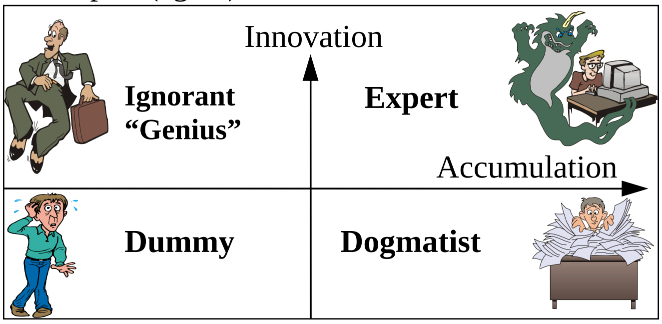
Q & A

? **Q.**: In RBN 6/2005 you discussed different types of coaches from a scientist's point of view. To be fair, it would be interesting to speculate about types of sport scientist from a coach's point of view.

✓ **A:** In the coach's quadrant we set the Y axis as ambition to use sport science. A scientist must have this ambition by default. Therefore, we will use another coordinate system: let the X axis represent ability to accumulate available knowledge in a specific area; the Y axis will be ability to develop new knowledge, i.e. research, invent, create something new. Let's conditionally call the four types of scientists Dummy, Dogmatist, Ignorant "Genius" and Expert (again):



Dummy is a person without good knowledge in the specific area and with no ability to learn or develop new things. This individual can be called a "scientist" by mistake only. However, it happens that a person with good manipulation skills or a loud commanding voice can find a position in science instead of placing himself in the administrative area. Life is not easy for this person. He/she is always anxious about his/her professional weakness. Usually this person picks up some fashionable ideas or technologies and uses them everywhere as a panacea, with or without a reason. Obviously, results are unpredictable and very often could be dangerous. Coaches should be very careful with this sort of person and can utilise them on minor tasks only, e.g. time-keeping, and equipment maintenance.

Dogmatist has read a lot of books and papers. He knows virtually everything not only in the specific area, but also many other things. It is very easy to understand what this person is talking about. He shares the opinions of many people, but he can hardly develop his own point of view. If established methods, testing protocols and analysis packs can be found, then Dogmatist can do a job successfully. However, in most cases it is necessary to define if a method would work or not, to adjust available knowledge to current conditions, which can be controversial. Here problems arise for Dogmatist. Quite often he loses the ability to make sense of known facts and ideas, or to put them together. It is extremely difficult for Dogmatist to invent something new. If he has to do research, he usually selects an objective, which is obvious without any investigation, e.g. stronger athletes produce higher power, etc. Coaches can use knowledge accumulated by Dogmatist, but they have to work out the application of concepts themselves.

Ignorant "Genius" is very good in "reinventing the wheel". Usually he has no specific education and does not care to learn what is already known. This person believes that only his ideas are important and everything done before by other people is "rubbish". Usually his ideas are very difficult to understand and people think that this person is "crazy". It is hard to talk to "Genius", he speaks in his own language and needs to be interpreted. This person is excellent in innovation, but results can be next to zero, because similar things were already invented. When such high ambitions are well grounded, and the person is really talented, then it makes sense to help and persuade him to learn. However, quite often the "Genius'" ideas are inadequate or wouldn't work in real conditions. Sceptical attitudes can make him aggressive and this can be a real problem for colleagues.

Expert is good in both accumulation and development of knowledge. He/she has learned everything that is available in the area, analysed it and found out where is a real "bottle neck" of the knowledge stream. At lower level, an Expert can find missing parts of the mosaic, do research projects and put them in place. At higher level, an Expert creates the "mosaic" structure himself, i.e. he/she creates a scientific theory, which explains and incorporates known facts. An Expert continuously develops his ideas and concepts, which can be difficult for coaches to follow. Something that is true today can be false tomorrow, which requires adjustment of training methods and technique.

Conclusion. Sport science has become very popular these days, but a coach needs to be aware what sort of scientist he/she works with. As it was with the coaches' types, the two opposites Dogmatist and "Genius" can make an efficient pair.

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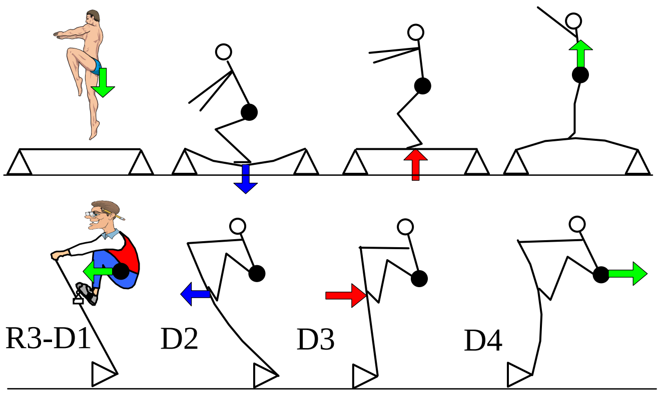
Ideas

✓ Recently we reached an interesting interpretation of our theory of rowing micro-phases (RBN 2004/1, 2 & 12). We call it the "**Trampoline effect**", which occurs at the catch and in the first half of the drive. The following logical steps will help us to understand the effectiveness of this theory:

1. To increase the boat speed, rowers have to expend more power to overcome higher drag resistance ($P = kV^3$).
2. The kinetic energy of the whole boat-rower system can be increased (accumulated) only during the drive phase. Increase of the shell velocity during the recovery is explained by transfer of the crew's kinetic energy (RBN 2004/7).
3. Because a crew's mass is higher than that of a boat, it accumulates 5-6 times more kinetic energy than the boat ($Ek = mV^2/2$). Therefore, the main target of an effective drive phase is to increase the velocity of a crew's centre of mass (CM).
4. The only force accelerating the rower's CM forward is the reaction force on the stretcher. The handle force pulls the rower backwards.
5. To apply a high stretcher force is not enough for a rower's acceleration. The stretcher must have a supporting connection to the water through the rigger and oar.
6. The stretcher (and the whole shell) has to move fast forwards at the moment of the leg drive.

In fact, rowing can be considered as a series of jumps. Each drive phase is a jump and recovery is a flight phase. The longer the jumps or higher their frequency, the higher the rowing speed. The major difference between rowing and real jumps is that rowers have to create support on the stretcher for themselves by placing the blade in the water and applying handle force. The picture below shows the analogy between rowing and real trampoline jumps. The "**Trampoline effect**" works as follows:



1. At the catch (end of R3 and D1 micro-phases), the rower approaches fast towards the stretcher and creates an impact push on the stretcher at the moment of the blade immersion.
2. This impact force is transferred though the rigger and pin to the oar sleeve and bends the oar (D2 micro-phase). The oar shaft accumulates elastic energy, which could amount to 25% of the total power at the catch (RBN 2001/05)
3. In the D3 micro-phase, the oar shaft springs back, i.e. the oar works as a trampoline. The recoil force goes back though the pin and rigger and creates a high positive boat acceleration called the "first peak".
4. Rowers use the accelerating stretcher as a support for effective acceleration of their CM during the D4 micro-phase.

The "**Trampoline effect**" theory can have a number of consequences. Here are some of them:

1. Fast approach to the stretcher before the catch is beneficial. This contradicts some theories, which propose a slower approach to the catch.
2. Good timing is really important. Each rower has to feel the moment when he/she: a) kicks "the trampoline" and bends it; b) applies the handle force to support "the trampoline" from the other side; c) picks up the recoil force and uses the legs to accelerate the body CM.
3. In crew boats, all rowers have one common trampoline because their stretchers are connected through the shell. Therefore, one rower can create the trampoline effect for other rowers in the crew. This happens quite often in pairs, where the stroke rower increases force much more quickly than the bow rower.
4. Optimal stiffness of the oar shaft is important and should correspond to the magnitude of the impact force. Oar shafts that are too soft or too stiff will decrease the trampoline effect.
5. Rowing on ergometers does not allow experiencing the trampoline effect.

What sort of drills can we use to improve the trampoline effect?

The best drill is to row using legs only with emphasis on fast explosive work through the stretcher. It is better to do this drill with the whole crew (not by seats), because the large passive mass of sitting rowers will significantly decrease the boat acceleration and trampoline effect.

