The reasons of lift force in rowing

Two further experiments were done to investigate the reasons of the lift force. A Concept2 erg was mounted on slides through three sensors measuring the whole weight force of the erg with a rower (Fig.1). The lift force was derived as the difference between static weigh and measured vertical force during rowing. The erg was instrumented to measure handle force and positions of the handle, seat and trunk.

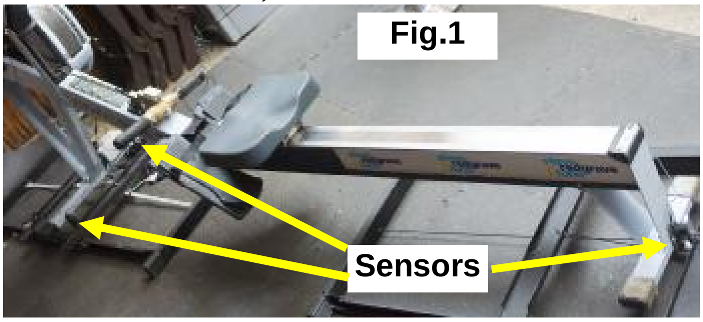

Fig.1

Three samples were taken 10 strokes each with various techniques: a) legs only (stroke rate 44 str/min), b) trunk only (41 str/min) and c) full length (36 str/min). As it was expected, the average lift force over stroke cycle was zero in all samples.

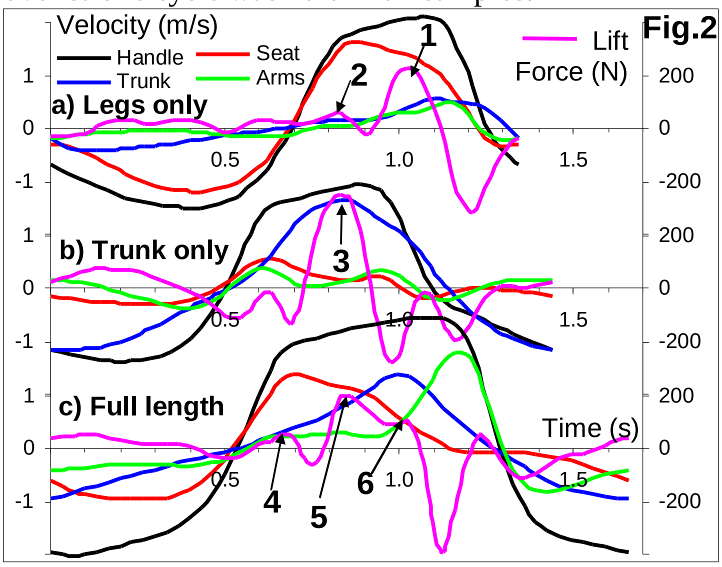

Fig.2

Maximal lift force at "legs only" rowing was 220N (Fig.2) and it appeared at the second half of the drive (1), when seat velocity is getting slower and thighs and shins are going down. Much smaller lift force 55N was measured at maximal seat velocity (2). Lift force at "trunk only" rowing was the most significant with a peak 350N, which happened at the maximal trunk velocity (3). The lift force at "Full length" rowing had even three peaks: at max. seat velocity (4), at max. trunk velocity (6) and the biggest one 190N in between them (5).

The second experiment was done in a mobile rowing tank "BRIS" (Fig.3), where two sensors of vertical force were mounted between a trolley and a frame with rower's workplace ("boat"), so they measured the whole weight of the rower with the "boat", minus buoyancy force. Also, oar angles, handle force and positions of seat and trunk were measured. Similar three samples were taken 10 strokes each at 40, 37 and 33 str/min correspondingly. The average lift force over the stroke cycle was more than zero: 33, 39 and 30N, which was 9-13% of the average handle force. This could be explained by vertical force at the blades at 6° pitch (sin(6°) = 10.5%). Though this average value of lift force is similar to what we've measured on-water (RBN 2013/08-9), its nature is different: on water, the forces were measured between the rower and boat frame, but here the forces were measured between the "boat" with rower and external support. Therefore, external vertical blade force was measured as the lift force in this case, but on water the vertical handle force pushed the rower downwards and decreased the lift force between rower and boat. Positive offset of the average lift force on water, could, probably, be explained by transfer of a part of vertical force through calves when they touch the boat at the end of the drive.

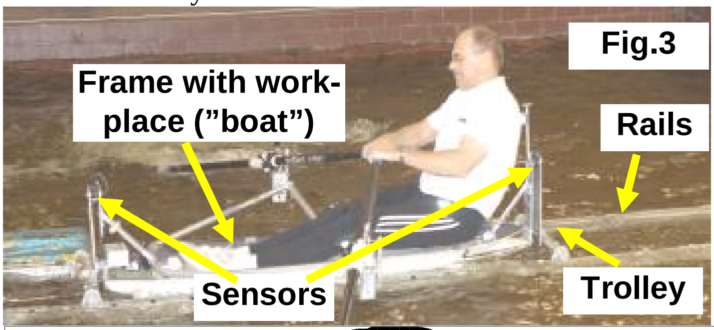

Fig.3

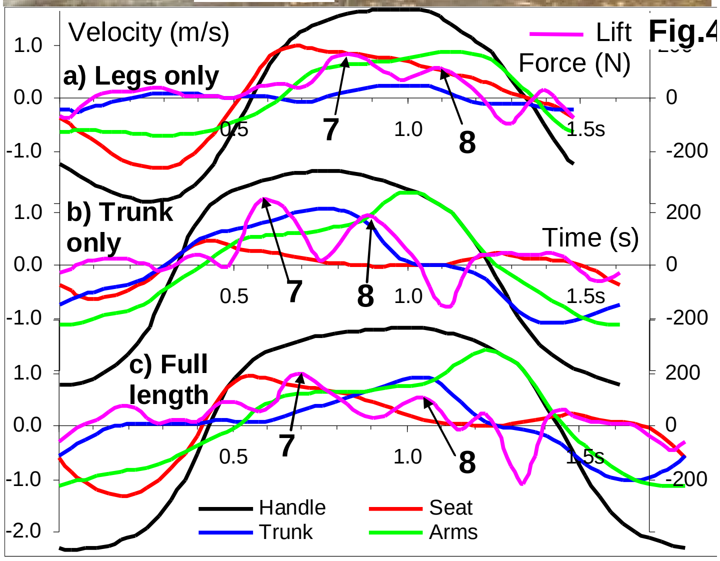

Fig.4

Dynamics of the lift force was quite similar to the erg (Fig.4): it had the highest magnitude 250N at "trunk only" and 170-200N at "legs only" and "full length" rowing. Peaks occurred after max. seat velocity (7), and coincides with the peak trunk velocity (8).

Conclusions: <u>1. Centripetal force of the trunk rotation appeared to be the main factor of the lift force during rowing.</u>

<u>2. Smaller lift caused by vertical acceleration of legs at the second half of their drive.</u>

<u>3. Vertical blade force is the only external factor lifting the whole system boat-rower, but it is relatively small.</u>

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