Morphological and mechanical characteristics of lower limbs in endurance runners and their relevance to running economy

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１．Purpose

The purpose of this thesis was to investigate the morphological characteristics of the lower limbs in endurance runners from inertia perspective and their relevance to running economy. I hypothesised that inter-individual variability in lower-limb inertia properties affects the energy required for leg swing and explains O_2 cost.

２．Methods

1） Participants: Endurance runners and untrained individuals.

2） Measurements: Lower-limb MRI in both group. Oxigen uptake and running motion in runners.

3） Main outcomes: lowe-limb moment of inertia around hip joint ($I_{lowerlimb}$), O_2 cost, energy cost for swing motion.

３．Results and Discussions

Study 1.1 $I_{lowerlimb}$ and lower-limb mass significantly smaller in runners than controls, but the inter-group difference in $I_{lowerlimb}$ was not as large as that in mass. The most notable difference was found in fat mass of the thigh. Fat mass in the thigh correlated significantly with $I_{lowerlimb}$ in non-runners, but not in runners. I suggest that the lower-limb of endurance runners have reduced fat mass and maneuverability, but there are limits to the reduction in fat mass and thus lower limb maneuverability.

Study 1.2 Normalized $I_{lowerlimb}$ was significantly correlated with O_2 cost. I revealed that lower-limb maneuverability is important for running cost.

Study 2.1 When using directly measured inertia parameters, a correlation between energy cost required for leg swing and O_2 cost was significant. However, the correlation was not significant when using the literature value for inertia coefficients, similar to conventional biomechanical analysis. These results imply that inertial errors caused by using literature values mask the relationship between O_2 cost and energy cost for motion.

Study 2.2 I found significant correlations between peak hip extension power and swing energy at all speeds and between peak hip extension power and O_2 cost. Normalized $I_{lowerlimb}$ was also significantly correlated with hip extension peak power. Therefore, I found that individual difference in inertial characteristics affects energy cost for swing motion and O_2 cost more than technical factors during the late swing phase.

４．Conclusions

Lower-limb maneuverability is an important factor in reducing O_2 cost. This provides practical implications that endurance runners should be careful not to increase the lower-limb moment of inertia, and that lower-limb maneuverability can be an important perspective for talent spotting.

５．Reference

1） Sado, N., Ichinose, H., Kawakami, Y., 2023. The Lower Limbs of Sprinters Have Larger Relative Mass But Not Larger Normalized Moment of Inertia than Controls. Med Sci Sports Exerc 55, 590–600.