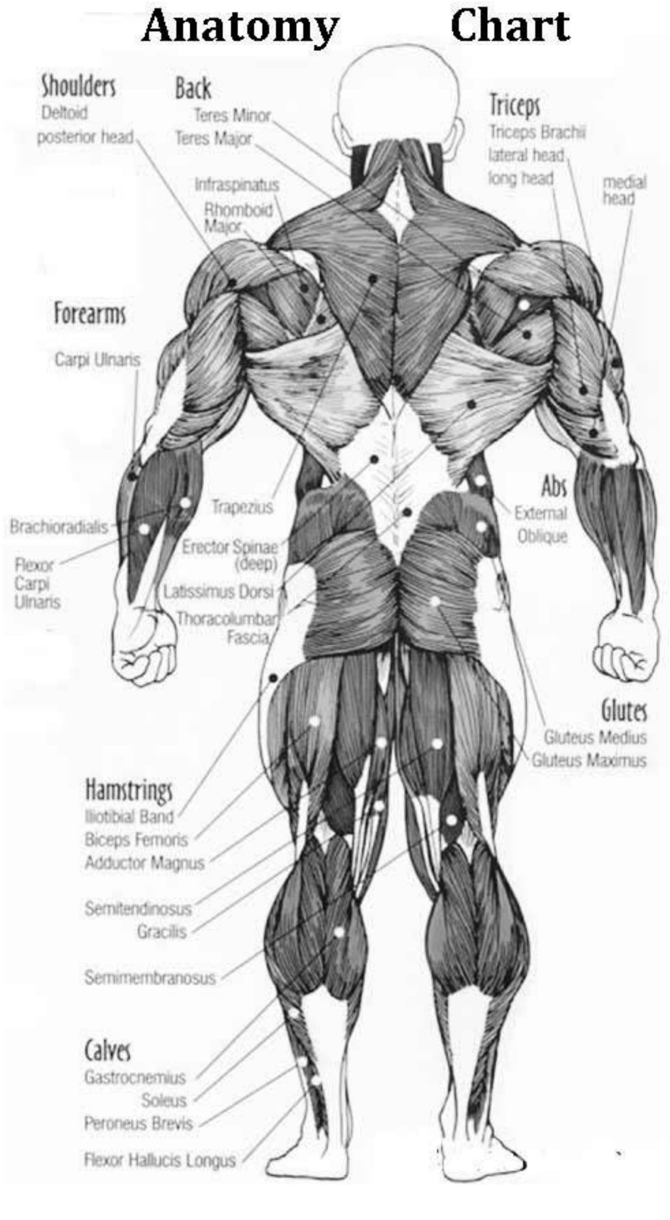


The flexors and extensors for bending the wrist are shown here.

Many of the physical aspects of Taekwon-Do such as kicks, balance, power, and movement will come from your lower body. The more technical aspects of hand techniques such as accuracy, defense, and landing punches will typically come from your upper body. It is up to you to decide whether to focus on more power, or hand speed, endurance, or all of it.

The key to effective training is understanding how your muscles are used in each technique and to be able to decide how to train them to best fit that purpose. Smart athletes will know that certain muscles should definitely be given priority over the others.

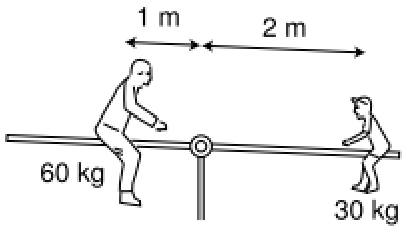

Human Muscle
Neck
Omohyoid
Sternohyoid
Sternocleidomastoid
Trapezius
Chest
Pectoralis Major
Pectoralis Minor
(beneath major)
Shoulders
Deltoid
anterior head
middle head
Biceps
Brachialis
Biceps Brachii
long head
short head
Pronator
Teres
Palmaris
Longus
Forearms
Extensor
Carpi Ulnaris
Extensor
Pollicis
Brevis
Abductor
Pollicis
Longus
Extensor
Pollicis Longus
Flexor Carpi Radialis
Brachioradialis
Abs
Serratus Anterior
External Oblique
Rectus Abdominis
Tendinous Inscriptions
Thighs
Sartorius
Pectineus
Adductor Longus
Gracilis
Tensor Fasciae Latae
Vastus
Medialis
Vastus Lateralis
Rectus Femoris
Patella (kneecap)
Calves
Gastrocnemius
Soleus
Tibialis Anterior
Tibia (bone)
Peroneus Longus
Extensor Digitorum Longus