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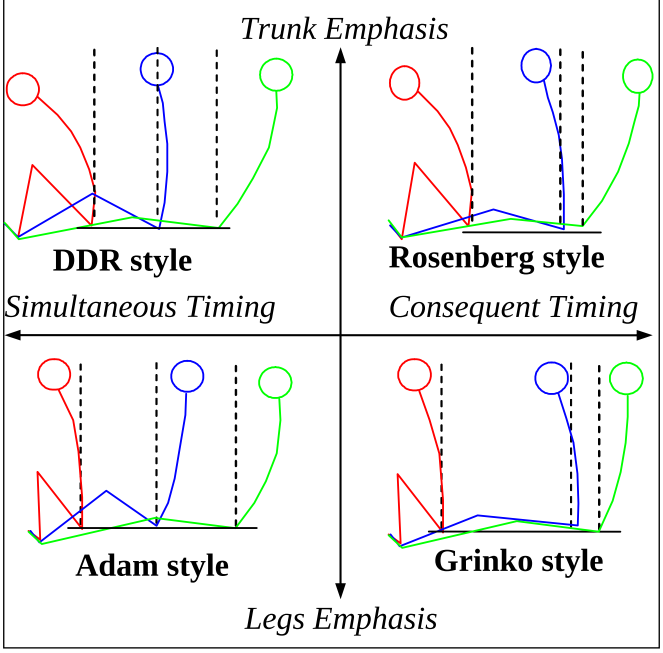
Ideas

✓ The most popular classification of rowing styles was introduced by Klavora in 1977 (1) and defined three rowing styles: the Adam style; the DDR style; the Rosenberg style:

- **Adam** - Comparatively long legs drive and limited amplitude of the trunk. Simultaneous activity of legs and trunk during the stroke;
- **DDR** - Large, forward declination of the trunk, which begins the drive, followed by simultaneous activity of the legs;
- **Rosenberg** - Large, forward declination of the trunk at the beginning of the stroke, then strong leg extension without significant trunk activation. At the end of the cycle the trunk stops in the deep backward position.

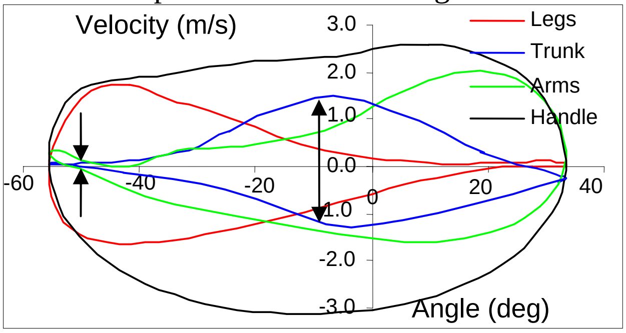
We defined two main factors, which distinguish these styles: timing (simultaneous or consequent activity of two biggest body segments) and emphasis during the drive (on legs or trunk). Then we put these factors as X and Y axes of a quadrant:



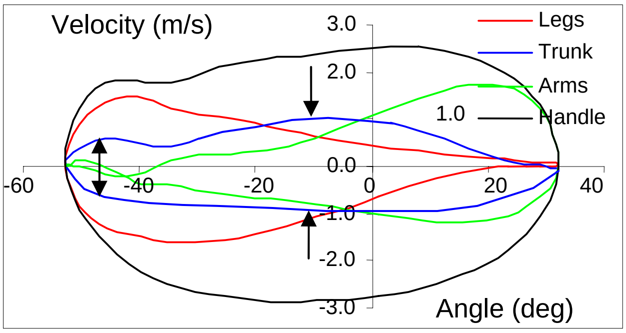
We found that the three styles perfectly fit three quarters. However, we found that the fourth rowing style must exist. This style has consequent timing and emphasis on the legs drive. We called it "**Grinko style**" after the name of talented Russian coach Igor Grinko, who practises this style. Igor coached many World champion scullers in USSR and USA. One of them is Silver Olympic medalist in M1x Jueri Jaanson (Appendix 1).

It is not very often we can see a pure example of these rowing styles. Most of the rowers have a style somewhere in between of these four extremities.

✓ We found that very often the sequence and velocities of the segments on recovery mirrors the sequence on the drive. If we plot the segments velocities relative oar angle, they will look like mirror images, where the negative part (recovery) resembles positive part (drive). Below are charts of two rowers plotted relative oar angle:



1



2

The first rower prepares his trunk earlier during recovery and approaches the catch with legs only. The trunks is ready for the drive (trunk speed is nearly zero). This rower has fast legs drive strait after the catch and increase trunk velocity in the second quarter of the drive. As we discussed in RBN 2001/07 this "consequent" rowing style produce higher relative maximal force and power.

The second rower spreads the trunks movement across the recovery and continues tilting the body until the last moment before the catch. As a result, this rower "opens the body" early during the drive and spreads its movement across the drive. This "simultaneous" rowing style produces lower maximal force and power, but the shape of force curve is more rectangular.

An interesting practical application of this principle could be the following: I you want to achieve certain sequence and velocities of the segments during the drive, you should practice the mirror sequence and velocities during recovery.

References

1. Klavora P. 1977. Three predominant styles: the Adam style; the DDR style; the Rosenberg style. Catch (Ottawa), 9, 13.

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Appendix 1 to the Rowing Biomechanics Newsletter 60(6), March 2005.

Drive phase of Jueri Jaanson during final race of 2004 Olympic Games in Athens.

News

Our Rowing Biomechanics Newsletter celebrates its 5 year anniversary! The first RBN had seen the world in April 2001. 60 issues were published since then. Originally, it was intended for a small audience of Australian coaches. However, the popularity of the Newsletter has grown amazingly. Now it has more than 200 subscribers from all over the World and a dedicated web site *www.biorow.com*. It is regularly translated into Russian and some issues were translated into German and French.

I want to thank specially the great swimming coach Gennady Touretsky, who inspired me for this project.

Thanks to everybody who contributed to the success of the Newsletter. Your feedback, comments and questions are very important stimulus for further development of rowing Biomechanics.

Q&A

✓ We received positive feedback from Igor Grinko in regards of rowing styles classification published in previous Newsletter. Now Igor is working in China and doing his best to get the Chinese rowers ready for their first home Olympics in Beijing-2008. He said: “Actually you are right about my style of rowing. I remember when my guys won the first gold medals in 4x in 1986-87, the coaches’ comments were: "I don't understand how they could win with this technique". However, a few years later coaches understood this style better and tried to copy it. Also, Viacheslav Ivanov (three times Olympic champion in single scull) told me in 1987, that he likes the style I was teaching. He said that it is very close to what he thinks about good rowing technique”

? **Q:** Cas Rekers, inventor of the RowPerfect rowing machine has asked us a question about the second section of the previous Newsletter: “In normal rowing, the time for the recovery is longer than the time for the stroke. … I timed a video tape of the Dutch eight in Atlanta Olympic Games; they had a drive time of around 0.6s, at a stroke rate of 38 str/min, resulting in a ratio of around 1.6 between drive time and recovery time. … In both your graphs however the handle speed during the recovery is higher at any moment of the cycle. In my opinion they should in both cases be roughly a factor 1.5 lower. Could you please explain?”

✓ **A:** We already published some analysis of the rhythm and drive/recovery times in RBN 2003/03, which you can find on our Web site. The analysis was based on an extensive data base (more than 7000 samples) of measurements done using the telemetry system, which is more accurate than video. We measure drive from the moment when the oar changes direction at the catch till the similar moment at the finish. You can see that the average drive time in 8+ is about 0.85s at a stroke rate of 36 and about 0.75s at 44 str/min.

If one measure drive using placement of the blade into the water, then the drive time will be shorter and the rhythm percentage lower. It is quite likely that this can be the case in Cas’s measurements using video. In the examples given in the previous Newsletter for two rowers in pairs, the stroke rates were 36.2 and 36.4 respectively, drive times 0.90 and 0.94 and rhythm values 54.3% and 57.1%, i.e the recovery time was 1.19 and 1.33 shorter than the drive time. Therefore, the handle speed must be on average 1/3 faster during recovery, than during the drive.

