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Rowing Biomechanics Newsletter

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Rowing Biomechanics Newsletter celebrates its 10th birthday! Thanks to all readers for their interest and positive feedback!

Q&A

Q: There was a discussion among rowing coaches and scientists about lift force at the seat: does it really lift the whole rower-boat system and decreases water displacement; or is it just transfer of weight from the seat onto the stretcher?

A: There are five factors affecting force at the seat:

F1. "Static Lift". It is a simple distribution of weight between the seat and stretcher, when the line of gravity force ***Fg*** from rower's CM passes between them (Fig. 1). At catch, about 30% of the rower's weight is statically placed on the stretcher and only 70% is left on the seat, which can be easily checked with bathroom scales on the seat.

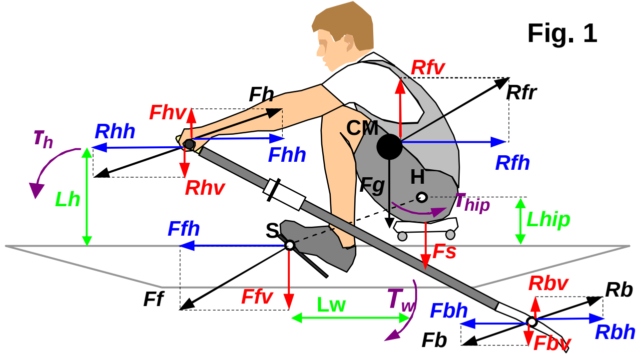
Fig. 1

When a rower pushes the stretcher, the force is usually applied at an angle to the horizon. Another two factors are:

F2. "Legs Lift". Hip joint ***H*** is located above the point of force application at the stretcher ***S***, so the line of leg (knee) extension force is not horizontal. This creates downward component ***Ffv*** and upward reaction force ***Rfv***, which lifts the rower.

F3. "Hips Torque Lift". When gluts muscles are activated, it creates a torque τ_{hip} around the hip joint, which increases the vertical component of the stretcher force ***Ffv*** and reduces the seat force ***Fs***.

However, reduction of the seat force related to the factors F1, F2 and F3 does not decrease water displacement of the whole rower-boat system, because upward force ***Rfv*** is internal one and balanced by force ***Ffv*** on the stretcher, which pushes the boat down. The higher this couple of forces, the more rower's weight is transferred from the seat onto the stretcher, which creates nodding oscillations of the hull: its pitch increases at the catch (bow goes up, stern down) and decreases at the finish.

F4. "Propulsive Lift". In a horizontal dimension, a rower applies oppositely directed forces to the handle ***Fhh*** and stretcher ***Ffh***, which are distanced vertically by the height of the handle relative to the stretcher ***Lh***. This creates a couple of forces, a torque τ_h around point ***S***, which decreases the oppositely directed torque τ_w of the rower's weight. This could be considered as a lift force ***Flift***, which reduces force on the seat ***Fs***. The handle force ***Fhh*** is transferred through the oar to the blade force ***Fbh***, which balances by an external reaction ***Rbh*** and has no counterpart inside the rower-boat system. Therefore, ***Fhh*** really decreases water displacement of the system and drag resistance. On an erg, the handle force is balanced by a reaction of the frame, which is an internal force, so, the total weight of the system is not changed.

F5. "Blade Pitch Lift". In fact, the handle ***Fh*** and blade ***Fb*** forces are directed at some angle to the horizon (RBN 2010/09), equal to the blade pitch angle. To create vertical blade force ***Fbv***, the rower applies upward handle force ***Fhv***, which creates downward "Handle Pitch Counter-lift" ***Rhv*** and increases force on the seat ***Fs***. This internal force ***Rhv*** is partly balanced by the force at the gate, so only ***Rbv*** is external and it pushes the whole system up and reduces water displacement.

Let's try to estimate the shares of each five factors. Fig. 2 shows data of a lightweight Olympic medallist in a single at 32 str/min (RBN 2002/05):

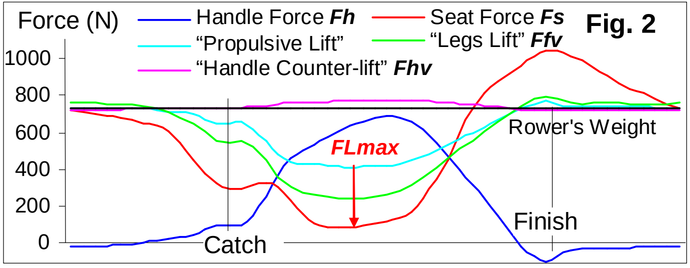
Fig. 2

Handle ***Fh*** and seat ***Fs*** forces were measured directly. "Propulsive Lift" ***Flift*** (F4) is presented as a difference from rower's weight and was calculated using the distance ***Lw*** derived from measured data of seat and trunk position:

$$F_{lift} = F_h\, L_h / L_w \qquad (1)$$

"The Legs Lift" (F2) was calculated using hip coordinates derived from seat position data. It was presented as an offset from ***Flift***, so these two lines represent shares in the total lift force.

"Static Lift" (F1) and "Hip Torque Lift" (F3) are quite difficult to estimate. We assume that they represent the residual between red ***Fs*** and green ***Ffv*** lines (Fig.2). At finish, these two factors change sign and push the seat down.

At the moment of maximal weight reduction ***FLmax***, only about 80N of force is left on the seat. About 320 N or 50% of the total lift force 640N is "Propulsive Lift", which decreases water displacement and reduces drag resistance. Another 25% is contributed by "Legs Lift". The residual 25% is related to the "Static Lift" and "Hip Torque Lift". The effect of "Blade Pitch Lift" (F5) is quite small: at peak force application ***Fbv*** is only about 20N (6% of "Propulsive Lift") and "Handle Pitch Counter-lift" ***Rhv*** at the rower's side is about 50N.

More horizontal stretcher force application reduces water displacement and the boat "nodding", and, hence, decreases of drag resistance and improves performance. To achieve it:

- Use only knee extensors muscles at catch without activating gluts and opening the trunk;
- Place the stretches higher and steeper, but this could reduce the length of the drive;
- Use a more vertical trunk position at the catch (Adam style, RBN 2006/03), but this could reduce power.