Anatomy Chart
Shoulders
Deltoid
posterior head
Back
Teres Minor
Teres Major
Infraspinatus
Rhomboid Major
Triceps
Triceps Brachii
lateral head
long head
medial head
Forearms
Carpi Ulnaris
Brachioradialis
Flexor Carpi Ulnaris
Trapezius
Erector Spinae (deep)
Latissimus Dorsi
Thoracolumbar Fascia
Abs
External Oblique
Glutes
Gluteus Medius
Gluteus Maximus
Hamstrings
Iliotibial Band
Biceps Femoris
Adductor Magnus
Semitendinosus
Gracilis
Semimembranosus
Calves
Gastrocnemius
Soleus
Peroneus Brevis
Flexor Hallucis Longus

Levers in the body

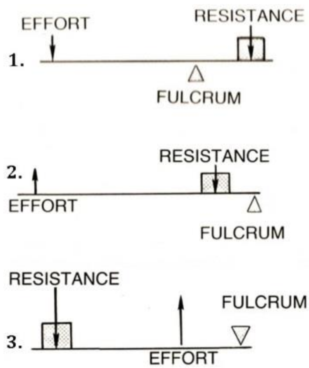
Bones, ligaments, and muscles are the structures that form levers in the body to create human movement.

There are three types of lever. All have a fulcrum or pivot, an applied force or effort, and a load, also called the resistance or the resultant force. Force times distance from fulcrum is called torque.



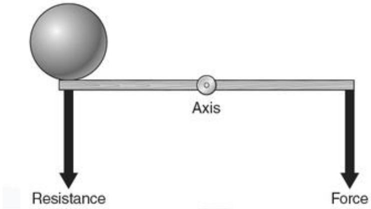
In all cases, the Effort force multiplied by its distance from the fulcrum will equal the Resistance force, or load, multiplied by its distance from the fulcrum.
Mechanical advantage is Load divided by Effort.

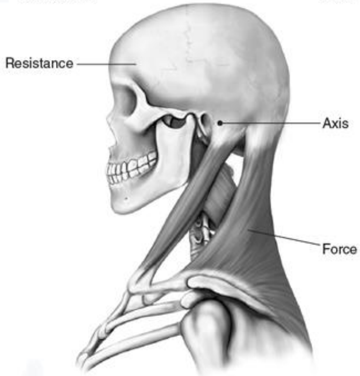
Type 1: Fulcrum in the middle: the effort is applied on one side of the fulcrum and the load on the other side. Mechanical advantage may be greater than, less than, or equal to 1.



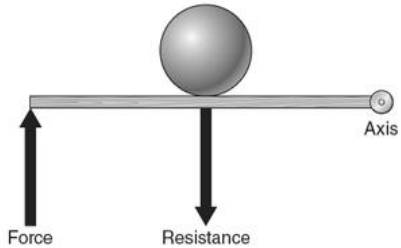
Type **2**: Load in the middle: the effort is applied on one side of the resistance and the fulcrum is located on the other side. Load arm is smaller than the effort arm. Mechanical advantage is always greater than 1. It is also called a force multiplier lever.

Type 3: Effort in the middle: the resistance (or load) is on one side of the effort and the fulcrum is located on the other side. The effort arm is smaller than the load arm. Mechanical advantage is always less than 1. It is also called speed multiplier lever.





Type 1 levers in the human body are rare. One example is the joint between the head and the first vertebra (the atlantooccipital joint). The weight (resistance) is the head, the axis is the joint, and the muscular action (force) come from any of the posterior muscles attaching to the skull, such as the trapezius.



The usual example given of a Type 2 lever in the human body is the lower leg when you stand on 'tiptoe' (actually on the ball of the foot).

The axis is formed by the metatarsophalangeal joints, the resistance is the weight of the body, and the force is applied to the calcaneus bone (heel) by the leg muscles through the Achilles tendon.

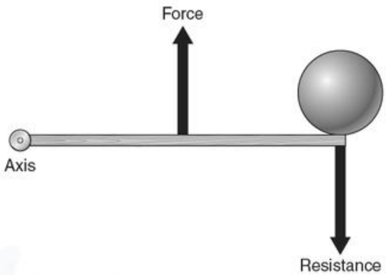
However, this description and diagram are not correct.

