

Zen and the Art of Kayaking

POWER CIRCLES & TENSEGRITY

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*"It is easy to lead a horse into the river,
But to make him do the back stroke is harder"*
My friend told me:
*"It's especially difficult because
The horse's swimming style is the butterfly, by nature"*

PREFACE:

We all know there is no one best method to improve paddling skill. For my athletes I suggest the exercises described in this work. The same exercises are recommended to other athletes who may find them fun, or who like to try new and different ideas. Athletes with a long background of kayaking on different levels will find my methods relatively simple to use.

The indoor kayak ergo meter is helpful in learning the forward stroke because it is stable (1). The athlete can paddle without fear of capsize. Afterwards athletes can paddle on the water repeating the same strokes they performed on the erg. It is easy to "recall the pictures" that were practiced during dry-land warm up or on the kayak - ergo. Mental pictures are an invaluable training aid. They help an athlete connect with the sensations felt while paddling.

No matter what age, type of sport background, or branch of kayaking (sprint, marathon, eco - challenge or recreational), it is useful for an athlete to develop a feeling for how the boat and paddle are reacting to the water. Exercises included in this work, such as the Power Circles, Line of Forces, or paddling drills will help athletes develop this important connection to the water. In my experience, after some practice, athletes realize how important it is to feel the boat-paddle reaction to the water, and to feel the water through the boat. This ability develops only after much practice. In the early stages the sensations and feel for the boat will come and go. This is seen in any kind of practice, dry land, on the water, and during the main paddling program.

Coaches are often confused because they can not see what their athletes are practicing or feeling. For example they don't recognize which Power Circles, or Lines of Force are being felt by the athletes. Also the practice skills don't look like they are increasing boat-speed. The coach may feel like an "outsider". However a keen observer will realize that new skills are being practiced by noting that after practice, the athletes are more exhausted from the same training that they have many times before. The fatigue is from using many new movements.

In order to establish better communication the coach needs to teach the athletes to verbalize their muscle sensation. Because words and expressions will be different between athletes daily practice becomes "colorful" and exciting.

1. INTRODUCTION

I want to underline that my analysis presented in the "inner structure of the kayak technique" is not scientifically proven. Instead I call it "*my training diary*" because it contains extremely subjective views on kayaking techniques that I have collected in nearly 50 years as a competitor and coach. The published exercises, descriptions, mental pictures, and analogies are simply my method of teaching technique. They include the comments and feedback from many athletes about muscle sensations experienced while paddling. This method of collecting anecdotal evidence is useful to coaches and is frequently used by researchers in the fields of pedagogy and psychology.

I find it nearly impossible to scientifically prove the accuracy of my kinesthetic and sensory "discoveries" of efficient technique. My goal was simply to increase the athlete's awareness of how a kayak reacts as it is propelled through the water. I want the athlete to "feel the water" through the boat and become aware that boat and paddle are only extensions of the athlete's body. My ultimate aim has always been to find the optimal body position and coordination of body parts to achieve the most powerful and efficient paddling manner possible.

I publish my experiences in order to motivate paddlers, coaches, and other professionals to experiment with the sensory approach to technique improvement. The process starts by writing down known philosophies about the teaching process, paddling skill, and then personal feelings about technique. This process causes coaches and athletes to compare styles and look for subtle differences in individual paddling technique. Eventually, as motion sensitivity develops, athletes discover helpful new images and analogies that they contribute to the growing number of case studies all of which enables other paddlers achieve a more efficient kayaking technique.

"Technique" is mentioned many times above. I am not going to define all details of one or two favored techniques or, in spite of being in the kayak sport since 1955, review all approaches to the topic. My own background is founded on two basic techniques. The first one is the "pure" Hungarian, the other one is the Hansen technique. The latter was "created and presented" by Eric Hansen from Denmark in Rome in 1960.

In addition to these two techniques the "wing" paddle appeared which modified and improved paddling technique. Boat speed increased and higher boat speed seems to be making the technique more "uniform". So far this trend in technique is not yet "dominant" in the woman events. In my judgment, this is because of the 10 seconds lower boat speed.

