

A sportsmedical survey during the Dutch National 15m-class Championships

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Although soaring is subject to a vast amount of research, as can be seen in the rich history of the OSTIV and the large number of contributions to this congress, only few studies have been made on pilot workload and physiological events encountered during multihour soaring flights (Beier '82; Clasing '74). More over no studies have been performed during contest flights, nor any on parameters other than subjective workload experience or physiological correlation as cardiovascular and respiratory events (Beier '82; Neubert and Mohr '76; Stedtfeld '77). From these studies we know that the workload encountered by the soaring pilot is mainly of psychophysical nature, while the muscular workload is small and consists of mainly isometrical contractions. The lack of knowledge of physiological events during long-duration soaring has led to largely different physical requirements of glider pilots all over the world (Bakelas et al. '78; Weinholz '81). The unsatisfactory state of affairs that many soaring accidents, which are in 60-70% due to human failure (Beier '82b), remain unsolved, is partly due to the lack of knowledge. Therefore a pilot study was performed during the Dutch National 15 m-class Campionships at Terlet, The Netherlands, during June 1981.

Material and Methods

Subjects:

From the whole thirty five competitors in the championships a group of nine volunteers was obtained. As indicated in table I the research group was very heterogeneous. The mean age was 40 ± 10 years,

Table I. Profile of the participants in the study.

subject	age no.	flight experience (hrs)	drinking in flight
1	23	250	yes
2	39	530	no
3	54	1480	no
4	33	1120	yes
5	56	1800	yes
6	39	1300	yes
7	36	800	yes
8	45	610	no
9	35	2000	no
$x \pm SD$	40 ± 10.4	1100 ± 600	

ranging from 23 to 56 years. Also flightexperience ranged widely (250-2000 hrs.). All of the competitors had previous competition experience, gained in regional competitions and worldchampion ships. Final competition results were widely

spread and ranged from the first to the thirtythird place.

A qualitative statement is made about the drinking and eating during flight. The amount drunk by the subjects varied between 500 and 1500 ml, during 4 to 6 hour flights. All pilots ate a normal breakfast at 9.00 AM local time.

Material:

All participants of the study flew types of aircraft which had in essence the same semi-supine sitting position, with slightly elevated legs. All aircraft were modern 15 m-class machines.

Methods:

In order to prevent disturbance during flight, which was essential to the volunteers, only few parameters could be determined before and immediately after flight. The protocol of the study was as follows.

Before or shortly after the daily briefing at 10.00 AM local time and immediately after completion of the task, on the landing area, all participants were checked for the following parameters:

Weight: body weight was determined on a scale reading to 0.5 kilo. Care was taken that the same clothes were worn before and after flight. Nevertheless the amount of perspiration soaked into the clothes could not be determined. This should be kept in mind in interpreting the results. Pulse rate and bloodpressure: These were both determined with the subjects in an upright position. Due to the safety guards on the landing area it was impossible to collect the data in the cockpit immediately after landing. The delay between landing and measuring was approximately two minutes. Care was taken that the subjects did not push their aircraft themselves. Pulse-rate was determined during 15 seconds and extrapolated, blood pressure was established with a mercurial blood pressure measurer. The same instrument was used before and after flight.

Urine-probes: Before and after flight pilots were asked to pass a urine sample for the determination of specific gravity, pH, ketonbodies, protein and glucose. The first parameter was measured with the aid of a classical densimeter, while the other parameter were determined with so called "Clinistix" (Ames). Values on ketonbodies, protein and glucose were only of qualitative nature.

In case pilots could not complete the task, they were requested to pass some urine into a feste supplied immediately after

landing and return it to the research team as soon as possible, in order to obtain additional data.

Blood-glucose: the blood-glucose level was determined with aid of an Ames glucometer. The blood was obtained by a fingerstab.

Statistics:

Statistics were performed with Student test, unless otherwise indicated. Regressionlines were obtain by the least square method (Colton '74; Siegel '59)

Results

Due to the relatively bad weather conditions, suitable weather for setting a task occurred only on four days. For the same reason only on the third day were pilots able to complete the task. Pilot number nine however completed the task in 3 out of 4 days. Fortunately on most other days, a urine-sample was obtained from most participants not completing the task. Due to these circumstances we first describe the results on day 3 and subject number 9 and then focus on the results from the urine-samples as a whole. All flight-times are indicated in table II. Weather conditions during the whole research period were relatively cool (13 to 20°C).

Table II. Flight-times on the different contest-days.