Facts. Did you know that…

…high handle speed during recovery is linked with another interesting issue: aerodynamical resistance of the blade. The blade velocity is higher than the handle velocity by an inboard/outboard ratio. E.g., the maximal handle velocity 2.92m/s in 8+ at 40str/min (RBN 2002/07) would give us 6.88m/s velocity of the centre of the blade. Boat velocity also contributes 7.03m/s to it (during the recovery it is higher than the average boat speed, RBN 2004/07). This gives us nearly 15m/s or 54km/h blade speed relative to the air, which is more than a race speed of a good cyclist. At this speed the air drag of the blade is very significant. It contributes about 3% of total drag at calm conditions and more than 10% at the head wind of 5m/s.

If a crew squares the blade early during recovery, this increases drag resistance dramatically. Engineers from Southampton University made calculations, which show us that every 10deg of early squaring blade before catch would add about 1.5s to the 2k race time and 3s at head wind 5m/s. Quite often we can see that some crews square the blade virtually at the middle of the recovery and lose about 5s and much more at head wind.

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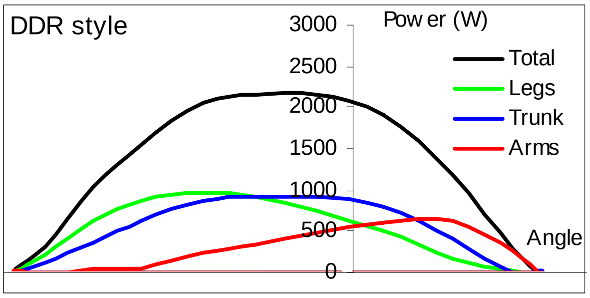
Q&A

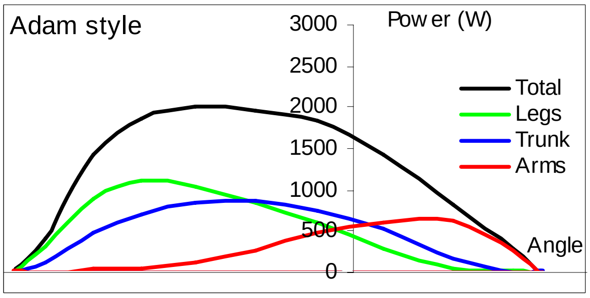
? Alex Field, 23, civil engineering student at Sydney University asks: “Regarding maximum and average handle forces you have listed in RBN 12/2001, what is "Average"? Is it an average force in a 2k race, a training session, or something different? Can you relate this force to a clean in weightlifting, i.e. how close is a 40kg clean to 392N of average force in the boat? Would doing 250 40kg cleans in 7 minutes be similar in any way to a rowing race?”

✉ The average force is calculated during the drive phase of the stroke cycle as an impulse divided by drive time. Impulse based on typical (average) pattern of the force curve over the sampling period (usually 500m). Yes, average force can be related to weight training. If the start and end velocities of the weight are zero, then the average force applied to it will be equal to its gravity force ($F_{average}$= m g). The amount of work done will be similar the work per stroke, if the height of the clean is equal to the travel of the middle of the oar handle (on average 85±4% of the body height).

Ideas. What if…

✓ … we use simple modelling to try to find the effect of rowing styles on force/power curves. We have modelled total power (product of force and velocity) as a sum of segment powers. Its relative magnitude and timing characterise four rowing styles described in RBN 3/2006:



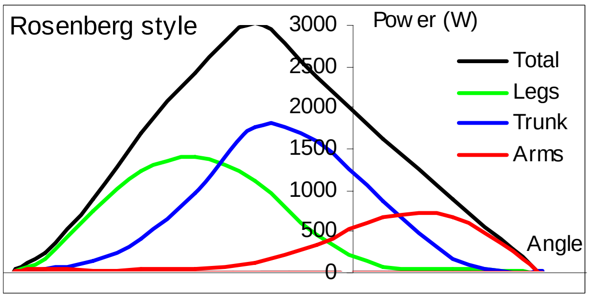


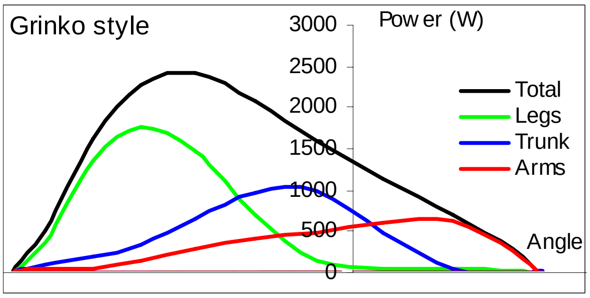
Simultaneous work of the legs and trunk (both German rowing styles) produces a more rectangular shape of the power curve, but the peak power is lower. More even pressure on the blade improves its propulsive efficiency. However, slower and more static movement of the legs and trunk does not allow the delivery of the optimal power.

Sequential work of the legs and trunk (Rosenberg and Grinko rowing styles) produce a triangular shape of the power curves and higher peak power values. This leads to higher slippage of the blade through the water that causes energy losses. However, lower blade propulsive efficiency can be more than compensated by higher values of force and power produced per kg of body weight. Active usage of the trunk produces even more power, so the Rosenberg style can be considered as the most powerful rowing style.

Emphasis on the legs or trunk affects the position of the force and power peaks. Styles with leg emphasis (Adam and Grinko styles) allow a quicker increase of the force and earlier peak of the force curve. This improves the initial boat acceleration micro-phase D3 (RBN 1-2/2004) and makes the drive timing more effective.

Styles with trunk emphasis (Rosenberg and DDR styles) produce more power owing to better utilisation of big muscles (gluteus and longissimus muscles). However, these muscles are slow by nature as they are intended to maintain body posture in humans. This fact does not allow a quick increase of the force and power when using trunk muscles. A shift of the peak of the power curve closer to the middle of the drive makes the temporal structure of the drive less effective.





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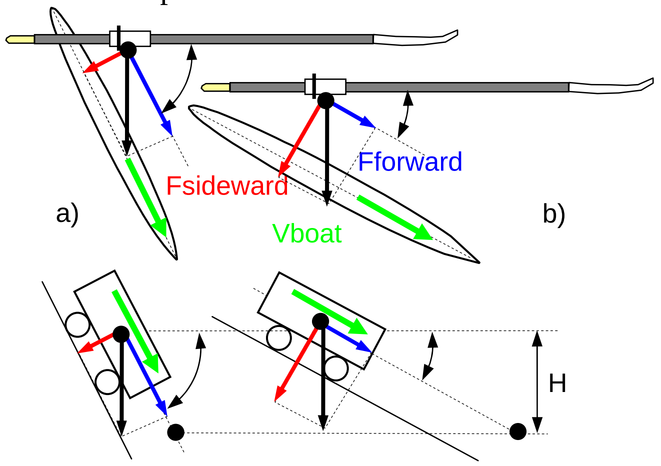
Q&A

? We receive a lot of comments and questions like these: "Applying high force at the catch is not efficient, because it pushes the pin inwards, which is a waste of power. Why do you tell us that the front loaded force curve is more efficient?"

✓ We would split the answer in two parts:

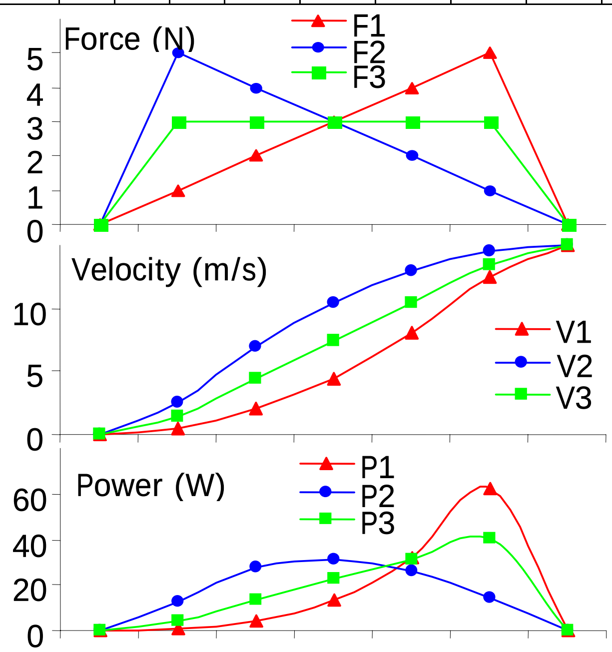
1) Why is a long catch not a waste of energy? A concept of inefficient long angles at the catch was quite popular in the 1960s-70s, but we can still hear it in some articles and comments. The picture below illustrates the pin forces at different oar angles in analogy with similar forces acting on a cart on slopes with different inclination:



In both cases the resultant force acts at the angle to the velocity vector and can be decomposed into perpendicular and parallel components. Power is the scalar product of the velocity and the force component parallel to it. Scalar product of two perpendicular vectors is equal to zero, so **sideward force does not produce any power and can not cause energy waste itself**. Analogy with the cart shows us that at any angle the resultant force produces the same amount of work proportional to the height H of the centre of mass displacement. Finally, at any slope angle the cart will achieve the same velocity, if no friction acts on it. The only difference is acceleration and time. At shorter oar angle and steeper slope (a) Fforward is higher, which produce higher acceleration. At longer oar angle and flat slope (b) the acceleration is lower and it takes longer time to achieve the final speed. It works like a gear in your car: you can achieve faster acceleration on a low gear at the same engine torque. A high gear requires less RPM from your engine at a higher speed of the car. Concluding, **longer catch angle makes the oar gearing heavier**, but does not create energy waste.