2. POWER CIRCLES.

The use of Power Circles to teach technique began in the early 70s. Since then the shape of Power Circles have changed, improving continuously year by year. For example, originally I thought the support arm has to help the pulling arm. Later, from athletes experience and my observations this view changed. The new focus was on the timing of the shoulder support, to help the arms. Then it became obvious the torso was used to support arm motion, and that there was a need for similar support from the legs. All modifications lead toward a better "visualization" of the "centre" of PCs, and what makes them so effective.

It seems to me unnecessary to talk with athletes during practice about the "final forms" of the kayak stroke. Instead I focus on sensory learning methods which will help all, sprinters, marathon, recreation, and eco-challenge athletes.

The Five Power Circles : This is the starting point, the first level, in my system.

Power Circle #1: This circle is initiated from the pulling side foot pushing against the foot-board. The reacting force (from foot-board to foot) is transferred toward the stroke-side hip. The stroke-side hip pushes against the seat. From the seat the motion is transferred up the torso to the "locked" stroke-side shoulder, and then to the stroke side hand which pulls against the paddle. Pulling force from the hand coupled with lower body tension and pressure on the foot-board acts to propel the boat forward. This circle becomes complete when the force from the stroke-side hand to the paddle is transferred back to the foot pressing on the foot-board. (*Dari Fisher*). Think of PC #1 as taking place on one side of the body (2).

Power Circle #2: In this circle the lower hand initiates the compression against the paddle and resulting force is transferred through the arm to the stroke-side shoulder. As the shoulder moves backwards the opposite shoulder moves forwards. Both shoulders work as a unit to transfer force from the lower hand to the upper hand. The shoulders must act in unison, held in a firm position, in order to accomplish an effective transfer of force. The upper hand now pushes against the shaft, which transfers force to the stroke-side hand to complete the circle. (*Dari Fisher*). Think of PC #2 as being about Body Rotation (3).

Power Circle #3: The "Powerful Bicycle" is initiated from pressing the foot against the foot-board. The resulting force moves toward the stroke-side hip. The hip is compressing against the seat. These combined forces are transferred to the opposite hip which is important in this power circle. The opposite hip presses sideways against the boat which counteracts the turning effect of the paddle stroke. This helps the boat to run straight. Once the resulting force from the hip compression is transferred back to the stroke-side foot, this circle is complete. (*Dari Fisher*). Think of PC #3 as about Leg Work (4).

Power Circle #4: The blade's compression against the water initiates force which is transferred to the stroke-side shoulder. That force is then transferred to the opposite hip. The opposite hip pushes against side of the boat opposite to the stroke-side. The resulting force from the opposite hip is transferred back to the pivot point of the blade in the water to complete this circle. (*Dari Fisher*). PC #4 is about the Shoulder to Hip Swing (5).

Power Circle #5: The final, and most difficult, power circle to master uses the compression of the stroke-side foot against the foot-board to transfer force to the stroke-side hip. The stroke side-hip then pushes against the seat, and the combined forces from the foot and hip are transferred to the opposite pushing side shoulder. This shoulder and arm then compress the hand against the paddle. Force is transferred back to the foot to complete the circle. (*Dari Fisher*). PC #5 is about the Body Swing and a firm Cross Frame Rod (6).

In the following section each PC is viewed as a sequence of forces. Mental images are given for each PC to help athletes "feel" the flow of forces. The KEYS paragraph focuses attention on the most important elements in the PC. Names, or short description, will remind athletes what each PC is about.

FORCE FLOW in each Power Circle: This is the second step in my teaching.

1-THE CATCH, all one side, PC (#1)

Force Flow: Heel ☞ Leg ☞ Hip ☞ Trunk ☞ Shoulders ☞ Arm & Hand ☞ back

Images: Blade fixed in cement, boat moves past stuck blade, shaft bends, pulling on a stuck door, Tug-of-War pull, pressing side of boat against a water wall (7).

HEELS: Push to support strong Catch

HIPS: Push leg and foot, rotate backwards. Hip and Shoulder work together

TRUNK: Body swings away from the shaft to counter blade pulling force

ARMS: Stiff frame with body, arm pulls with torso, upper arm pushes bent shaft

KEYS:

*Lock blade against water cone for split second.

