先端工学を活用した脚のむくみ(浮腫)の包括的評価とその応用
―スポーツ用弾性靴下の効果と作用機序の検討―

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Comprehensive Assessment of Leg Swelling Using Advanced Technologies: Physiological Effects and Mechanisms of Sports Compression Stockings on Fatigue and Recovery

by

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ABSTRACT

We have recently developed a comprehensive approach for monitoring leg swelling using several advanced technologies. With this approach, the present study aimed to investigate the exercise-induced leg swelling and its recovery in humans. The effect of wearing a compression stocking on leg swelling and muscle fatigue was also investigated. Healthy young volunteers performed unilateral calf-raise exercise for both legs, wearing a compression stocking only on one leg. Before and immediately after the exercise, maximum calf circumference was determined by tape measure, extracellular fluid resistance (R_0) of the lower leg by segmental bioelectrical impedance spectroscopy, foot and lower leg volume by modified water displacement

volumetry, and the gastrocnemius muscle stiffness by ultrasound shear-wave elastography. Concurrently, muscle soreness, contractile force during voluntary and evoked contractions, and unilateral vertical jump performance were examined. These measurements were repeated 1, 2 and 5 days after the exercise. There were significant increases in calf circumference, the reciprocal of R_0 (an index of extracellular fluid volume), and total lower leg volume immediately after the exercise. However, further measurements suggest that the exercise-induced leg swelling found in this study was mainly due to the increase in blood flow and metabolite accumulation, not due to muscle damage and subsequent inflammatory response. We also found a limited impact of sports compression stocking on the exercise-induced leg swelling, while the decrease in maximal voluntary contractile force tended to be attenuated in the leg wearing the stocking. These results suggest that wearing compression stockings accelerates force recovery during the first few days after exercise, which may not be related to its edema-preventing effect.

要　旨

本研究の目的は，我々がこれまでに開発・確立した評価系を用いて運動により生じる脚のむくみとその回復について検討すること，およびスポーツ用弾性靴下による脚のむくみ軽減効果を検討することであった．健康な若齢男女が片脚のレジスタンス運動（カーフレイズ）を行った前後と 1, 2, 5 日後において，脚のむくみの指標となる下腿部周囲長, 下腿部細胞外液量指標(生体電気インピーダンス法)，足部・下腿部の体積（改良版の水置換法），腓腹筋スティフネス（超音波せん断波エラストグラフィ）などを測定した．運動時，一方の脚のみに弾性靴下を着用させた. 結果から, カーフレイズにより生じる脚のむくみは一過的であり，筋の損傷や炎症に由来するとされる運動 1 日後以降のむくみは起こらないことがわかった．また，弾性靴下の着用脚で運動 2 日後に観察された筋力低下の軽減については，むくみの除去や軽減とは独立したメカニズムの関与が示唆された.