Pressure differential on a swimmer’s hands and swimming direction

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1. Introduction
It is vital to maintaining a constant direction during locomotion. Turning in walking is triggered by the impulse from the leg located outside its rotation axis. Then, the centre of gravity is relocated in the direction of an inside limb [1]. It is commonly believed that similar correlation can be observed in swimming. Greater propulsion forces produced by the right limbs cause turning left. The upper and lower limbs may generate the propulsion while swimming. However, its main source are the upper limbs [2]. Their activity seemed to determine the swimming direction. Hand surface is the main propulsion surface of the upper limb. Propulsion is determined by the pressure differential P(t) exerted by the water on the back of the hand and palm [3]. The purpose of this research is to check the correlation of asymmetry of pressure differentials exerted on the right and left hand with the swimming direction in breaststroke. During the research the propulsion will be produced only by the upper limbs. The analysis will be related to the propulsion phase.

2. Methods
The research stand consists of the pressure sensors attached to the subject’s hands and connected to a computer and camera which records the course of movement. Nine subjects participated in three tests. The first test aimed at determining subject’s swimming skills. The subject was required to swim 25 m breaststroke in the shortest time. In the second test the subject was required to swim 20 m breaststroke, at moderate velocity, using only the upper limbs. In the third test, in order to change the swimming direction, the subject swim wearing opaque swimming goggles and ear stoppers. The remaining requirements were identical with those of the second test. The measured pressure differentials were synchronised with the recorded video. The phases of the upper limbs propulsion were defined. First, \( \int P(t) \, dt \) for the propulsion phase of each hand was computed, and then the difference between \( \int P(t) \, dt \) for the right and left hand in the subsequent phases was determined. Next, the propulsive phases of the P(t) values were normalised. Their mean values for each subject’s right and left hand obtained in the second and third test were calculated.

3. Results and discussion
The obtained results are not unequivocal. A slight pressure differential asymmetry (fig. 1a) and domination of the right and left hand were observed in the subsequent propulsion phases while swimming along a linear trajectory (test 2). In the third test the subject (without visual control and with auditory limitations) was expected to swim along curvilinear trajectory. One subject – with the highest swimming skills – swam along a linear trajectory. The remaining subjects turned both ways often displaying no correlation between the swimming direction and generated pressure differentials (fig. 1b).

![Fig. 1](image-url) The difference of \( \int P(t) \, dt \) between the right and left limb propulsion phases during linear (a) and curvilinear swimming (b) – example (Solid line – trend curve).
Only in half of the examined subjects the analysis of mean P(t) values (fig. 2) confirmed the consistency of deviation from the linear trajectory with the generated pressure differential. The resistance forces created by locomotion in the water, in contrast to this on land, are much higher. They may be important in changing the movement direction [4]. In breaststroke the resistance force increases mainly in the lower limbs recovery phase [5]. Since their participation was eliminated, they should not generate active resistance force. The deviations from the linear trajectory might have been caused either by the active resistance forces produced by the upper limbs and trunk or passive resistance of the lower limbs.

4. Conclusions

The obtained results suggest that the asymmetry of pressure differential exerted on the swimmer’s hands in the upper limbs propulsion phase in breaststroke is not related to the swimming direction. It may imply that it does not constitute a diagnostic value for the purpose of this research or that the upper limbs movement in the propulsion phase does not determine the swimming direction. To answer those questions further analysis is required.

References