2) Why is a front loaded drive more efficient?. Let us use a very simple model for analysis of the force curve. Imagine three force curves: F1 (back-loaded) increases from 0 to 5N with simple arithmetical progression, F2 (front-loaded) jumps to 5N and then decreases, F3 is constant at average 3N. Imagine that each of these three forces act on a body mass 1kg. We can derive the body's acceleration, velocity and applied power:

	Force (N)			Velocity (m/s)			Power (W)		
T(s)	F1	F2	F3	V1	V2	V3	P1	P2	P3
0	0	0	0	0	0	0	0	0	0
1	1	5	3	0.5	2.5	1.5	0.5	12.5	4.5
2	2	4	3	2.0	7.0	4.5	4.0	28.0	13.5
3	3	3	3	4.5	10.5	7.5	13.5	31.5	22.5
4	4	2	3	8.0	13.0	10.5	32.0	26.0	31.5
5	5	1	3	12.5	14.5	13.5	62.5	14.5	40.5
6	0	0	0	15.0	15.0	15.0	0	0	0
Sum	15	15	15				113	113	113



In all cases we have the same total amount of force, power and the same final speed of the body. However, front-loaded curve F2 creates the most even power distribution. The back-loaded F1 requires two times higher peak power. In rowing this late power peak would overload trunk and arms, which are weaker body segments than legs.

Therefore, **one of the advantages of the front-loaded drive in rowing is more even power distribution**, when the handle accelerates. On ergometers this advantage is much less because of more even handle velocity (RBN 2005/3). Athletes with late force peak are more likely to achieve success on machine than in a boat.

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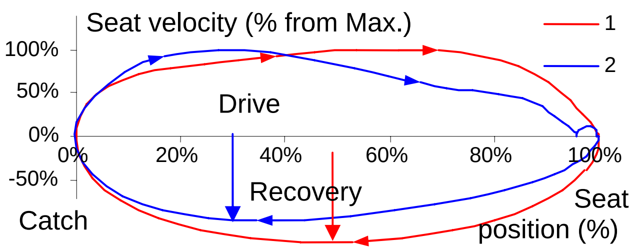
Q&A

? We receive many questions from coaches about legs movement during recovery. Here are some of them: Coach Dmitry Streltsov from Saratov, Russia asked: “What leg movement during recovery is better: accelerating, decelerating or with even speed?” Coach Bob Becht from West Side Rowing Club, Buffalo, USA asked: “At what part of the recovery (cm/in before full compression) do you start to accelerate into the foot stretcher to create the momentum for the trampoline effect”?

✓ First of all, there is no such a thing as pure accelerating, decelerating or even speed of the seat movement during recovery. Both the rower and boat-oars components of the system have a certain mass. Their relative velocity can not be changed instantly from zero at release to a certain speed and then stopped suddenly to zero again at catch. They have to accelerate, maintain an even speed (if it is provided) and then decelerate.

We would rephrase both questions in the following biomechanically correct way: “**At what point of recovery should the highest seat velocity be achieved to provide the most efficient catch and drive?**”

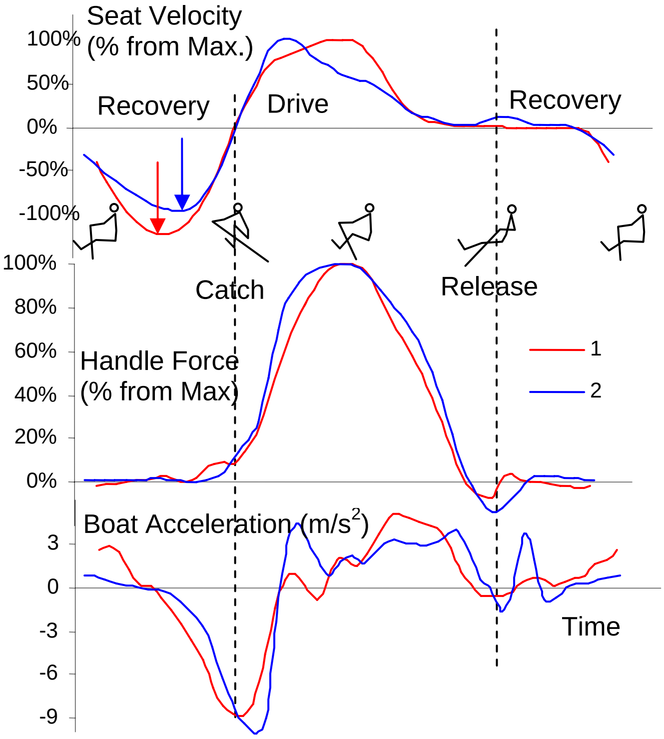
As example, we selected from our database two samples of single scullers at stroke rate 32str/min: the first rower achieved the peak seat velocity at the middle of recovery, and the second one had it at about 25% of total seat travel before catch. Their seat velocities plotted against seat position are shown below:



The second graph below represents the data of the sullers plotted against time. The second rower starts pushing the stretcher later before the catch, which creates deeper, but narrower gap of the boat acceleration. This sharp negative force/acceleration pushes the oar sleeve backward through the rigger and pin, which has a double effect:

- Firstly, it helps oar change direction quicker from recovery to drive. In this case, the oar works as II type lever with the pivot point at the handle. This is about 40% more efficient for the blade velocity, than pulling the handle with the same speed with the pivot point at the pin.
- Secondly, when the blade is inserted into the water, it creates an impact at the pin, quickly increases the forces, bends the oar and creates the “trampolining effect” described in RBN N59/2006.

The second sculler achieves maximal seat velocity earlier during the drive, increases the force faster and accelerates the boat quicker.



Statistical analysis has show that on average the position of the peak leg velocity (PPLV) during recovery increases with the stroke rate (r=0.56, n=4626) from 33% at 20 up to 48% at 40str/min, i.e. usually at higher rate rowers start pushing the stretcher earlier. On the contrary, PPLV during the drive gets slightly closer to the catch (r=-0.28): from 45% down to 37%, correspondingly. For this reason there is no correlation between these two variables. To eliminate influence of the stroke rate, we took residuals from the trend lines and found a moderate correlation (r=0.38). This confirms our hypothesis mentioned in RBN N60/2006 about the tendency of mirror matching of the drive-recovery velocity patterns. Also, we have found a moderate correlation of PPLVrecovery residuals with the time to increase force up to 70% (r=0.34) and duration of initial boat acceleration micro-phase D3 (r=0.31).

Concluding, **the later peak of the seat velocity during recovery can help to achieve a quicker catch and more dynamic drive**.

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News

The Rowing World Championship has just finished at Dorney Lake rowing course in Eton, UK. Congratulations to all winners and medallists!

Rowers from 20 countries got medals. The most successful nations in Olympic boat classes were: Germany (6 medals, 1 gold), Australia (5, 2), New Zealand (4, 1), Great Britain (3, 1).

