The effect of Nordic walking on Knee-ankle coordination patterns in the sagittal plane: A vector coding analysis

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Summary

This study investigated knee and ankle kinematics and coordination patterns during normal and Nordic walking using a smartphone-based motion capture system (OpenCap). Twelve healthy participants performed normal and Nordic walking, and vector coding was used to analyze the knee-ankle coupling angles in the sagittal plane. Results revealed smaller range of motion (ROM) of knee joint and less knee flexion during early stance and push-off to swing phases in Nordic walking compared to normal walking. Ankle plantarflexion increased during early stance, while dorsiflexion decreased in mid-stance but increased before the push-off phase. Nordic walking showed less dominance of Anti-Phase Knee Flexion (AP-KF) patterns. These findings highlight Nordic walking's potential biomechanical benefits in reducing load absorption demands and promoting effective push-off through pole assistance.

INTRODUCTION

Nordic walking has gained popularity for its benefits on lower extremity joint biomechanics [1]. Although previous studies have examined joint kinematics during Nordic walking [2], limited evidence exists on how the Nordic walking technique influences ankle and knee joint kinematic coordination. Therefore, this study aimed to examine knee and ankle joint kinematics and coordination patterns in the sagittal plane during normal and Nordic walking.

METHODS

Twelve healthy subjects performed normal and Nordic walking, with joint kinematics captured using a smartphone-based motion capture system (OpenCap). We calculated knee and ankle angles, range of motions, and coupling angles in the sagittal plane of a dominant leg. In addition, we counted phases categorized as In-Phase/Anti-Phase and dominancy of knee flexion/extension and ankle dorsiflexion/plantarflexion [3]. Paired t-tests were used for discrete values including ranges of motion (ROM) and phase counts. Statistical Parametric Mapping (SPM) was used to analyze time-series joint angles.

RESULTS AND DISCUSSION

Knee ROM was significantly smaller in Nordic walking (56.04 ± 5.24°, $p = 0.040$), with less knee flexion during the early stance phase (0-7 % and 18-27% of gait cycle, $p = 0.001$) and push-off to swing phase (53-100% of gait cycle, $p < 0.001$). Ankle plantarflexion was greater during the early stance phase (3-13% of gait cycle, $p = 0.001$), while ankle dorsiflexion was less during mid-stance (23-32% of gait cycle, $p = 0.002$) but greater before push-off (49-51% of gait cycle, $p = 0.047$) (Figure 1).

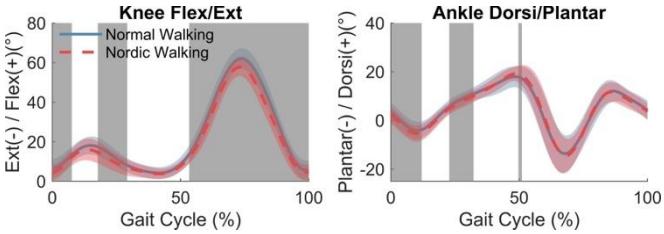

Figure 1: Normalized time series (Mean ± SD) of knee flexion/extension and ankle dorsiflexion/plantarflexion angles during normal walking (blue) and Nordic walking (red). Dark gray bars below indicate significant regions from SPM {t} analysis.

Additionally, Nordic walking showed less Anti-Phase Knee Flexion (AP-KF) pattern than normal walking (Figure 2).

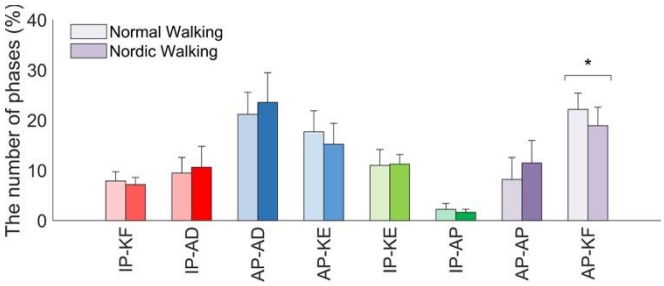

Figure 2: Mean ± SD of the number of phases (%) for the normal walking (light color) and the Nordic walking (dark color). *Indicates a statistically significant difference ($p < 0.05$).

CONCLUSION

The results suggest that Nordic walking reduces the demand for load absorption and helps keep the leg in favorable lower extremities kinematics to enhance push-off power through additional support from the poles. This study is the first to apply the vector coding technique to analyze Nordic walking and highlights its biomechanical benefits in load absorption and propulsion assistance.

Acknowledgments

This work was supported by BK21 FOUR (Fostering Outstanding Universities for Research) (No. 5199990914048) and the Soonchunhyang University Research Fund.

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