*All forces link together to power the stationary, but bending, shaft.

*Pull on stuck door with a straight arm. Feel a string is attached to the shaft.

*Fix the blade, and then pull the boat past it.

2-BODY ROTATION PC (#2)

Force Flow: Arm ☺ Shoulder ☺ other Shoulder ☺ Arm ☺ Shaft ☺ Pulling arm

Images: Stiff carbon rods connecting a four sided frame (8).

HEELS: Push on foot rest

HIPS: Rotate hips with torso

TRUNK: Keep a stiff 4 sided frame, don't wrinkle the new membrane shirt.

ARMS: Spear fish, bend shaft, pull string, force travels to top hand push

KEYS:

*Keep shaft and chest parallel, arms ridged.

* Move boat past fixed blade, use water don't fight it _

* Relaxed, light, swinging rhythm, pausing for glide, soft, catlike

* Accelerating paddle stroke

* Swift blade removal, pause for glide

* Lift elbow and spear a fish with blade

3-LEG WORK PC: (#3)

Force Flow: Heel push ☺ Hip ☺ other Hip ☺ other Foot ☺ back to 1st Foot

Images: water skier, fish tail, snake, pole vault, water wall, eggshell, bicycle, stiff carbon rods, Rubber Ducky, wet soap, (9).

HEELS: Push the heel; lift other heel, lean boat.

HIPS: Push back; rotate with trunk, lift other knee, hip thrust against water wall

TRUNK: Vigorous swing to other side, other knee lifts high

ARMS: Hands at eye level

KEYS:

*body works as a ridged, carbon frame, hip transfers force to other hip

*Water wall supports body motion, force rebounds back to squeeze boat forward

*Skier and Kayaker feel for the best boat angle against water wall

*Body hangs on flexing shaft as trunk rotates and swings hard to side.

*Arm holding paddle stretches forward, cross center line, no pull at start

*Knee up and toward power side helps body motion to the other side.

*Watch Natasa Janics and Larsen use boat tip control and glide.

*Plant pole as a fixed support for body weight, force flows to other side

*Hip Flick at end of stroke to push on water wall

4-SHOULDER to HIP PC (#4)

Force Flow: Foot ⇄ Shoulder ⇄ Cross to other Hip ⇄ Push vs. Wall ⇄ back

Images: Carbon rod transmits forces, Penguin walking on stilts, snake motion, a stiff rectangular frame is transferring force to the boat (10).

HEELS: Starts the sequence of forces

HIPS: Push away from shaft, against water wall to snake boat forward

TRUNK: Flexible full swing, ridged frame transfers force across body

ARMS: Keep a stiff framework to transfer force to blade

KEYS:

*See from front or back. Watch the back bend countering stroke force

*Hip presses tipped hull against water, rebound squeezes boat ahead

*Put equal force on both ends of stiff body framework

*This PC connects upper Shoulder PC to lower Legwork PC.

5-BODY SWING, Cross Frame Rod PC (#5)

Force Flow: Cross body ⇄ Hip ⇄ Shoulder ⇄ Arm ⇄ Hand

Images: wet soap squeezed forward, water wall, fish tail, snake, carbon rods (11).

HEELS: Supports hip force going to opposite shoulder

HIPS: Pushes other shoulder forward, cross the body, by stiff carbon rod

TRUNK: Strong base for transfer of force from hip to other shoulder

ARMS: Provide ridged frame for force transfer to blade.

KEYS:

* Fish tail force from body swings hip against water wall.

* Get an Action - Reaction from the water wall, rebound, use of water.

* Force flow pushes shoulder well forward to starts next stroke.

* Vigorous torso and back swings toward off side, and against water wall.

* Hip presses side of boat against water wall at optimal angle.

* Hip flick with good legwork.

* Think of a water skier finding best angle of ski pressing against water.

* Keep weight leaning on paddle

Power Circle Discussion:

According to my observation these PCs are already part of super athlete's technique without consciously learning them. Therefore it is worth the time spent to practice them. They help paddlers reach higher boat speeds in all types of kayaking: sprint, marathon, eco challenge and recreational racing. After a few weeks practicing PCs the subtle parts of the technique will start "finding their place" like pieces in a large puzzle (11).

