競泳中の泳者の肺気量推定法の開発

産業技術総合研究所　鷲野壮平
（共同研究者）同　村井昭彦
鹿屋体育大学　荻田太
同　萬久博敏
信州大学　吉武康栄

Development of Estimating Lung Volume of a Swimmer During Swimming

by

Sohei Washino, Akihiko Murai
National Institute of Advanced Industrial Science and Technology
Futoshi Ogita, Hirotoshi Mankyu
National Institute of Fitness and Sports in Kanoya
Yasuhide Yoshitake
Shinshu University

ABSTRACT

The purpose of this study was to test if lung volume during swimming can be estimated from optical motion capture system. To achieve this goal, we tried to develop a digital human model expressing respiratory motion. A male swimmer performed lung function tests during the quiet standing and tethered front crawl swimming under the water, and respiratory flow rate and three-dimensional (3D) motion data were measured synchronously. Respiratory flow rate was integrated to obtain lung volume (measured lung volume) as a function of time. 3D motion data of trunk segment was collected by an underwater motion capture system. 3D shape data of the whole body

was scanned for the swimmer on dryland. Digital human model expressing respiratory motion was created based on the 3D shape data. Then, digital human model was fitted to 3D motion data by using inverse kinematics computation, and lung volume was estimated from the change in volume of the model (estimated lung volume). Measured and estimated lung volume were compared by using the Intra-class correlation coefficient (ICC). As a result, ICCs during standing were 0.981 for quiet breathing, 0.995 for force vital capacity, and 0.972 for maximal voluntary ventilation ($P < 0.001$). On the other hand, ICC was smaller during swimming compared with values during standing, with being 0.717 ($P < 0.001$). These results suggest that our digital human model with motion capture data under the water can accurately estimate lung volume at least in lung function tests during standing. Further study is needed to improve our digital human model to estimate lung volume more accuracy during swimming.

要　旨

本研究は，競泳中の肺気量の推定法の開発を目的とし，モーションキャプチャデータから呼吸運動を表現するデジタルヒューマンモデルの開発に取り組んだ．競泳選手を対象に，立位姿勢における呼吸テストおよび牽引クロール泳を行わせた．その際，呼吸流量データと体幹部のマーカーデータを同期計測した．呼吸運動表現モデルは，3Dスキャナで取得した身体形状データを基に，体幹部の各マーカーに対応するようにリンクセグメントを配置して作成した．呼吸流量データから算出した肺気量を真値とし，呼吸運動表現モデルから推定した肺気量の妥当性を級内相関分析より評価した．呼吸テストとして実施した立位姿勢における安静呼吸（ICC = 0.981），努力性肺活量（ICC = 0.995），最大随意換気量（ICC = 0.972）は，いずれも算出方法間で非常に高い一致性が確認された（$P < 0.001$）．一方，競泳中では高い一致性（ICC = 0.717，$P < 0.001$）が認められたものの，呼吸テストと比較して，級内相関係数は低値を示した．以上より，本研究で開発した肺気量推定法は，立位呼吸時には非常に高い精度で算出可能であったが，競泳中に応用するには，さらなる改善の必要性が示唆された．