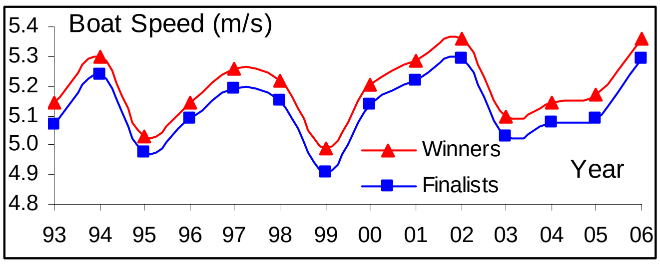
A more comprehensive analysis of the countries standings can be achieved using a system, which counts points down to 7th place. The Table below shows 12 best nations using this system:

	Place	1	2	3	4	5	6	7	
	Points	*8*	*6*	*5*	*4*	*3*	*2*	*1*	*Sum*
1	GER	1	4	1	1	1	1	3	49
2	AUS	2	1	2	2	0	1	0	42
3	GBR	1	1	1	1	3	2	0	36
4	CHN	2	0	0	2	1	0	0	27
5	NZL	1	2	1	0	0	0	1	26
6	USA	1	0	1	2	1	1	0	26
7	FRA	1	1	1	1	0	1	0	25
8	CAN	1	0	1	2	1	0	0	24
9	POL	1	0	0	1	1	1	0	17
10	ITA	0	2	0	1	0	0	0	16
11	CZE	0	1	1	0	1	0	1	15
12	RUS	1	0	0	0	0	2	1	13

The most impressive progress was shown by the Chinese team, which has won two gold medals in Olympic boat classes and is obviously going to move further in Beijing-2008 Olympics.

Facts. Did you know that…

✓ …it was the second fastest Worlds in the history. Strong tail wind helped to achieve very fast boat speed in spite of moderate temperature of the air and water (18-20^{o} C) and quite rough water at the end of the course. The graph below shows dynamics of the average boat speed in 14 Olympic boat types in the winners and finalists.



During the last Worlds the average boat speed of the winners in Olympic boats was 5.337m/s, which is just a little bit slower than during the fastest Championship in Seville-2002 (5.340m/s).

Four World Best Times were set in Eton altogether; two of them in Olympic boat types.

In men's singles Mahe Drysdale from New Zealand has shown 6:35.40 and beatten by 0.91s the previous best time shown in 2002 by Marcel Hacker from Germany, who came second in this final. It was a very dramatic race. Marcel was leading during for most of the race, but was overtaken at the last 100m. He was so exhausted that fainted after the race and couldn't attend the medal presentation.

W8+ of USA made 5:55.50 and improved by 1.05s the record of the same country shown in Athens-2004.

Australian W4- made 6:25.35 and very narrowly (by 0.12s) improved the 15-years old record.

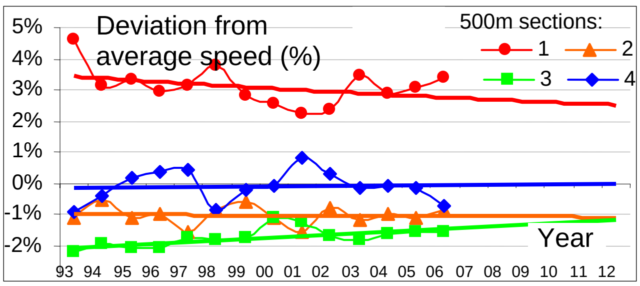
British LM1x Zac Purchase showed 6:47.82 and beat by 0.15s the previous 7-years old record.

✓ …prognostic Gold Times for 2008 were corrected in some boat types since we published them in RBN 2005/5? The Table below shows **average growth of the boat speed per year** based on 1993-2006 results and **prognostic Gold Times for 2008**:

W1x	M1x	W2-	M2-	W2x	M2x	M4-
0.70%	0.56%	0.90%	0.33%	-0.13%	0.86%	1.18%
7:11.7	6:35.2	6:52.8	6:16.5	6:45.3	6:04.4	5:41.4
LW2x	**LM2x**	**LM4-**	**W4x**	**M4x**	**W8+**	**M8+**
0.44%	2.00%	1.09%	0.85%	1.09%	2.67%	1.23%
6:51.9	6:04.9	5:46.6	6:09.8	5:35.8	5:52.7	5:21.5

The highest growth was found in W8+, LM2x and M8+. The only negative trend was found in W2x and the next lowest growth was in M2- and LW2x. It is interesting that if the current trends persist, then in 2008 the speeds in M2x and LM2x will be nearly equal.

✓ …average pattern of the race strategy of the winners has marginally deviated from the previous years trend. The winners were faster at the start section (+3.36% compare to +3.05% in 2005) and slower at the finish (-0.73% compare to -0.14% in 2005):



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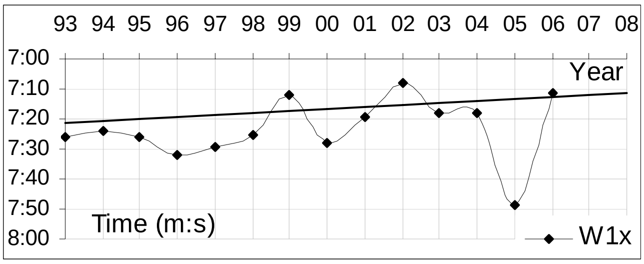
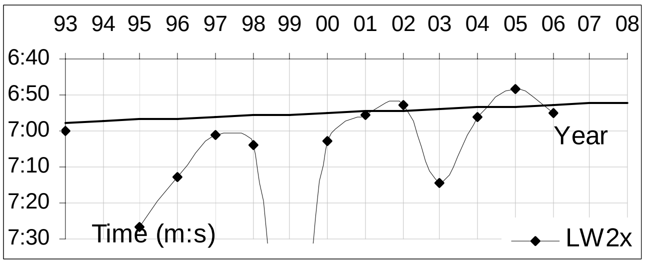
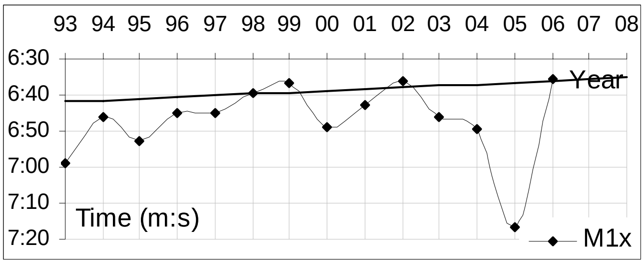
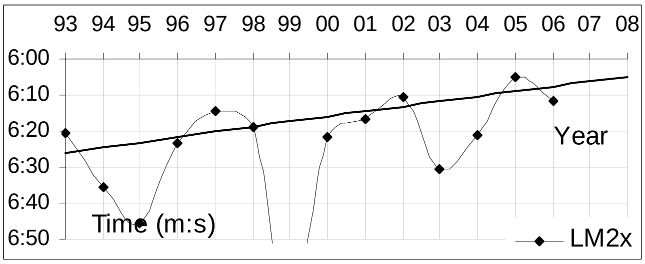
Appendix 1 to the Rowing Biomechanics Newsletter N65, August 2006.

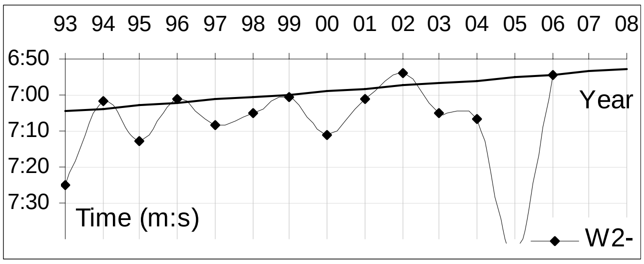
Trends of results of the winners of Worlds Championships and Olympic Games during 1993-2006