To demonstrate, try this: stand facing a wall, with your toes touching the wall. Attempt to stand on tiptoe.

Balance

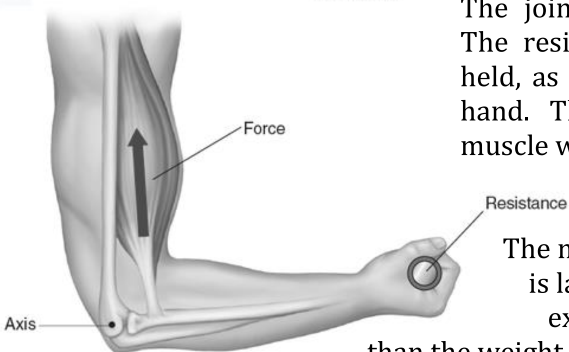
Your 'footprint' is the area between and including your feet. If your centre of mass is not directly over your 'footprint', you will fall over.

The first, and essential, part of lifting your heels, even a little, is leaning your whole body slightly forwards so your centre of mass is over that small footprint, the ball and toes of your feet. Stand with your face against the wall and try it.



In a third-class lever, force is applied between the resistance (weight) and the axis (fulcrum). There are numerous third-class levers in the human body; one example can be illustrated in the elbow joint.

The joint is the axis (fulcrum). The resistance is what is being held, as well as the forearm and hand. The force is the biceps muscle when the elbow is flexed.



The mechanical disadvantage is large . . . . the biceps must exert a much greater force than the weight being held in the hand.

Board Holding for Breaking The diagrams show boards in a holder, held by one person and by two. Hold with the ball of the hand firmly behind the board, and fingers tightly curled and out of the way in front. The support must be parallel with the grain, and as close to the edge as possible, to maximize the blow's torque.



Legs (Power)
By 'legs', we refer specifically to the quads and the calf muscles. This is something that should be ingrained into anybody wanting to do anything powerful with their body. ALL power comes from the ground, nowhere else. Your legs are most responsible for pushing off the ground to generate power throughout your body. Your legs also hold the biggest muscles in your body. So they generate the most power. Not the chest and definitely not the triceps. Look at the body of a boxer, and just about any athlete (except for weight-lifters) and you won't find over-developed pecs or huge triceps. Mike Tyson, as dynamic a puncher as he was, was still more muscular in his legs than his arms.

Hips (Balance & Lower Body Core)
The hips generate a huge amount of power by pivoting your whole body when you need. Another important function is that stronger hips give you better balance. Balance essentially determines the effectiveness and efficiency of your offence, defence, movement, and overall fighting ability!

You can also think of your hips as the centre of your body weight. By twisting your hips with every punch you will be able to put your entire body weight into each punch or strike or thrust, maximizing its power. This is well worth practising.

Abs (Frontal body core)

The abdominal muscles are a very powerful set of muscles that hold your whole body together. Every limb in your body generates a certain amount of power individually but it is your abs that allow you to combine the force generated by every limb into one total force. Simply put, your abs let you connect the force generated by all your limbs into one powerful punch. Aside from connecting your whole body together the abdominal muscles help you breathe and can make a strong wall to withstand frontal blows.

Back (Rear body core and punch recovery) The back also functions as a total body core muscle by holding your body together and combining the power generated by all your limbs. Another little known fact is that the back helps a lot in punch recovery - the speed of pulling your hand back after a punch.

Involuntary Muscles

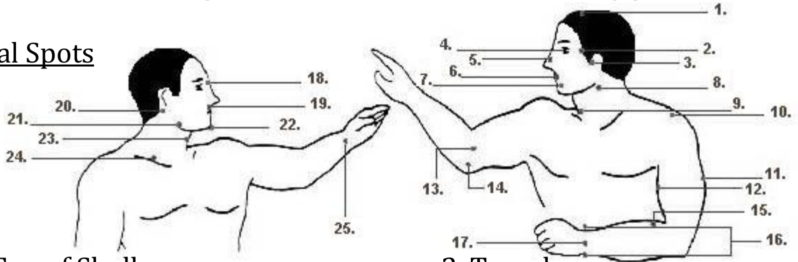
Smooth muscles and cardiac muscles are under involuntary control – they work without us thinking about it. They are not attached to bone. Smooth muscle is responsible for the contracting of hollow organs, such as blood vessels, the gastrointestinal tract, the bladder, and the uterus. Like skeletal muscles, smooth muscle fibres contract, causing the muscle to shorten. Smooth muscles have numerous functions, including the following.