Subject no.	Flight-time			
	day 1	day 2	day 3	day 4
1	4.50	5.05	6.10	2.00
2	3.48	1.28	7.05	1.08
3	1.55	2.08	5.49	2.13
4	4.52	2.14	4.36	3.19
5	4.37	1.40	6.42	4.56
6	4.23	6.32	5.34	1.10
7	4.47	1.11	4.59	4.01
8	3.56	2.39	6.17	1.29
9	4.11	5.21	3.56	5.07

Day 3, a 364 km triangle

All results are indicated graphically in fig. I. The pulse rate rises explicitly in all subjects, before flight 76 ± 15 beats per minute and after flight 114 ± 11 beats per minute ($x \pm sd$). The rise is significant ($p < 0.02$). The systolic blood pressure rises also (pre: 127 ± 7 mmHg; post: 136 ± 13 mmHg) but not to a significant level. Diastolic pressure, on the contrary, rises significantly after flight compared to preflight values (pre: 84 ± 8 mmHg; post: 91 ± 9 mmHg; $p < 0.005$). Weight changes highly significant ($p < 0.001$) to a lower level: pre: 76.6 ± 9.6 kg, post: 73.4 ± 9.0 kg. The loss of weight ranges from 2 to 5 kg in flights of between 3.56 and 6.17

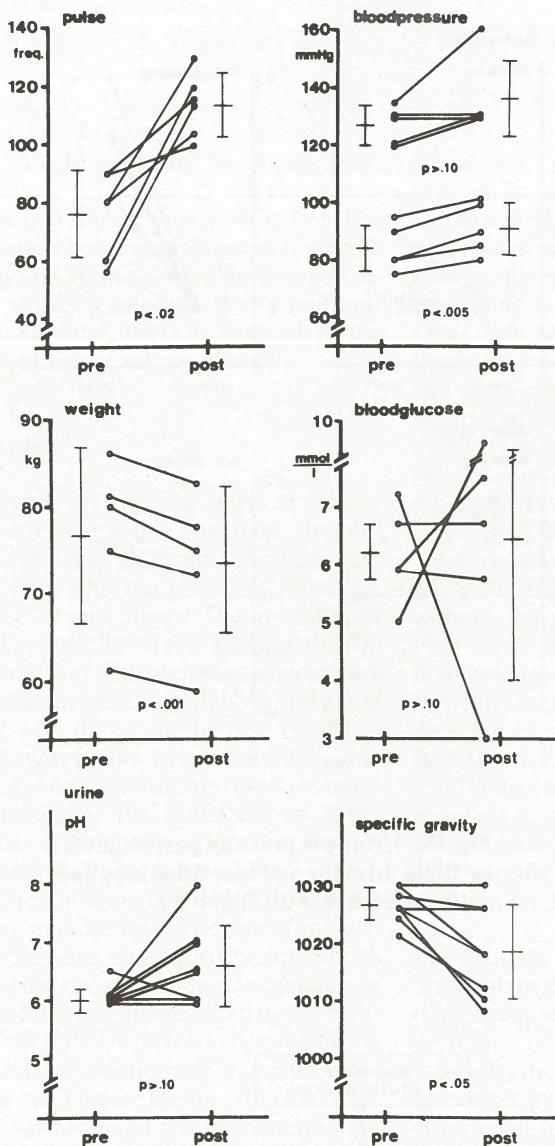


Fig. I.: Values of pulse, bloodpressure, weight, bloodglucose and urine pH and specific gravity, before (pre) and after (post) a 364 km triangle on day 3. Mean and s.d. are indicated.

