OVERLOAD TRAINING IN SPRINT SWIMMING: KINEMATIC AND DYNAMIC PARAMETERS

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INTRODUCTION

Overload training is used frequently to improve specific strength endurance in competitive sprint swimming. The principle of this kind of training consists in swimming under competitive conditions, demanding a higher propulsive force output. This is obtained by swimming with added external loads raising the swimmer's water resistance.

An essential secondary factor here is to keep the kinematic parameters of the swimming cycle as close as possible to the race-specific technique.

The objective of this study is to present data about the additional water resistance of load equipment types commonly used and to give an insight into the changes within the swimming cycle kinematics under defined load conditions.

METHODS AND EXPERIMENTS

Experiments were taken with two elite swimmers (male and female) and, for comparison, with two additional persons of lower swimming performance levels. In the first series, the test persons were ordered to swim 10 metres with maximal effort with and without added loads. Information about the kinematics of the swimming movement was obtained by measuring the swimming speed. The dynamographic aspect was taken into account by measuring the passive drag forces of the swimmers with and without added load, using constant towing velocities corresponding to the mean values obtained from the free swimming series.

The different loads applied were: life saving clothes, resistance belt, and two buckets of different volumes attached to the swimmer. Kinematic parameters were obtained by using a "Control Aqua Training System " (C.A.T.S.), delivering the swimmer's moving speed by registration of the movement of a cable attached to the swimmer's waist.

The towing forces were measured during tethered swimming by use of a strain gauge system fixed to a carriage moving above a 50 m pool.

The analogue swimming speed and towing force data were transferred via AD-conversion into a laptop, the sampling frequency being chosen 50 Hz. All further mathematical procedures of data treatment were performed by means of the Software program "Analog" of the Institute of Biomechanics.

RESULTS AND DISCUSSION

Presentation and discussion of the results are based on the mean values (obtained by time averaging) of swimming speed and drag forces of each test person. In this way, effects referring to inertial forces and the influence of non-stationary flow phenomena could be taken out of consideration.

Kinematic Parameters

In the domain of kinematics, the following data were extracted from the speed -time curves: mean swimming speed, speed variation (maximum - minimum) within the cycle, stroke frequency and, as secondary results the distance per stroke values.
It is remarkable that for each test person, despite of the different absolute swimming performance levels, the decrease of mean swimming speed takes place in the same order of test conditions.
A better view of the losses of the mean speed is reached by expressing the individual values as fractions of the results in the unloaded situation. This is shown in fig.1.

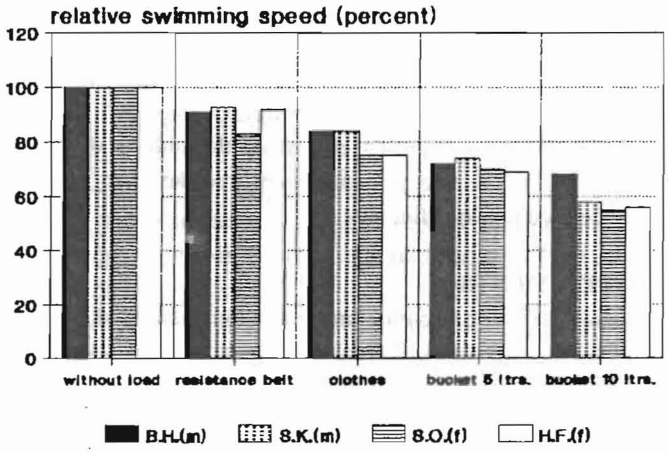

Fig.1. Relative mean swimming speed under different load conditions.

It can be seen, that irrespective to the individual absolute values the mean speed data expressed as percentage show no large differences regarding the same load condition for the test persons. Since a statistical treatment of the data here is beyond the scope of this study, only a certain tendency can be pointed out here. Concerning the stroke frequency chosen by each individual the results are not changed dramatically in the different testing situations, with the exception of the hardest load (bucket 10 ltrs.), when the female test person of low swimming performance level showed a considerable decrease of stroke frequency. In this case, the "normal" technique could not be performed further by this subject in this situation, announcing thus a contradiction to the philosophy of overload sprint training. At moderate load conditions, the speed variation in the swimming cycle did not exceed a range of 0.8 - 1,2 m/s, being relatively constant for each test person as long as the swimming technique was not altered too much.