- Smooth muscles move food through the digestive tract.
- In arteries, smooth muscle movements maintain the arteries' diameter.
- Smooth muscle regulates air flow in lungs.
- Smooth muscle in the lungs helps the airways to expand and contract as necessary.
- Smooth muscles in arteries and veins are largely responsible for regulation of blood pressure
- In the bladder, smooth muscle helps to push out urine.
- The smooth muscle in the uterus pushes out a baby.

The nervous system

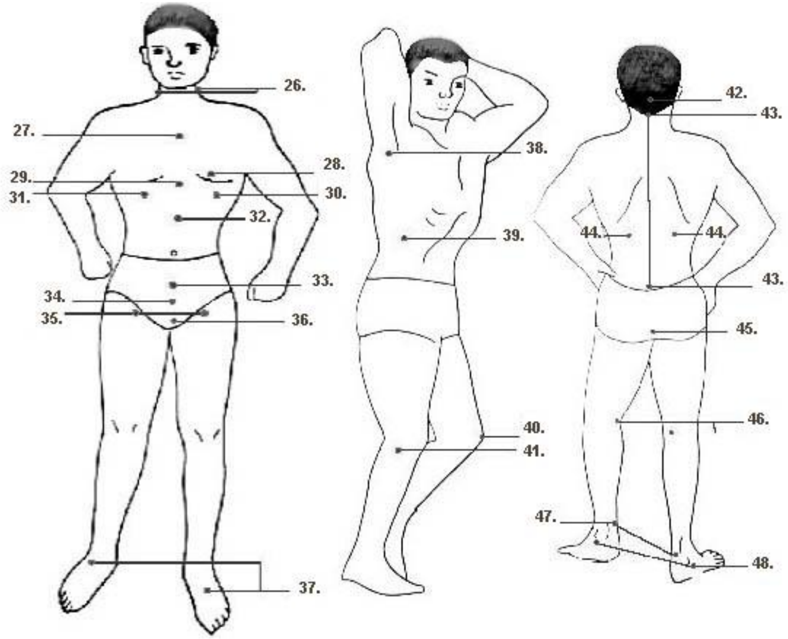
Nerves send messages to muscles, both voluntary and involuntary. The coeliac plexus is often popularly referred to as the solar plexus, because of its radiating nerve fibers. It is a complex network of nerves located in the abdomen, near where major arteries branch off from the aorta. It is behind the stomach and close to the diaphragm. It is listed as one of the vital spots in Taekwon-do. In many cases, it is not the coeliac plexus itself being referred to, but rather the region where it is located. A blow to the stomach can upset this region. This can cause the diaphragm to spasm, resulting in difficulty in breathing—a sensation commonly known as "getting the wind knocked out of you". A blow to this region can also affect the coeliac plexus itself, possibly interfering with the functioning of the viscera, as well as causing great pain.

Vital Spots



1. Top of Skull.
2. Temple.
3. Mandibular joint.
4. Eyeball.
5. Nose.
6. Lips.
7. Jaw.
8. Upper neck.
9. Wind pipe.
10. Shoulder joint
11. Triceps muscle.
12. Bicep Muscle.
13. Inner Elbow Joint.
14. Funny bone on Elbow.
15. Top of forearm muscle.
16. Wrist joint.
17. Back wrist artery.
18. Bridge of nose.
19. Philtrum.
20. Post auricular.
21. Angle of mandible.
22. Point of chin.
23. Adam's apple.
24. Clavicle (collar bone).
25. Under wrist artery.

Note: The 'funny bone' is not a bone, it is a common term for the sensitive nerves and tendons over the humerus bone at the elbow.



26. Neck artery.
27. Sternum.
28. Heart.
29. Solar plexus.
30. Spleen.
31. Liver.
32. Epigastrium.
33. Lower abdomen.
34. Bladder.
35. Groin.
36. Scrotum.
37. Instep.
38. Armpit.
39. Floating ribs.
40. Kneecaps.
41. Side of knee.
42. Occiput.
43. Spinal column
44. Kidney.
45. Coccyx.
46. Back of knee joint.
47. Achilles tendon.
48. Ankle joint.