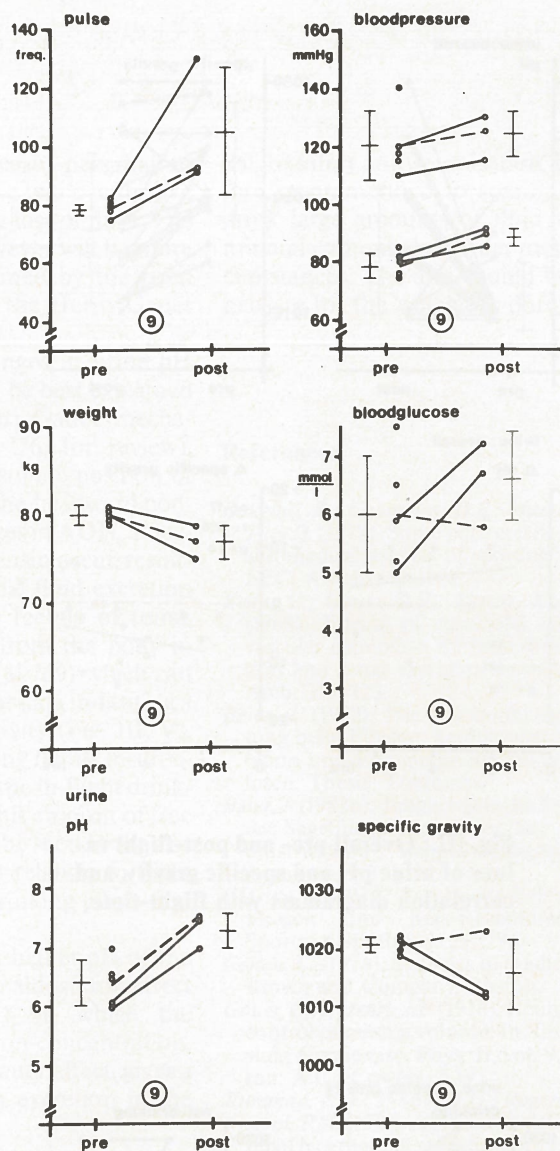


Fig. II.: As fig. I. Values of subject no. 9. on three different days. Preflight mean was obtained from five morning values.

hours (mean $5.31 \pm .55$ hrs.). Blood glucose levels however give very different values for various participants and no general pattern can be concluded. Urine values gave no qualitative changes, as far as protein, ketonbodies, and glucose are concerned. However pH as can be seen in Fig. I rises, although not significantly (6.1 ± 0.2 to 6.6 ± 0.7), while specific gravity falls sharply from 1026.4 ± 3.0 to 1018.5 ± 8.2 ($p < 0.05$).

Subject number 9

Additional information was obtained from the values of subject number 9. He completed three out of four tasks, thus providing more data, indicated in Fig. II. Unfortunately the morning values of day 3 are not obtained, values of this day being indicated with broken line. The morning values were extrapolated from similar values on five other days. Of course these values were not used for statistical inference.

However the data should be handled with caution. It can be seen that the overall

pattern, described above is followed: a rise of pulse-rate and diastolic pressure as well as systolic pressure, a fall in weight, a rise in pH and fall of specific gravity of urine. Blood glucose levels tend to rise during flight. From these figures it is concluded that the changes that occur in one person on several days are the same as those in several persons on one day.

pH and specific gravity of urine

All figures concerning the pH and specific gravity of the urine samples are gathered in Fig III. As seen in the values of day 3, the overall picture gives also an increase in pH levels during flight (pre: 6.15 ± 0.31 post: 6.53 ± 0.65). This increase is significant ($0.01 < p < 0.02$). The specific gravity therefore decreases to an even higher significance level (pre: 1022.9 ; post: 1017.2 ; $0.001 p < 0.01$). To find out whether drinking or not drinking was of any influence to the changes of these parameters, values were separated, as can be seen in Fig IV and V.

The pH for drinkers does not change

significantly (pre: 6.17 ± 0.35 ; post: 6.22 ± 0.36), whereas pH for nondrinkers increases (pre: 6.08 ± 0.23 ; post: 6.69 ± 0.70 ; $p < 0.01$). These differences are significant (signed rank test $p < 0.05$). Specific gravity therefore does not give a significant difference (signed rank test) between drinking and not drinking (drinking: pre: 1023.5 ± 5.3 ; post: 1017.5 ± 7.8 , significant decreases $p < 0.10$; notdrinking: pre: 1022.4 ± 5.1 ; post: 1017.0 ± 5.7 , significant decrease $p < 0.01$).

In an attempt to find out what factors could be of any influence to the values, they were correlated against age, temperature, flight-time and drinking behaviour. None of these however gave any conclusive correlation.

The correlations between flight-time and the Δ pH and Δ specific gravity are indicated in Fig III. The correlation coefficients of -0.131 and 0.214 respectively are not significant. What is indicated however is, that the changes found occur within two hours of flight and are maintained at this level throughout flight. The

