Effect of lumbar spine motion on psoas major length during running at different speeds

Tempei Tominaga[1], Yoshiki Tasaki[1], Natsuki Sado[2,3]
[1] Graduate School of Comprehensive Human Sciences, University of Tsukuba, Tsukuba, Japan
[2] Institute of Health and Sport Sciences, University of Tsukuba, Tsukuba, Japan
[3] Advanced Research Initiative for Human High Performance, University of Tsukuba, Tsukuba, Japan
Email: sado.natsuki.gm@u.tsukuba.ac.jp

Summary

The psoas major (PM) generates a greater force during faster running. Longer PM shows lower force-generating potential, due to its force-length relationship confined to the descending limb. Anatomically, PM length is affected by lumbar and hip movements. As running speed increases, hip extension would increase, which lengthens PM. Meanwhile, lumbar lordosis also increases, potentially shortening PM. However, the effect of lumbar spine motion on PM length has been neglected. We estimated PM length during running at 4.0, 5.5, 7.0, and 8.5 m/s, using fixed and moving lumbar spine models. As running speed increased, PM length increased in the fixed model, but no notable differences were observed in the moving model. PM was shorter in the moving model than in the fixed model at 7.0 and 8.5 m/s. Lumbar spine motion offset PM elongation due to hip extension. This may contribute to maintaining the force-generating potential.

Introduction

The psoas major (PM), a major hip flexor, generates greater force during faster running [1]. The force-generating potential of PM decreases as it is lengthened, due to its force-length relationship confined to the descending limb [2]. Based on its anatomy, PM length is affected by the motion of the lumbar spine and the hip. As running speed increases, hip extension would increase, which is believed to lengthen PM. Meanwhile, lumbar lordosis also increases [3], potentially shortening PM. However, the effect of lumbar spine motion has been neglected [4]. We examined the effect of lumbar spine motion on PM length during running at different speeds by comparing the models with and without lumbar spine motion.

Methods

Male track and field athletes [n = 18; 21.8 ± 1.7 years; 1.75 ± 0.05 m; 67.8 ± 5.0 kg; 100 m personal best, 11.05 ± 0.32 s] ran on a treadmill at 4.0, 5.5, 7.0 and 8.5 m/s. We collected three-dimensional coordinates of the whole-body landmarks including C7–L5 spinous processes by a motion capture system. To calculate PM length, we estimated the position and orientation of the L3 vertebra from the position of its spinous process and the curve of the whole lumbar spine. We employed two models: 1) fixed lumbar spine model (FIXED) where the vertebra is fixed to the pelvis at the position during upright standing, 2) moving lumbar spine model (MOVING) where the vertebra moves relative to the pelvis, reflecting lumbar spine motion during running. We used established methods to estimate the via points on the pelvis and the insertion on the femur for both models [4, 5]. We tested differences in PM length and maximal hip extension angle between running speeds, and in PM length between models.

Results and Discussion

All running speed increments caused significant increases in the maximal hip extension angle and the PM length in FIXED at the maximal hip extension. Meanwhile, the PM length in MOVING showed no significant differences for all running speed increments. The PM lengths were significantly shorter in MOVING than in FIXED at 7.0 and 8.5 m/s. Pronounced lumbar spine motion during faster running substantially counteracted the effect of hip extension and prevented PM elongation. This may contribute to maintaining the force-generating potential of PM during faster running. PM has been considered poorly suited for running because of lower force-generating potential in extended hip position [2]. However, we suggest that lumbar spine motion mitigates this disadvantage when a large force is required.

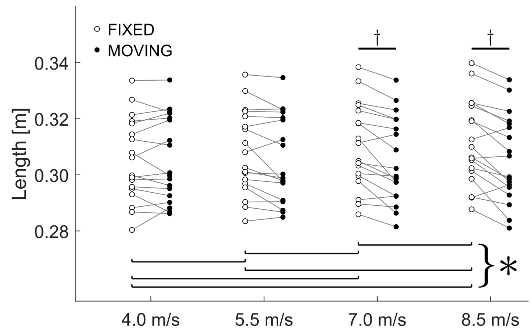

Figure 1: Psoas major length at the maximal hip extension. † and * indicate significant differences between models and running speeds, respectively.

Conclusions

We revealed the substantial effect of lumbar spine motion that prevents PM elongation during faster running. It can improve the force-generating potential of PM, which is relevant to the running performance.

Acknowledgments

This research was supported by JST SPRING, Grant Number JPMJSP2124 and a grant 2024(I)13 from Advanced Research Initiative for Human High Performance (ARIHHP), University of Tsukuba.

References

[1] Anderesson et al. (1997). *Acta Physiol Scand*, 161(3): 361-370.
[2] Regev et al. (2011). *Spine*, 36(26): E1666-E1674
[3] Tominaga et al. (2024). *ISBS Proc Arch*, 42(1): 69
[4] Delp et al. (1996). *J Orthop Res*, 14(1): 144-151
[5] Sedlmayr et al. (2022). *Anat Rec*, 305(5): 1147-1167