Relationship between Joint Quasi-stiffness and Joint Power of the Ankle and Knee Joints in the Sprinting Start

Koki Yamamoto[1], Keiichiro Hata[1], Yohei Yamazaki[1,2], Misato Ishikawa[1], Lee Rou You[1], Kazuyuki Kanosue[2], Toshio Yanagiya[1,2]
[1]Graduate School of Health and Sports Science, Juntendo University, Chiba, Japan
[2] Institute of Health and Sports Science & Medicine, Juntendo University, Chiba, Japan
Email: proymmt32@gmail.com

Summary

This study aimed to elucidate the relationship between knee and ankle joint quasi-stiffness and sprint performance in the first and second steps of a sprint start. Fifteen sprinters performed a 10-m sprint starting from blocks, with ground reaction force and motion data recorded. No significant correlation was observed between joint quasi-stiffness and horizontal external power or negative joint work both at the ankle and knee. These findings differ from a previous single-athlete study, suggesting that joint stiffness affects sprint performance within individuals and not between individuals. Therefore, joint quasi-stiffness may not play an important role in sprint start performance.

Introduction

In the acceleration phase of sprinting, the knee joint power was highlighted in the first step and the ankle joint power in the second step after a squat start [1, 2]. Both joints exhibit negative joint power immediately after foot contact, indicating energy absorption, followed by positive joint power [1]. Sprinters with higher joint quasi-stiffness have been shown to have less negative joint work at a constant speed, indicating reduced energy absorption during the stance phase [3]. This suggests that greater joint quasi-stiffness may reduce the magnitude of negative joint power, allowing more efficient energy transfer and resulting in greater net joint work during the stance phase. However, the relationship between joint quasi-stiffness and sprinting start performance remains unclear. Therefore, the purpose of this study was to elucidate the relationship between ankle and knee joint quasi-stiffness and sprinting start performance in the first and second steps, specifically by examining horizontal external power as an indicator.

Methods

A total of 15 sprinters (13 males and 2 females) performed a 10-m sprint starting from blocks on an indoor track. Ground reaction forces during the stance phases were measured by three force platforms embedded in the surface. Kinematics parameter was measured using a three-dimensional motion analysis system (VICON). Inverse dynamics revealed the joint moments at ankle and knee joint. Joint power was calculated by multiplying joint moment and joint angular velocity. Joint work was determined by integrating joint power. The negative phase was defined as the period of the negative joint power. Horizontal external power was determined and averaged during the stance phase. Joint quasi-stiffness was evaluated during the negative joint power phase.

Results and Discussion

As no negative knee joint power was observed during the second step, knee joint quasi-stiffness was calculated only for the first step. For both the ankle and knee, no significant correlation was found between joint quasi-stiffness and mean horizontal external power, regardless of whether it was during the first step or the second step (Figure 1). Additionally, no significant correlation was observed between joint quasi-stiffness and negative joint work at the ankle and knee, for either the first step or the second step (Figure 2). These results differ from a previous study analyzing for individual athletes [4], suggesting that joint stiffness may influence sprint performance within individuals and not between individuals. Our results suggest that joint quasi-stiffness may not explain the difference in the start performance of sprinters, as both ankle and knee joint quasi-stiffness did not affect horizontal external power or negative work of each joint.

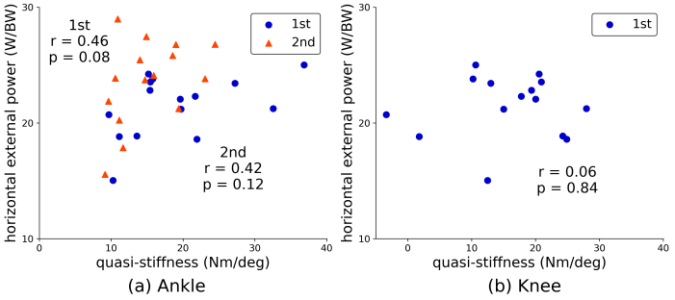

Figure 1: The relationship between joint quasi-stiffness and average horizontal external power

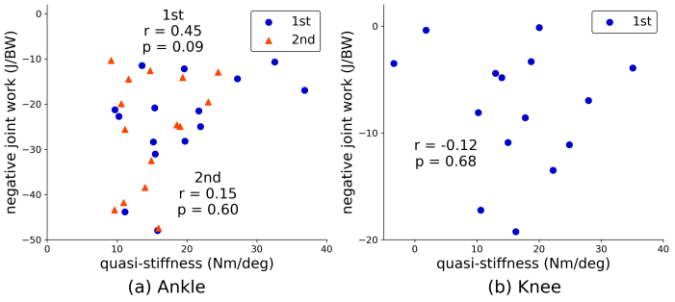

Figure 2: The relationship between joint quasi-stiffness and negative joint work

Conclusions

Ankle and knee joint quasi-stiffness had no significant correlation with horizontal external power or negative work of each joint in either the first or second step.

References

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