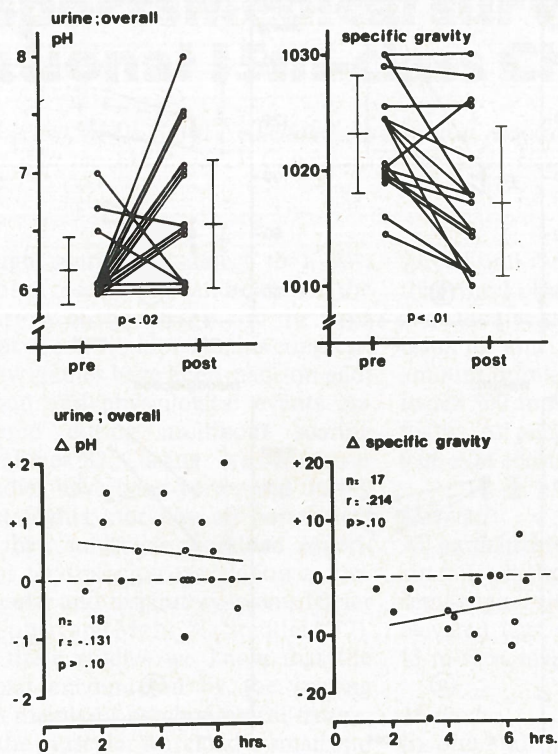


Fig. III.: Overall pre- and post-flight values of urine pH and specific gravity, and correlation diagrams with flight-time.

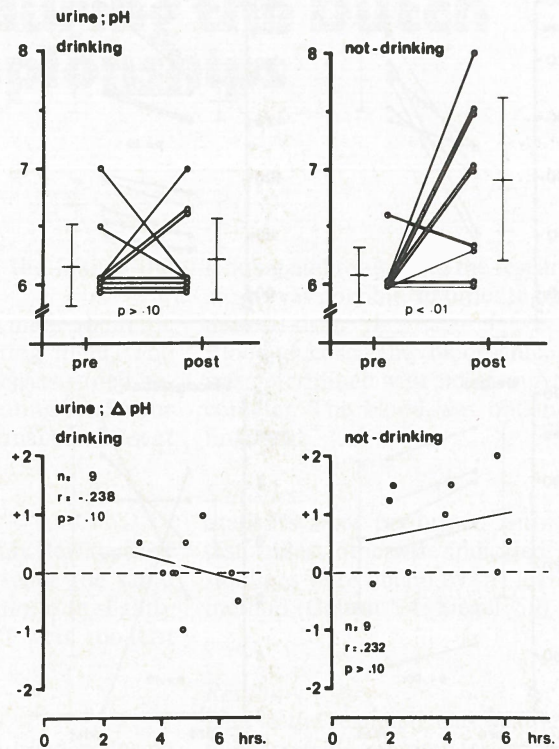


Fig. IV.: Urine pH pre- and post-flight for in-flight drinking and non-drinking pilots with correlation with flight-time.

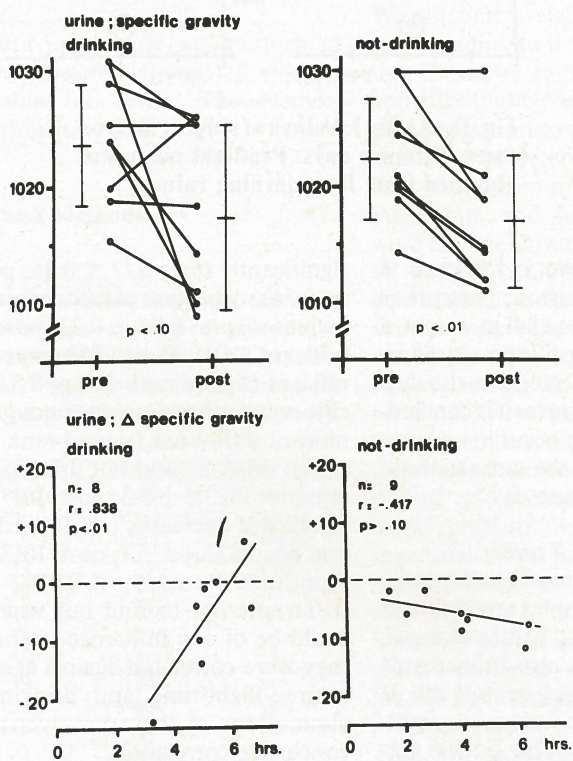


Fig. V.: Urine specific gravity pre- and postflight for in-flight drinking and non-drinking pilots, and correlation with flight-time.