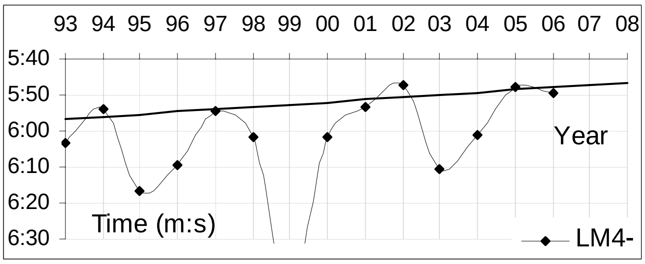


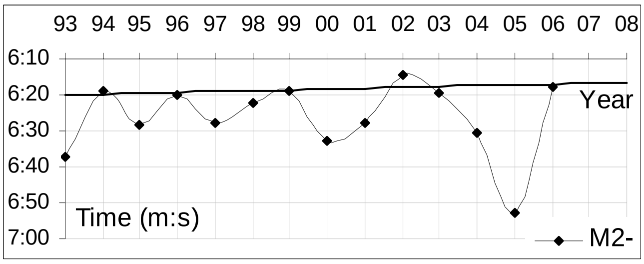


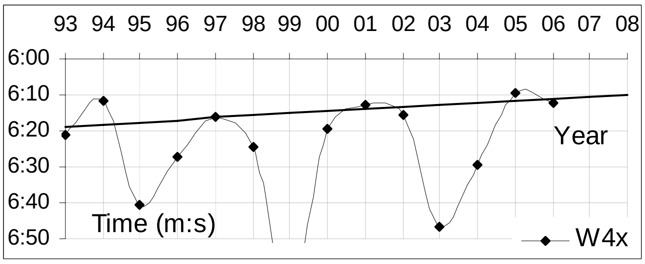


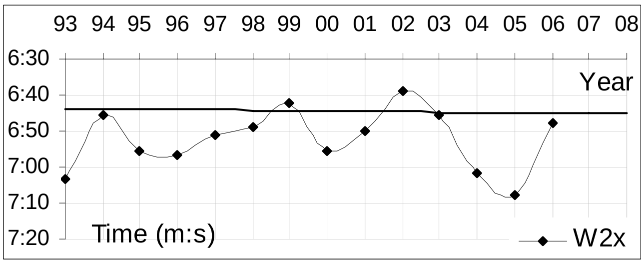


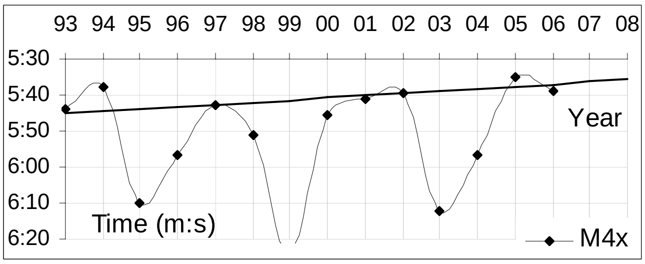


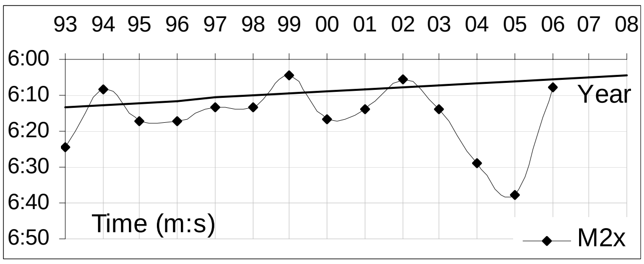


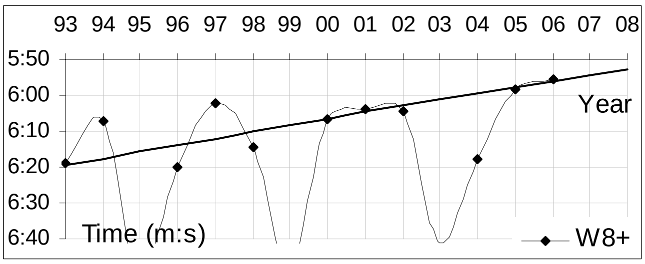


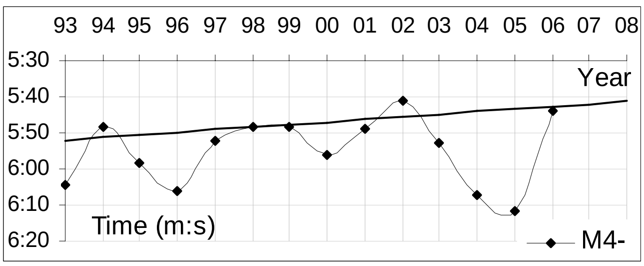


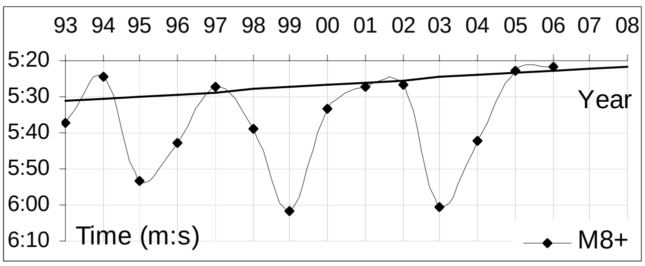












Q&A

? **Q:** We received quite positive feedback on the method and spreadsheets for the boat speed at different stroke rates (RBN 2005/10). However, some coaches found that the spreadsheet is too complicated to use. Also, it was based on the results of a step-test, which are not always available.

✓ **A:** We have developed a new spreadsheet, which is also based on the concept of constant effective work per stroke, but is much simpler and does not require any measured data. You only need to input the race distance (e.g. 2000m), your target result (6:40.0), racing rate (36 str/min) and training lap (500m). That's all! You can print out training speeds at different stroke rates, which will lead you to the required result.

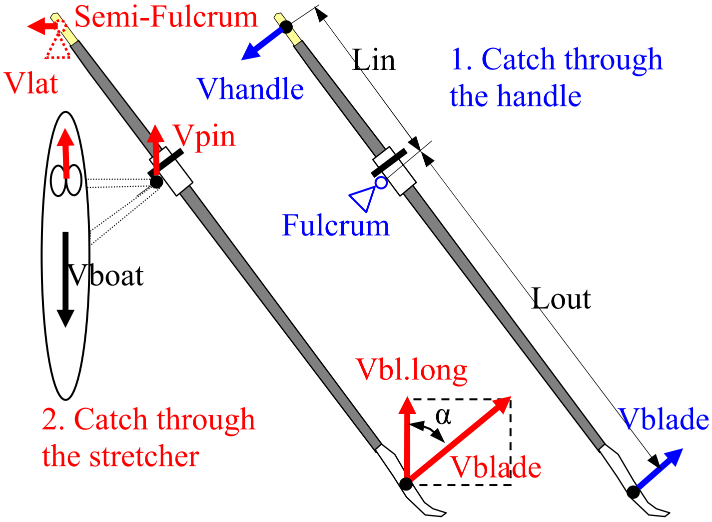
To get the most out of it correctly, we'll give you some recommendations and hints:

- First of all, **the calculated times are valid only in similar weather conditions and for the same boat type**.
- The sheet "Model 1" is the simplest. You only enter the data described above in grey-shaded cells and see results.
- "Model 2" adds the water temperature correction. The target speed is always at 25^o C., but if you train at a lower water temperature (e.g. 10^o C), then your speed will be slower (1.08%).
- "Model 3" adds correction for power training and for shorter pieces. If you want to apply higher Work per Stroke in a shorter piece, then you can enter a value in the "eWPS extra (%)" cell and watch the results.
- The sheet "Model 4" combines both water temperature and extra eWPS corrections.

Try it, use it and send us your feedback.

? **Q:** We receive a number of questions like this: "What should the rower concentrate on at catch? Why it is more efficient to push the stretcher at the catch than to pull the handle?"

✓ **A:** At the catch the blade must change its direction of movement and accelerate very quickly from negative velocity during recovery to positive velocity, which overcomes the boat speed. This can be done in two ways: 1) By means of pulling the handle and leaving the pin as a fulcrum; 2) By means on pushing the stretcher and holding the handle as a fulcrum. The power goes through the boat – rigger – pin - swivel, pushes the oar sleeve and accelerates the blade. Obviously, the handle doesn't work as a real stationary point, but it can be considered as a "semi-fulcrum", which is stationary in longitudinal direction and moves in lateral direction.



In the first case the blade velocity is equal to:

$$Vblade = Vhandle\ (Lout\ /\ Lin)$$

In the second case longitudinal speed is:

$$Vbl.long = Vpin\ ((Lout + Lin)\ /\ Lin)$$

and the normal blade velocity is:

$$Vblade = Vbl.long\ /\ \cos\alpha$$

Using these equations and common gearing (oar length 2.90m and inboard 0.88m) we can calculate that the first catch method would give us 2.19m/s blade velocity for 1m/s handle velocity. The second method would give us 3.19m/s longitudinal blade velocity ***Vbl.long*** for 1m/s pin velocity (46% higher ratio). The normal blade velocity ***Vblade*** at 60^o catch angle is 6.38m/s (nearly 3 times higher ratio), but it must be complemented by 1.73m/s lateral handle velocity ***Vlat***.