I have received very useful comments from all over the world. One Hungarian doctor bought my book and was able to learn the technique by following the directions in it. He learned to "compresses his boat into the water-wall" and found his kayak is now moving better. He is paddling a NELO, with swivel seat. And, since he is using *kemecsey technique*, frequently "hits the limit" of rotation with this seat. Just like the book proscribes, he coordinates rotating the torso and leaning the boat to produce powerful strokes. He is very pleased with the methods and his paddling progress.

One of the most important things Power Circles can teach us is a strong trunk rotation that enables athletes to "lead their boat" through the water much like a wind surfer or water skier. (Further on I am going to explain the details with suggestions about using this exercises. There will be pictures to show how the Line of Force is transferred through the trunk from the paddle to the boat.)

Often it is useful to reverse an image. For example think about starting from the water and following the line of force to paddle, hand, arm, and to the boat. No matter which way you trace the lines of force, PCs will help athletes develop a firm body structure which maximizes the transfer of power in each paddle stroke.

I want to emphasize again that I do not have a new technique. Nor are my methods the only way to teach technique, or to learn it on your own. Rather the motions described here are the natural adaptations being made by talented athletes in today's high racing speed. My goal has been to continuously follow the process of evolution in kayaking technique and, with the help of ideas from world class paddlers, teach it to my athletes.

Numerous comments and feed-back from athletes are my "proofs". Like this comment: "one thing is for sure: your technique coaching makes the paddling motion a lot more fluid and efficient. The full body motion - with all parts contributing in a coordinating chain - makes it enjoyable. The rhythm and swinging motion are very recreational. There ought to be some way to set it to music" (12).

This is a wonderful recognition from an athlete. It is a good "reason" to teach technique in this way. In my opinion it is one of the most effective methods to teach the efficient, economical movements in modern kayaking.

3. BOAT & WATER

The reaction of the water to boat movement is obvious. We can find many papers, studies or essays about the horizontal rocking and bouncing motions of the boat. The motion is very similar to a playground seesaw. In addition, because Kayaking is a two blade cyclical motion, the kayak will develop a left to right sideway motion like a snake.

Take them one by one. First is the rocking motion of the boat, the side leaning or tipping of the boat. The challenge is finding the best position between paddle and water, and between boat and water. The most comfortable, as well as the most efficient, position is to lean the boat towards the pulling side. This motion starts gradually at the end of the recovery phase. At this moment our boat is completing a stroke and is still leaning towards that side. As we start to change paddling sides, the boat leans toward the locked blade at new catch position. We can observe this on video clips and still photos of the super athletes.

We can observe the opposite as well, a boat leaning away from the pushing side during power phase. This is a common way to loose power and control of the boat. The "inner structure of the kayak technique" has been loosened up. The connection between the blade in the water and the water in front and beside the boat on the opposite side is getting weak.

The proper leaning of the boat: This is the *third step in my plan*.

Let's see some video clip of the greats. I highly recommend observing video clips of Knut Holmann (13), Akos Vereczkei (14), Eirik Veraas Larsen (15), Adam van Koevorden (16)& Natasha Janic (17). Use pictures taken from the front, a few strokes are enough. Watch each video a minimum of 10 -20 times. Focus on the horizontal movements, and rocking motion of the boat. Then watch the leaning of the boat to the pulling side. I suggest watching these athletes because they are working together with the boat in a perfect harmony. We should memorize their rhythm, which is like a symphony, the symphony of kayaking. (18).

Feel the water supporting the hull. The hull uses that it to provide a solid base of support for the powerful motions used in a good paddling technique.

Now look for the swinging motion of the trunk to the opposite side from the paddle (19). At this point the boat is leaning towards the blade which is locked in the water (20). On the opposite side of the boat the "water wall" supports the force of the swinging trunk. (21).

Next watch the position of the shoulders (22). The shoulder on the support side moves as if locked to the hip on the pulling side (23). Because we cannot see this muscle action we need to feel it during our own practice on water or on a kayak erg. (A paddling erg is particularly helpful for any "outsiders", coaches, professional helpers, or research scientists.)