Vital spots are pressure sensitive points near the surface of the body. Blows aimed elsewhere may hurt, but will not stop an attacker.

Your senses as a defence

For awareness, you need all your senses. Wearing a pulled-up hoodie restricts peripheral vision. Wearing earphones cuts down aural awareness. And having your head down and concentrating on your phone is like having EASY TARGET written on your back.

Sound A loud yell can intimidate an opponent and also summon assistance. A hard two-handed palm slap across an opponent's ears will cause pain and temporary deafness.

Light and dark Opponents can of course be dazzled with a torch, but using dark as a weapon? If you're in a place more familiar to you than to your opponent then turn the lights off – you know where the escape routes and the potential weapons are. Don't forget that a handful of sand or dirt thrown in the opponent's eyes can be a formidable weapon.

Spatial Awareness

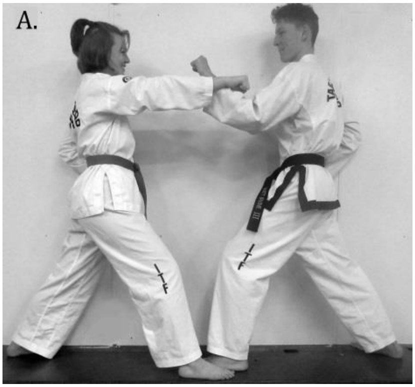
It is very important to be aware of your surroundings. Not only to notice possible dangers, but also possibilities … escape routes and potential weapons. Make no assumptions. Vehicles can be a threat even when stationary. Doors can be opened suddenly. Groups of people can offer either you a safe place to run, or an added danger of aggression. It's best to have made that assessment before you need it. Walking under ladders isn't unlucky, it just carries a higher risk of something falling on you.

Correct Distances

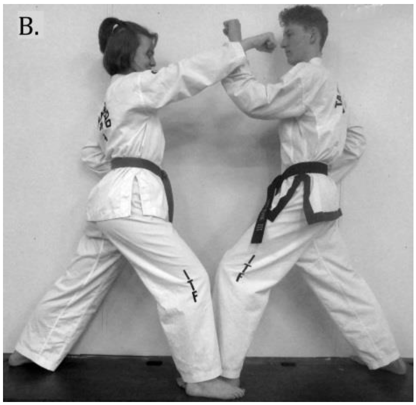
When beginners start free-sparring, they often flail about at a great distance from their opponent. Hitting or kicking at pads, or breaking boards, improves their knowledge of the necessary distance for each technique. The distance which is best for defence is learned by measuring as in three-step sparring. You will notice from these photos that the right initial measuring will give the correct distance for the attack and the block to meet at the correct body parts, the lower third of the forearms.

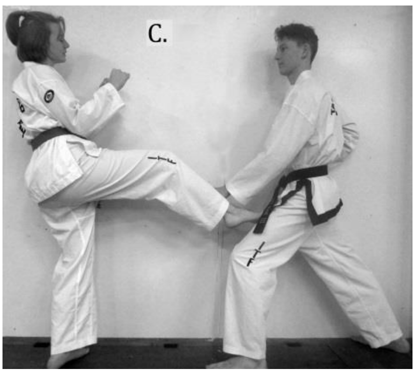
Shown by Lexy Ollington and Matt Irvine.

A. Spacing for middle punches.



B. Spacing for high punches.





C. Spacing for foot attacks.

Breath Control

If you've ever wondered why instructors stress the importance of breath control, try punching while breathing IN. Exhaling strongly at the time of your attack adds power and coordination to the technique. Practise breathing using the abdominal muscles beneath the diaphragm, rather than the intercostal muscles between the ribs.

Psychology & Posture

Holding your head up and your back straight gives the impression of confidence and competence, as well as making your patterns look so much better.
Learn how to defuse a potentially dangerous situation, while being prepared to defend yourself if necessary. Be confident but not antagonistic. Don't be too proud to run away if necessary.
The ideal outcome is when both parties can walk away without any blows. Talk them down if possible, but be ready to give a strong and committed kiyup (yell) if you need to drop into a strong block and counter-attack.

Know yourself, your strengths and your weaknesses. So you will know which techniques will or won't work for you in each situation. And learn as much as possible about your opponent. Watch their eyes, but be aware of the rest of their body with your peripheral vision.