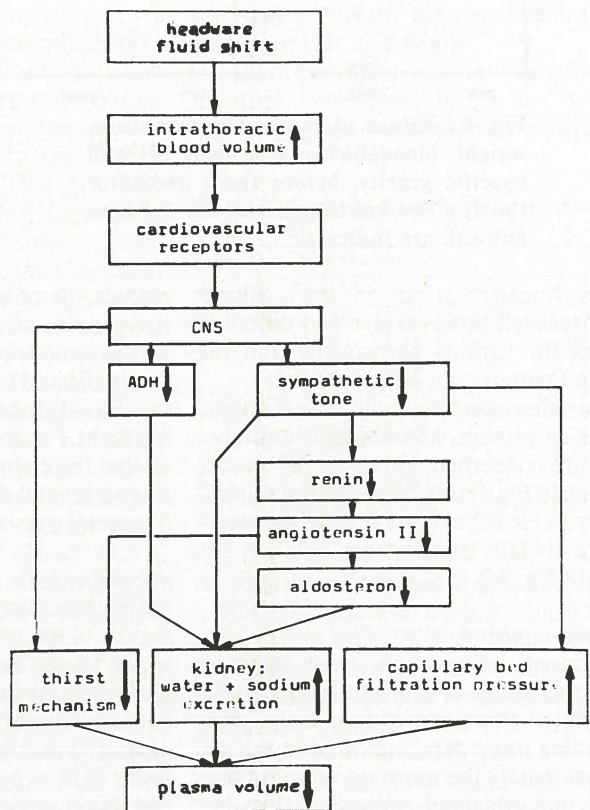


Fig. VI.: Flow-chart of the Henry-Gauer mechanism. For explanation see text. Modified after Gauer and Henry '76.

same conclusions can be drawn from separate Δ pH-values of the two aforementioned researchgroups (Fig IV). The correlation between changes in Δ specific gravity and flight-time for the group of in-flight drinking pilots is very significant ($r = 0.838$; $p < 0.01$) in contrast to the values of non-drinking pilots.

Discussion

Circulatory events: the marked rise of pulse-rate is probably due to the stressful event of final glide and landing, and in keeping with the results of Beier '82, Clasing '74 and others. The insignificant rise of systolic blood pressure and the significant rise of diastolic blood pressure are in accordance to the results of Shvartz et al. '82 who found comparable results in six volunteers after 5 hours of sitting, due to a triggering of aortic and carotide baroreceptors after the initial fall in blood pressure after changing posture from a semisupine to an erect position.

This phenomenon could also account for the rise in pulse-rate. The rise of the diastolic pressure might also be an expression of the rise of peripheral resistance of the vascular system mediated by the Henry-Gauer reflex, which is generated by the semi-supine position of the pilots (for review see Gauer; Henry '76) (Fig VI). On the other hand the aforementioned stressful events of final glide and landing could well have some influence on blood pressure.

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Weight: several mechanisms could initiate the decrease of weight up to 6.25% under these moderate circumstances. It should be kept in mind that transpiration fluid soaked into the clothes was not accounted for and there were no corrections for fluid-intake. As demonstrated by Beier '82 in the starting and landing phase and by Schönherr (in preparation) in normal flight situations a moderate hyperventilation occurs, underlining the stressful events in soaring. This situational

stress will also increase perspiration through the skin. Those two events give rise to a moderate extra loss of fluid. The decrease of weight however will be more than sufficiently explained by the risen renal fluid loss due to the Henry-Gauer reflex (see below).

Urine parameters: changes in urine pH and specific gravity can be best explained by the so called Henry-Gauer mechanisms (Gauer, Henry '76, for review), generated by the semisupine position of the pilots. Because of the headward pooling of bodyfluid, changes in ADH, aldosterone, renin and angiotensin occur, resulting in an increased renal fluid excretion without the subjective feeling of thirst. Free water is cleared from the body in first instance (Behn et al. '69) which can be clearly seen from our data indicating a decrease of specific gravity (Fig. III, V). Probably in longer lasting flights insufficient fluid was taken by the in-flight drinking pilots to maintain this amount of free water clearance, as can be seen in the rise of Δ specific gravity in relation to flight duration for in flight drinking pilots (Fig V).

The changes towards a higher pH of the urine might be due to an aldosterone effect (Kurtzman et al. '71), in which the decrease of aldosterone-concentration, caused by the Henry-Gauer effect, gives a decreased hydrogenion excretion in the distal renal tubule.

Differences between drinking and non-drinking pilots in urine pH are explained by the differential response of the kidney to hydration state of the organism. In well hydrated individuals less sodium is excreted than in water-depleted individuals (Behn et al. '69). This is probably due to the effect of aldosterone, which induces in well hydrated individuals a larger exchange of sodium for hydrogen ions in the distal tubule (Rose '77).

It is concluded that soaring is a special kind of aviation sport with a specific workload under special, ever changing circumstances. This study, first of its kind in soaring, gives rise to the assumption that the Henry-Gauer reflex plays a major role in soaring, which implies that the maintenance of a good fluid balance is essen-

tial for safety and optimisation. It is therefore recommended to soaring pilots to drink large amounts of fluid with little mineral content also under moderate circumstances. The aim should be to compensate for the weight loss during flight.

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