Obviously, the difference in the ratio of handle and blade velocities is not the only advantage of the "Catch through the stretcher" technique. It also benefits by use of the most powerful muscles (ie the legs) (RBN 2006/5), the trampolining effect (RBN 2006/2) and effective acceleration of the rower's centre of mass (RBN 2004/1-2).

In conclusion: What a rower **shouldn't do** at the catch: 1) Pull the handle toward the bow of the boat; 2) Be scared to push the stretcher or "disturb the boat run".

What a rower **should** do at the catch: 1) Concentrate on a fast kick on the stretcher and create a sharp peak of negative boat acceleration; 2) Hold the handle in the longitudinal direction and allow its movement in the lateral direction.

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News

Many thanks to Olivier Schwebel for French translation of the Newsletter, which can be found on our web site.

Q&A

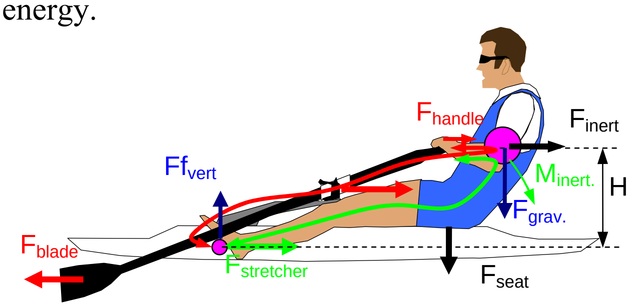
? We received a number of positive replays on the speed/rate spreadsheets published in previous Newsletter. Wayne Maher, Support Services Manager of Rowing New Zealand has asked us to include the stream speed, wind speed and direction in the model.

✓ A: We have developed a new sheet based on the wind effect data of Klaus Filter (2000) and provided it in the attachment and on our web site.

? **Q:** Rowers and coaches ask questions like this: "What is the best way to execute the finish: by means of pulling the handle or pulling the stretcher?"

✓ **A:** During the final stage of the drive the rower's body must be quickly decelerated and then accelerated towards the stern of the boat. In other words, the kinetic energy of the rower's mass, accumulated during the drive, must be transferred to the boat mass. It can be done in two ways: 1) Finish by means of pulling the Stretcher (FS); 2) Finish by means of pulling the Handle (FH).

Some coaches still believe that the first method is more efficient, because it require less effort, when the force is transferred through straight legs. They argue that in the second case the inertia force goes through bent arms that require some muscle energy.



We can put forward the following arguments in favour of the Finish by pulling the Handle:

1. FH creates additional force on the blade, which is the only external force moving forward the whole rower-boat system. FS works as a simple transfer of kinetic energy from rower to the boat and does not create any blade force.
2. FH does not push the boat down. At the finish, the legs are practically stationary relative to the boat. The upper body rotates around the hips, so its higher parts have a greater velocity. The radius of inertia (imaginary point where resultant inertia force is applied) is located somewhere about 2/3 of trunk height, i.e. the centre of a moving rower's mass is very close to the level of the handle. Therefore, FH acts linearly and does not create any moment. In comparison, the stretcher force acts at a significant distance H from the centre of trunk inertia. This creates a moment of force $M_{str.} = F_{inert} \cdot H$, which add extra 30-40% of the body weight to the vertical seat force (RBN 2002/05). The extra vertical force pushes the boat down and increases its water displacement and drag resistance force. Another contributor to the seat force is the moment of the weight of the trunk. At FS this force is balanced by an upward vertical force on the stretcher and this pair of forces increases the pitching movement of the boat and wave resistance of the shell. The weight of the trunk also can be balanced by pulling the handle.
3. FH works more efficiently using oar leverage. At FS the forces applied to the rower and boat CM are equal:

$$F = m_{boat}\ a_{boat} = m_{rower}\ a_{rower}$$

At FH the force acting on the boat is

$$F = m_{boat}\ a_{boat} = m_{rower}\ a_{rower\ (Loar/Loutboard)} \cos\alpha$$

This creates 25-15% higher boat acceleration at the oar angles α in a range 30-40 deg.

4. FH allows earlier relaxation of the leg muscles and a longer recovery. The quadriceps of thigh is a two-joint muscle, which is connected to the shin and pelvis and goes across the knee and hip joints. At FS this muscle must be used in static mode to prevent the knee from bending and pulling the trunk.
5. FH has less risk of injury of the hip and stomach muscles and tendons, which can be overloaded at fast FS at high stroke rate.

Concluding, **a finish by pulling the handle is the only effective rowing technique**. The only benefit of a finish by use of the stretcher is a nicer looking "six pack" stomach muscles, but this can be achieved in a safer and efficient way in a gym.

The drill for developing the finish using the handle is very simple: just take the feet out of stretcher shoes and try to row normally. Try it at different stroke rate, but do not compromise the stretcher push. This means the rower should push the stretcher as long as possible during the drive and then perform quick counter-movements of the arms and trunk providing impulse for recovery.

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Facts. Did you know that…

…a rigging survey was conducted as a FISA project during the last World Championship in Eton? Here we will give some analysis of the oar/scull gearing. The table below shows the average, minimum and maximum values of the inboard and oar length, measured in 620 oars and sculls in the 14 Olympic boat classes:

		Inboard (cm)			Oar Length (cm)		
Boat	N	Aver.	Min	Max	Aver.	Min	Max
M1X	17	88.9	87.5	91.0	289.5	287.5	293.2
LM2X	46	88.2	87.2	89.0	288.3	284.0	290.0
M2X	42	88.3	87.4	90.0	289.8	288.0	291.0
M4X	60	88.0	86.8	90.0	290.8	287.7	293.0
W1X	15	88.2	86.8	89.0	288.0	285.5	290.0
LW2X	32	88.2	86.5	90.5	291.5	280.8	368.0
W2X	24	88.3	87.5	89.0	288.1	286.0	290.0
W4X	28	87.5	86.0	88.3	288.6	287.0	291.0
M2-	26	116.3	116.0	117.5	376.4	374.0	379.0
LM4-	64	115.2	114.0	116.0	374.3	368.0	377.0
M4-	64	115.1	114.0	116.5	375.3	370.0	377.5
M8+	104	113.8	113.0	115.0	376.1	375.0	377.5
W2-	18	116.4	116.0	117.0	373.1	371.0	374.5
W8+	80	114.6	113.5	116.0	373.7	371.5	375.5

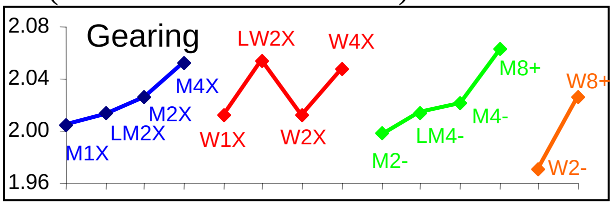
We derive the actual gearing ratio using inboard ***Inb*** and outboard ***Out*** in the equation:

G = (Out.-SL/2- SW/2) / (Inb.-Hnd/2+SW/2)

where ***Hnd*** is the handle width (12cm in sculls and 30cm in sweep oars), ***SW*** is the swivel width (ie thickness, 4cm) and ***SL*** is the spoon length (measured for each oar). If we divide average speed of the boat by the gearing, then the value will reflect the average speed of the handle during the drive. In fact, the actual average speed is different because of two factors: circular motion of the handle (increases the estimate by 10-20% depending on the oar angles) and slippage of the blade in the water (decreases the estimate by 15-18% depending on the boat type and external resistance). These two factors more or less compensate for each other, so the actual average speed of the handle must be quite close to the values below:

	Gearing (Outboard /Inboard)			"Average Handle Speed" (m/s)		
Boat	Aver.	Min	Max	Aver.	Min	Max
M1X	2.004	1.970	2.068	2.39	2.20	2.53
LM2X	2.014	1.967	2.040	2.52	2.27	2.68
M2X	2.027	1.967	2.079	2.59	2.33	2.73
M4X	2.052	2.001	2.086	2.76	2.59	2.95
W1X	2.012	1.971	2.038	2.16	1.94	2.28
LW2X	2.053	1.944	2.833	2.23	1.99	2.41
W2X	2.013	1.969	2.048	2.38	2.24	2.46
W4X	2.048	2.021	2.082	2.58	2.51	2.65
M2-	1.998	1.981	2.016	2.54	2.20	2.62
LM4-	2.013	1.937	2.057	2.66	2.46	2.82
M4-	2.022	1.987	2.064	2.78	2.56	2.89
M8+	2.063	2.026	2.095	2.84	2.70	2.98
W2-	1.970	1.952	1.991	2.39	2.34	2.46
W8+	2.027	1.983	2.056	2.67	2.63	2.74

