Stability and variability of rower's motions

Rowing is a cyclic sport that means it requires repeating a similar cycle of motions many times. Usually, 200-250 stroke cycles is performed to cover the standard racing distance of 2000m. Visually, all strokes look the same and only good experts could see some small differences. Biomechanical equipment allows very accurate measurements of rowing motions and software allows determining how consistent or variable motions of each rower in a crew are.

The simplest measure of consistency is variation of the stroke rate: the higher variability, the lower consistency or stability and vice versa. Usually, a coach sets a task for rowers to row a piece of certain duration at a certain stroke rate. If all stroke periods are recorded, it is possible to derive an average stroke rate ***AV*** over the piece and its standard deviation ***SD***. The common measure of consistency is variation ***VAR*** equal to the ratio of ***SD*** to the average:

$$VAR = SD / AV \qquad (1)$$

In our ***BioRowTel*** software this operation is performed every time before processing the typical patterns over the sample. Then, the data is filtered and all strokes with duration outside a certain range (usually ±2SD) are rejected to produce reliable average patterns.

International level crews usually maintain variation of the stroke rate within 1%, but beginners could have it up to 4-5%. To convert it in absolute numbers, we can use a statistical rule, saying that 99.7% of the data remains within ±3SD range (assuming the normal distribution). At 32 str/min variation 1% means that practically all strokes are within rates 31-33, but 5% variation means the range 27-37 str/min.

Usually, we analyse arrays of average values of each biomechanical variable (angles, forces, accelerations, etc.), which represent typical patterns (curves) of rowing technique over the sample period. Also, ***BioRowTel*** software allows deriving SD values for each variable at each moment of the stroke cycle, which represents variability of rower's motions.

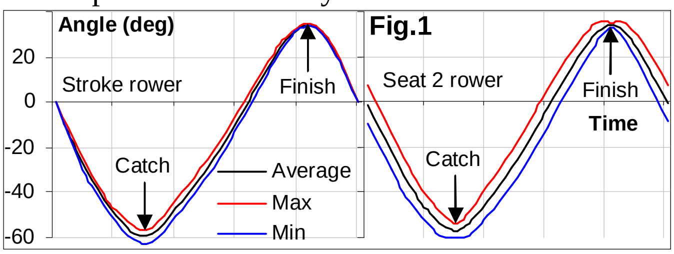
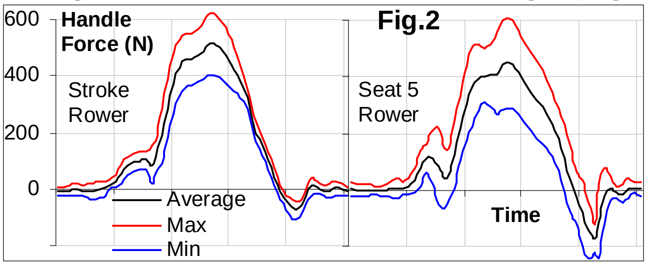


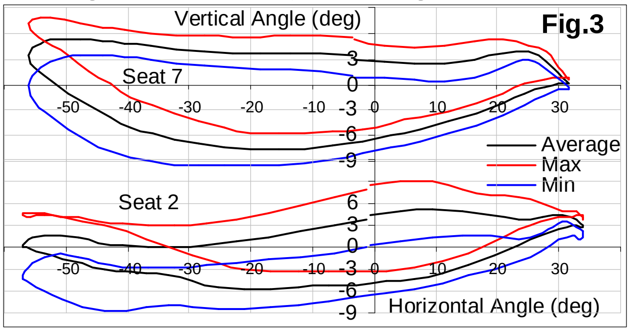
Fig.1 shows average curves of the oar angle and its maximal (+3SD) and minimal (-3SD) curves in two rowers of a collegiate eight at the stroke rate 36 str/min. It was found that stroke rower has the lowest variation in the crew (average SD over stroke cycle is 0.7deg = 0.8% VAR rel. angle amplitude), but the seat 2 rower had the highest variation (SD 2.1deg = 2.3% VAR). At the catch, all rowers had higher variation of the oar angle (average SD = 1.1deg) than at the finish (SD = 0.5deg). This fact illustrates the point that **<u>the catch is more difficult for coordination of rower's motions than finish</u>**, where the oar position is quite firmly defined by rigging and rower's posture.

Variation of the handle force was found to be at a much higher level than it was for the oar angle (Fig.2):

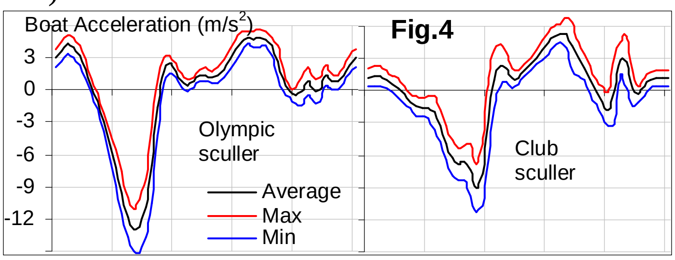


The stroke rower in this crew, also, had the lowest variation of the force in the crew (average SD 16N = 5.7% VAR), the seat 5 had the highest variation (SD 29N = 12.6% VAR). This fact could be explained by the point that **<u>crew rowers have higher complexity of their motions, because they have to coordinate them with the stroke rower</u>**, who set the timing in the crew.

Variation of the vertical angle (Fig.3) was also high, but the stroke rower was not the best here. It was randomly distributed in the crew, where seat 7 had the lowest variation (SD 0.7deg = 5.3% VAR) and seat 2 had the highest variation (SD 1.0deg = 10.1% VAR).



The boat acceleration as a resultant variable (RBN 2012/11) reflects consistency of rowing technique of the whole crew, which was found to be much higher in elite rowers. Fig.4 shows variation of the boat acceleration at 36 str/min in Olympic single (SD 0.31m/s^2 = 1.9% VAR) and in a club sculler (SD 0.59 m/s^2 = 4.1%).



There are many open questions in this area, which require further work: e.g., how to define consistency near zero values of the average, where the variation goes to infinity; normative values and functions.