Symmetry of support scull and vertical position stability in synchronized swimming

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1. Introduction
Biomechanics description of the specific movement structure in synchronized swimming is one of the most important research problems of technique in this sport discipline [1,2,3]. One of the most difficult technical element of synchronized swimming is maintaining a vertical position. The execution of this position has a large impact on the sport results and is based on sustaining the stability of surfacing body with legs upwards under the condition that the hip joint and knee joint are extended. The performance of this position is allowed by the specific technique of underwater movements of arms called support scull (SS) [4]. SS in vertical position is a technique that significantly diverge from natural forms of movement. SS is a movement combination of upper limbs: surround in shoulder (the linkage of flexion and extension with abduction and adduction), flexion and extension in elbow joint as well as supination of forearm with cooperation of elbow and radial-cubital joints [5]. Few studies on the SS in a vertical position selected parameters that describe the technique. Hall [2] and Homma & Homma [3] do not indicate precise relationship between the movements performed under water and the stability of the vertical position.
The level of movements symmetrization depends on the level of motor coordination and allows execution of complex exercises [6]. Very often research on symmetry in swimming concerns techniques of competitive swimming where the spatial symmetry reflects the high-class swimmers [7].
The aim of present study is to determine criterions of effective execution of vertical position in synchronized swimming and to establish relationship between underwater movements and the stability conditions of body surfacing.

2. Material and method

2.1 Material
Twelve healthy synchronized swimmers (age 16±3; body mass 52±7; body height 160±6) of the Lowsilesian and Greaterpoland sport clubs were filmed under water while performed exercise. All subjects were selected to have the leading right leg. Each of the subjects was to perform eight cycles of sculling movements.
All of the participants signed a written consent form. Research approval for the study was obtained from the local ethics committee of the University School of Physical Education in Wroclaw.

2.2 Method
The vertical positions were studied using three-dimensional analysis. A set of 18 reflective markers was used to denote the subjects’ main upper and lower body parts as described by Winiarski [8]. Two 50Hz digital cameras recorded the y-direction movement. Cameras were placed opposite to each other in waterproof enclosures and mounted on tripods at the wall of the swimming pool.
Subject’s movement was recorded on a video tape and was played on TV screens. Optical axes of both cameras were arranged perpendicular to each other. The frequency of shooting was 50 fps. Reference system was a rigid cube of dimensions 1m × 1m × 1m which was designated by eight markers.
The specific points chosen for analysis were: right and left shoulder (acromion), right and left elbow, right and left wrist, right and left middle finger, symphysis and head. On the basis of three markers set, angles of wrist, elbow and shoulder joints in both upper extremities were computed. The dynamical asymmetry index (DAI) was then acquired which is the relative difference between the range of motion of the right and left joint angle, i.e.:

\[ DAI(t) = \frac{|X_R(t) - X_L(t)|}{0.5(X_R(t) + X_L(t))}, \]  

where \( X_R(t) \) , \( X_L(t) \) is the time characteristics of an arbitrary gait parameter for right (R) or left (L) site.
Data registration and computation was supported by the SIMI Motion software. Since 2001 the Laboratory of Biomechanical Analysis of AWF Wroclaw has an ISO Quality Certificate nr 1374-b/3/2009, PN-EN ISO 9001:2009.
2. Results

Example asymmetry characteristics of DAI for the shoulder-elbow-wrist angle (SEW), shoulder-elbow-fingers angle (SEF) and elbow-wrist-fingers angle (EWF) for the contestant nr 3 are shown in the Picture 1. At the top of each graph phases of the movement cycles are shown. All DAI characteristics are synchronized in time.

3. Discussion

In literature the symmetry issue is often neglected. It seems to us that it is significant in maintaining body stability and posture control. Our research showed great asymmetry (up to 30%) between left and right side in sculling movement pattern which is the cause of the loss of postural stability. Dynamical asymmetry index (DAI) varies between synchronized swimmers. The ability to perform symmetrical support scull movements characterises few contestants. Large values of the DAI coefficients allows us to identify critical points in time of sculling movements. The DAI for the SEW angle and SEF angle did not match, thus leaving the wrist stiffness assumption unconfirmed. Large values of the DAI indicate usefulness of the indicator to assess the stability of the vertical position. However the relation of the DAI characteristics with the posture stability variables still needs to be confirmed.

References