We notice that in all categories the gearing increases in bigger boats, except women's sculling. There was abnormally heavy gearing in the LW2x (two outliers: the doubles of IRL with 86.5/286 and NED with 87.5/288) and a lighter gearing in W2x (outlier: ITA with 88.7/286):

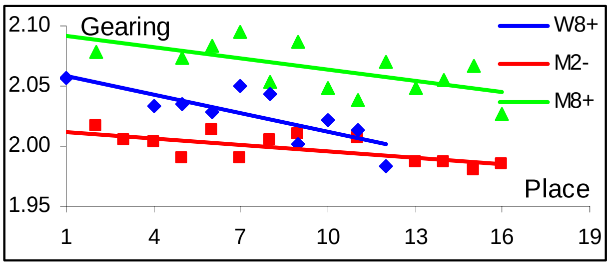


The difference in gearing between faster and slower boats does not compensate for the difference in boat speed: on average, M4x had 13.4% faster handle speed than M1x**;** W4x had 16.1% faster handle speed than W1x, and both M8+ and W8+ had 10.6% faster handle speed than M2- and W2-**,** respectively. These differences are less than differences in the stroke rate (RBN 2003/01), which were 10.2%, 9.7%, 4.6% and 5.6%, correspondingly. This means that rowers in big boats either use longer oar angles or have a relatively shorter ratio of the drive time.

The table below represents the correlation between gearing and the final place of the crew:

M1x	LM2x	M2x	M4x	W1x	LW2x	W2x
-0.05	-0.26	0.14	0.04	-0.29	-0.31	0.14
W4x	M2-	LM4-	M4-	M8+	W2-	W8+
-0.11	-0.68	-0.27	-0.32	-0.64	-0.29	-0.77

There was quite a high negative correlation in M2-, M8+ and W8+ means that the better performers usually had heavier gearing. M2x and W2x were the only classes with a small opposite correlation.



Some countries had heavier gearings relative to the average for the boat class (IRL +1.08%, RSA and CAN +0.71%) and others had lighter gearings (SVK -1.05%, UKR -0.97%, ITA 0.60%).

In 14 Olympic events**,** 65.0% of all oars/sculls (64.0% of the crews) were made by Concept-II, 29.0% (28.1%) by Croker, 5.3% (6.9%) by Empacher and 0.6% (1.0%) by other manufacturers. 53.4% of all oars/sculls were smoothie, 33.6% - standard big blade with a rib, 8.2% - "slick". 16.0% of all oars/sculls had the Vortex strip.

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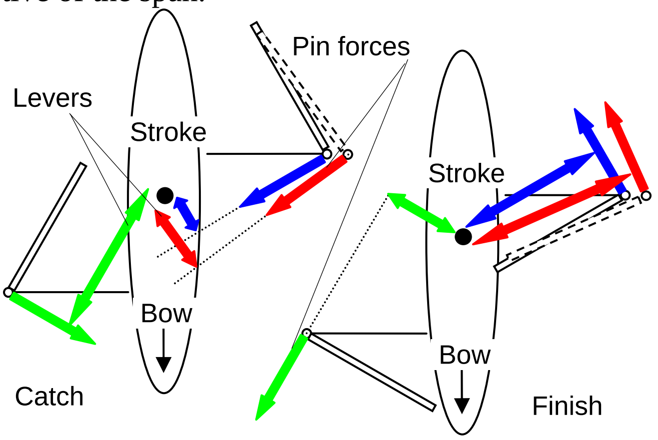
Q&A

? **Q:** When talking about gearing, coaches very often relate it to span or spread. .During the latest FISA rigging survey the gearing was officially defined as a ratio of the span/half-spread to the outboard. The common opinion is that the wider span/spread is "lighter" and the narrower is "heavier". We even heard an opinion that change of one centimeter of the span/spread is equal to the change of three centimeters inboard, but no evidence found for this opinion. On the contrary, from the theoretical point, the ratio of the handle/blade forces/velocities depends on the oar inboard/outboard ratio only and should not depend on lateral position of the centre of oar rotation. Here we try to investigate this controversy.

✓ **A:** The most obvious influence of the lateral position of the pin can be seen in sweep rowing, where the span works as a lever of the rotational moment of the pin force (RBN 2002/04). In a pair the rower with wider span will produce more torque relative to the centre of the boat at the same force, or the same torque at less force, which looks like lighter gearing. However, it is not a real gearing, because if we determine ratio of the handle/blade forces/velocities, it is the same irrespective of the span.

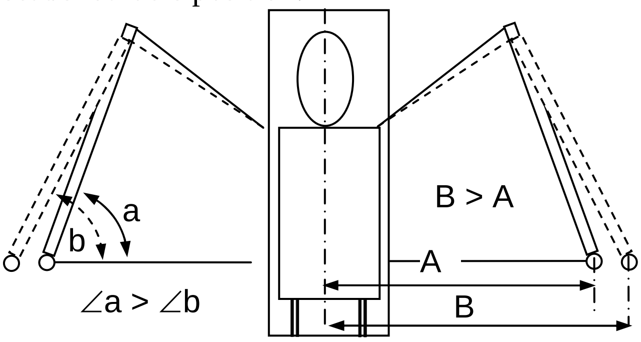


Half of the pairs measured during the latest FISA rigging survey had different span. Usually stroke had 0.5-1cm wider span (with one opposite exception in GER M2-), which would help him to overcome the difference in torque of the pin forces at catch. The picture illustrates the mechanics of the leverage in a pair, which is equal to the distance from the line of pin force to the boat center of mass. On the contrary, at the finish the stroke rower in pair has longer lever of the pin force and His wider span increases the boat rotation.

The table shows average, minimal and maximal values of the spread and span, measured in FISA rigging survey during Worlds-2006 in Eton. The bigger/faster boats had narrower span/spread:

	Span/Spread (cm)			Overlap (cm)		
Boat	Aver.	Min	Max	Aver.	Min	Max
M1X	159.92	158.8	161.1	21.91	19.3	26.8
LM2X	158.96	156.9	160.3	21.46	18.8	23.7
M2X	159.22	157.0	161.2	21.46	18.8	25.0
M4X	158.75	157.2	160.4	21.22	18.6	26.4
W1X	160.03	157.4	162.2	20.27	16.3	22.9
LW2X	159.51	157.0	162.5	20.87	18.6	24.5
W2X	159.35	157.9	161.0	21.22	19.4	23.2
W4X	159.09	157.2	160.2	19.92	15.9	22.8
M2-	86.09	84.5	88.5	32.26	31.0	34.0
LM4-	85.10	83.5	86.0	32.07	31.0	33.3
M4-	84.72	83.8	86.0	32.29	31.0	33.7
M8+	N/M	N/M	N/M	N/M	N/M	N/M
W2-	86.34	85.0	87.5	32.10	31.3	33.0
W8+	84.41	83.0	86.3	32.20	31.3	34.5

In sculling the lateral distance from the boat centreline is usually the same for the right and left pins. However, its value changes geometry of the arms-inboard and affects angles at catch and finish. The picture below shows that narrower spread allows longer angles at the same inboard and seat/shoulders position:



As we discussed in RBN 2004/05 and 2006/06 the longer angles at catch work as a heavier gearing. However, from the pure geometrical point the effect of the spread on the angles is quite small: every two centimeters of narrower spread (at the same inboard) add only 0.5 degrees to the catch angle, which can hardly affect the rower's feeling. Changing inboard accordingly (maintaining a constant overlap) is slightly more effective and adds 0.8 degree for each two centimeters of the spread. Above changes affects overlap and allows moving the stretcher, which changes angles again. However this is a topic for other discussion.

Concluding, the reason of exaggerated importance of the spread/span for gearing still remains unknown to us. We greatly appreciate if you can sand us your thoughts, opinions or references.

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