Watch front view videos of the superstars 20 times or more. Slow the motion down, speed it up. Notice that the height of the power side shoulder is correlated to the leaning of the boat toward the pulling side (24). If the shoulder moves too high (even 2-3 mm) the athlete will be unable to lean the boat to the paddle side. Without that lean there won't be sufficient support from the boat and water to swing their trunk to the support side (25).

The position of the shoulder on the pulling side determines both the quality of the power stroke and the compression on the water-wall beside the hull on the support side.

Good athletes will be able to watch the video a few times and discover the "connection" between the heights of the pulling side shoulder and the "rising up" side of the boat on the support side.

At this moment we have two diagonal Lines of Forces: one is "moving" from the shoulder on the support side into the hip on the pulling side (26). The other one is coming from the shoulder on the pulling side and "going" across the body to the hip on the support side (27). The two lines of force diagonally cross each other somewhere in the "middle of the trunk" (28).

Here is a valuable discovery: the bouncing motion of the boat will disappear when the athlete is using the water-wall. This is done by compressing the boat into the water on the side opposite to the blade (29). The "snake-motion" of the boat will disappear if there is good compression against the water-wall.

4. LEGWORK The legwork is the *forth step in my teaching progression*.

The technique of leaning or "edging" a kayak appeared more than 10 years ago in the technique of super athletes. When I first saw this rocking motion I was confused, not able to understand or explain it. The first step was to talk with my former elite athletes about the new "phenomenon". We recalled past conversations about pushing against the water-wall, and then we watched video and studied paddling on the Kayak ergo. At first we had limited knowledge about legwork because the legs are usually covered by a splash-cover (spray-deck). But on the kayak-ergo the legs are not covered which helped us.

We were lucky that Zoltan Bako, Knut Holmann's coach, had video that we could watch thousands of times. Slowly we "discovered" the secrets of Holmann's legwork: he used his legs very powerfully up & down (30). We called it "bicycle motion" and he never decreased this bicycle motion during the race. Then we observed another important detail, his support side knee was moving above his pulling side knee. I saw something else in this "knee movement". His support leg knee "covered" the other knee (31). At the same time the heel of the support side leg is raised from the foot board while the heel of the pulling side leg is pressed against the foot board.

Athletes, coaches and other experts were talking about a perfect "equilibrium" in Holman's technique. Others called it a "well balanced" motion. Actually they were very close to each other. Personally, I like both of them but knew I was missing something.

I still didn't understand why the athletes were "edging" the boat. To study it we invented an exercise called A.B.S. (Anti-lock Break System). The athletes were asked to "visualize" four points, the two heels and the two hip joints, and focus on the movements of each. These were the four points where the athlete contacted to the bottom of the hull. I asked the athletes to modify the horizontal position and the longitudinal direction angles of the boat. They were to use these movements to find the best support from the water through the boat to the paddler. (We were looking at the base of good technique.) Without exception, during these tests, all the athletes leaned the boat to the pulling side. It turned out there is a strong correlation between the swinging motion of the trunk & the boat leaning.

The water-skier, skier, or wind-surfer all use edging to control forward motion. Of course they get propulsion from the motor boat, momentum, or from the wind while Kayakers generate their own power. But both use their equipment to press against the water wall to control their direction (32).

We have to watch again the video clips of Akos Vereczkei, Eirik Veraas Larsen, Knut Holmann, Natasha Janic. They may not be aware at that they move their boats sideways against a water wall. However it is obvious that they are rotating and swinging their trunk like a punching bag. This swinging motion sends more power to the blade than trunk rotation which is produced by abdominal muscle power (33). As the athlete is swinging, it produces sideways motion of the boat (34). The talented athletes automatically will modify the position of their boat in a natural way. They are edging their boat, because this is the best position of the boat to transfer the power from the blade through the hull to the water. Edging is also the best way to transfer momentum from swinging body weight into boat speed. We concluded that an edging position is essential to support the whole technique. It makes good use of the water by not fighting against it.