Dynamic Parameters

The passive drag forces for each swimmer and each load situation do not show at the first glance a clear tendency for all individuals, but it must be kept in mind, that the drag forces were measured at velocities corresponding to those measured during untethered swimming under the indicated load conditions. Furthermore it is important to recognize the different nature of the resistance-raising apparatus the application of which may change the person's position in the water and thus leading to unforeseen results with no clear tendency. Additionally, the body mass of the test persons ranged from 58 kg (H.F.) to 92 kg (B.H.), surely influencing -in combination with sex differences- the body shape and thus the drag. In order to get a better view of the results including the above-mentioned factors, the mean drag forces were divided by the square of the actual velocity and then related to the swimmer's body mass. The result of this procedure represents a kind of "drag coefficient per kilogram body mass" allowing to compare the test persons to each other. The values obtained are listed in tab.1.

test condition	drag coefficient/body mass (m^{-1})				
	B.H. (m)	S.K. (m)	S.O. (f)	H.F. (f)	mean
swimming without load	0.32	0.36	0.35	0.34	0.34
swimming with res. belt	0.43	0.48	0.42	0.52	0.46
swimming with clothes	0.44	0.46	0.47	0.56	0.48
swimming with 5l-bucket	0.54	0.57	0.67	(0.79)	0.59
swimming with 10l-bucket	0.82	0.95	0.93	(1.31)	0.90

Tab.1. Drag coefficient / body mass of the test persons under different load conditions

The numbers in parentheses were excluded from computing the mean because they diverged too much from the other values. This can be justified by the fact, that corresponding to the data of tab. 1 the discrepancy in the absolute swimming speed of this test person might have led to a relationship between towing force and towing speed which does not suit the square - law dependence as supposed here. With the assumption, that the measured drag forces (and related values) represent a more or less true measure of the swimmer's water resistance at a fixed swimming speed, a relationship between drag forces induced by the use of external loads and the variation of mean swimming speed are of interest. So, by comparing the results of tab.1 , expressed as a percentage increase of the drag coefficient per body mass in the non-loaded case to the relative decrease of swimming speed as cited in fig.1, for each test person a regression line was found as shown in fig.2. The percentage increase of drag cited here is in good agreement with results of Wilke and Madsen (1986).

The lines show a linear relationship for all test persons, so it seems to be possible to coordinate added relative loads to a reduced swimming speed, irrespective of the absolute individual performance level, the results being valid up to 70 percent of added resistance.

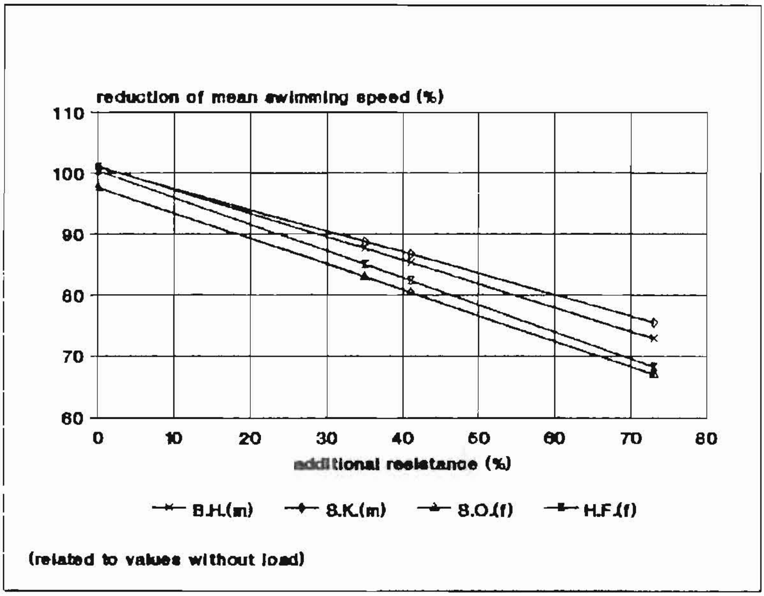

Fig 2. Regression lines of the reduction of relative mean swimming speed vs. additional relative drag variation of the test persons.

CONCLUSIONS

The results give reason to the following conclusions with respect to the application of resistance raising apparatus in overload sprint training:

* By using of the apparatus investigated here with exception of the 10l-bucket the kinematic parameters of the swimming cycle are not changed to a greater extent.
* The percentage decrease of mean swimming speed is related to every single type of apparatus used in overload training.
* A quantitative relationship can be established between the added loads and the resulting loss of mean swimming speed in order to perform an overload training which can be controlled numerically and may thus be planned and executed more effectively.

REFERENCES

- Wilke and K., Madsen, O. (1986) Coaching The Young Swimmer, Pelham Books Ltd., London