Space & Movement

Students learn in free sparring to be light on their feet, not flat-footed. With your weight on your toes rather than on your heels , fast movements and reactions are possible. All the movements which occur in patterns, not just stepping but pulling or slipping the foot,, sliding forward or back, skipping in and dodging away – they should all be practiced enough to become automatic.

Sociology – I believe that continued training in Taekwon-do will improve your strength, self-confidence, stamina and posture, regardless of any limitations of health and age.

Prediction

Those who are good at sparring usually recommend watching the opponent's eyes, rather than their feet or hands. Picking up the very beginnings of the intention to attack as well as seeing the actual movement with their peripheral vision.

Not astrology or crystal-ball gazing, just being conscious of the slight moves which begin different attacks. If they start to pull the right shoulder back and at the same time begin to shift their weight onto the left leg, then you know they're beginning to step forward for a right obverse punch. Unless they also begin to twist their torso. To their left, they're planning a backfist strike or knifehand strike, to the right, a reverse knifehand strike.

If your opponent is good at a spinning back kick, then you need to see it coming so you can move behind them on their blind side, hoping to counter-attack as you move. The best way to learn what precedes each attack is to practice the attacks yourself slowly, being aware of what your body does in preparation.

Philosophy

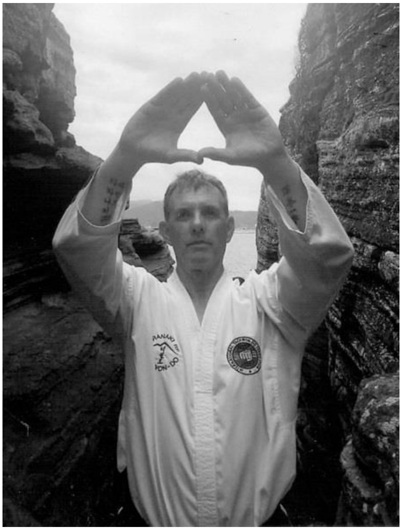
Students of Taekwon-Do can do no better than to study what General Choi has written. The first 47 pages of the Condensed Encyclopedia cover the philosophy and ethics of Taekwon-Do.

Summarised by:

1. Be willing to go where the going may be tough and do the things that are worth doing even though they are difficult.
2. Be gentle to the weak and tough to the strong.

3. Be content with what you have in money and position but never in skills.
4. Always finish what you begin, be it large or small.
5. Be a willing teacher to anyone regardless of religion, race or ideology.
6. Never yield to repression or threat in the pursuit of a noble cause.
7. Teach attitude and skill with action rather than words.
8. Always be yourself even though your circumstances may change.
9. Be the eternal teacher who teaches with the body when young, with words when old, and by moral precept even after death.

General Choi Hong Hi 2.11.1918 – 15.6.2002



Master Neill Livingstone QSM

Neill Livingstone started the **Taranaki Taekwon-do Club** in 1993, when he was a 1st Dan. Based in New Plymouth, New Zealand, the club has produced more than 50 Black Belts, with 20 of them still actively training and assisting with juniors.
Master Livingstone was awarded a Queens Service Medal for services to Taekwon-Do and the community, in April 2019.

The Encyclopedia is our reference book, and decider of differences.

The club's mission statement is:

Empowering students with skills and values
through the ART of TAEKWON-DO.
Building a more peaceful world.

The club's website is at https://www.taranakitkd.com/

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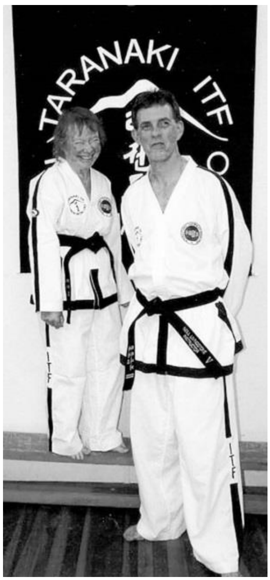
<u>The author</u>

Dale Devereux Copeland began Taekwon-do training at the age of 56. Now 76 and a 5th Dan training towards 6th, she regards herself as being the most fortunate person in the world, for having found this martial art, the Taranaki Taekwon-do Club, and the international Taekwon-do community.

She has also written the textbook **Taekwon-do Patterns (Tul)**, now in its 5th edition.



Dale Copeland a new 4th Dan in 2011, and Master Neill Livingstone, then a 5th Dan.