My final conclusion is that the two Lines of Forces in the athlete's body are leading the boat (35). They are directing, regulating the edging movement, longitudinal direction and compression of the hull into the water-wall. It is similar to edging by a snow skier, water skier or wind-surfer.

5. LINE OF FORCES The Line of Forces in PCs are the fifth step

Each Power Circle consists of a sequence of forces which are repeated every paddle stroke. There are usually two or three lines of force in each PC.

For example in PC #1 a force sequence flows along the following Force Line: (1) heel push and stretching out of the leg, to (2) the hip and gluteus muscles, up to (3) the shoulder on the pulling side, to pulling arm, and finally to the hand. Then the cycle repeats during the next stroke (36).

The Line of Forces runs through the torso to connect the upper to the lower body. The lower body is supported by the water through the boat. Power is transferred from the locked blade in the water to the athlete's torso. It is utilizing the two Lines of Forces, LF #4 & LF #5.

In PC #2 forces are working in a different way. PC #2 starts with the hand on the shaft. It moves along the (1) arm on the pulling side into the (2) shoulder. From the shoulder on the pulling side force travels to the (3) shoulder on the support side, then along the support side arm into the hand. In this Force Line we are working with the shoulder on the pulling side to the shoulder on the support side (37). This LF crosses the body to produce a 3D structure technique.

PC #3 starts at the footrest and moves to the (1) pushing leg. In the second part of PC #3, force flows from the (2) hip on the power side to the (3) hip on the support side. Picture it as a giant triangle with force flowing from the gluteus on one side to the gluteus on the other side (38).

PC #4 can also be pictured in 3D. It starts at the blade in the water and moves up to the (1) shoulder on the pulling side. The second LF in PC #4 starts in the shoulder and goes down to the (2) gluteus muscles on the support side. The most important part of the PC #4 takes place between the shoulder on the pulling side and the hip muscles on the support side (39).

PC #5 forces goes from (1) footrest through the straightening leg to the seat. The second part of the PC is moving across the torso from the (2) hip up to the shoulder on the support side. Force travels from the shoulder along the (3) support arm into the hand on the shaft. Both PC #4 and #5 LF use the torso which is important in controlling hull edging. Strong torso forces compress the hull into the water wall on the support side and regulate the leaning of the boat on the pulling side (40).

In this first part of my work I have focused on the LFs in the torso. We have been analyzing the function of the LFs: their direction, modification and adaptation during each Power Circle.

6. BENDING & DIRECTING THE LFs. This is the sixth step

All of the five LFs in the torso contribute to correct body posture (41). They also have other benefits, which I once underestimated. One important result of good torso motion is that the boat will use LFs, to increase water support in front and beside the hull. We are immersed in water and need to learn how to use it effectively. Watch a salmon or trout use the water while swimming up a fast water-fall. They generate all their power just by moving from side to side. Did you know that a Barracuda uses the water so effectively that he can accelerate from zero to 100 km/hour in less than a half second? We need to learn how to use the water-wall effectively and not let the boat be fighting against it.

Another important role of the LFs is how they affect the torso. They have a significant function in building up a firm "internal technique" structure. In my view, the effective use of torso LFs is the only way to transfer full power from the blade to the boat, so generating maximum speed.

Next let's look at the whole movement system to see what forces affect it. This system includes: boat ? water ? athlete's body ? paddle. The job of a coach is to apply knowledge of an efficient system to help athletes coordinate their movements and generate power by use of force lines. Good instruction will enable athletes to create a firm, effective, and economical technique. This is best accomplished by focusing on the "inner structure of the kayak technique".

I think the "Tensegrity" principle will help us understand it. This principle occurred to me when I was thinking about the numerous "compression - tension" pairs in paddling technique. I recognized that "compression will awake a tension" and that this connection is very similar to Newton's third law. My athletes, other coaches, and I started to talk about these observations. We collected a lot of ideas, took notes, and continuously modified our ideas. This became a never ending process as we corrected, and modified our ideas in the development of the Tensegrity theory.

The following are some of our conclusions about the inner workings of technique:
(These require a thorough understanding of Force Lines to be well understood.)

In PC#1, the shape of the LF through the torso is changed when it is acted on by forces coming from different directions. The leg on the paddle side pushes on the footrest as the hip rotates back. This motion acts on the torso to bend the lower part of the LF backwards. This causes the upper torso to bend backwards (42).

The first part of the PC #4, from the blade up to the shoulder, is bending the upper part of the LF in the torso backwards (43).

Next think about the LF of PC #2 in the torso area. This LF is moving from the shoulder on the pulling side to the shoulder on the support side. The end of the LF on the pulling side is bending backwards because of the compression from the first part of the PC #4. The other end of the LF on the support side is bending

backwards. The support arm is compressing in that direction from the bending shaft. This bending shaft is compressing the whole support arm backwards (44).

The PC #3 has three LFs, but only one is of interest to us in this work. It is the LF in the torso, between the gluteus muscles on the pulling side and the gluteus muscles on the support side. The pulling side end of this LF is being bent backwards, because the straitening leg is pushing back toward the gluteus muscles. The support side end of the LF is flexing backwards, because of the water resistance is holding it back (45).

So far we have 3 LFs in the torso and both of ends are bending backwards. PCs #4 & #5 also modify their shape, under the effect of the external and internal forces. The compression and tension pairs are deforming the shape of the PCs.

PC #4 LF in the torso is moving down from the pulling side shoulder into the opposite side gluteus muscles. The first LF in PC #4 is coming up from the blade in the water to the shoulder on the pulling side. This LF bends the LF in the upper part in the torso and shoulder. The other end of the LF in the gluteus muscles on the opposite side is bending because of the resistance of the water (46).

PC #5 LF in the torso is coming from the gluteus muscles on the pulling side and moves up to the shoulder on the opposite side. The LF in the support side shoulder is bending backwards, because bent shaft is compressing the support arm backwards (47).

7. HULA HOOP is the seventh step in our learning sequence

Obviously the work of the arms is very important. We look at arm work as being either pulling or pushing movements. Actually the work of the arms is much more complicated. For example the arms flex the shaft of the paddle at the catch and during the power phase. According to our tensegrity theory, the support arm is prying the shaft forward and slightly downwards. This movement generates tension in the entire length of the paddle. The tension is "moving" along the support arm into both of the shoulders. The elbows moving downwards together with firmly held arms and circular body rotation bring to mind a bent "hula-hoop" ring. All these compressions-tensions are perfectly supported by the LFs in the torso, because of the LFs are flexed a bit backwards.

From the above discussion we understand these topics:

1. the bending hula - hoop, caused by the pulling-pushing arms, and elbows (48).
2. a tension in the bending shaft (49).
3. this tension is moving further through the arm (50).

4. then to the shoulders and towards on the LFs in the torso, which is responsible to "keep up" the flexing shape of the hula - hoop (51).
5. the LFs are tensed in the torso and LFs are transferring the tension (52).
6. into the boat through the gluteus muscles and legs (53).
7. this tension in the boat is pushing the boat into the water-wall, around the boat (54).
8. the friction of the water - wall is compressing, prying the whole system forwards through the water (55).

TWO POWER EXERTION (This section takes the place of a summary.)

Usually we think of power moving from the bending shaft through the arms-torso-legs-boat to the water wall. The bending shaft starts the compression through the athlete's body and ends by pushing into the water-wall (56).

In Reverse Order:

However force also flows in the opposite order: from the water-wall->boat-> legs-> torso-> arms and the bending shaft (57).

In Reverse direction:

The compressed water also exerts force back to the athlete's body causing the paddle shaft to bend (58).

Combined together the system: ? water ? kayak ? athlete's legs, arms, torso ? paddle will create a balance (equilibrium) between compressions and tension forces. This balance of forces often develops automatically in the most talented athletes. We can also teach it, at least up to a certain level. This equilibrium is easy to see when watching paddlers from the front. It brings to mind a stretched out frame structure like an umbrella (59). This structure is creating a "dome-like" formation, with the starting point being the blade in the water. The Power Circles are like a "spider web" stretched all around the athlete's body. Literally this web is the inner structure of the kayak technique.