Real-Time Spine Analysis: Bridging Statics and Dynamics with 3D Motion Capture System

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Summary

This study examines the effects of high heel (HH) use on spinal posture and biomechanics compared to barefoot (BF) walking. Although there is ample evidence of the detrimental effects of HH usage on spinal health, the majority of studies have relied on static spine examination, which frequently yields contradictory findings. Recognizing the need for dynamic evaluation, this study employs a 3D motion capture system to assess the spine under static and dynamic conditions during different phases of the stance phase using a simple displacement calculation. The findings reveal that wearing HH leads to lumbar compression under static and dynamic conditions and prolonged usage might lead to lower back pain (LBP). Employing a dynamic approach enhances understanding of movement biomechanics while serving as a versatile tool for evaluating other spinal deformities and related conditions, thereby contributing to better comprehension and management of spinal issues.

Introduction

Postural issues can result from various factors and lead to significant health problems. Numerous traditional methods exist for evaluating the spine; however, they are only capable of static assessment. Rehabilitation depends on an accurate clinical evaluation of lumbar curvature, but there is currently little research on this evaluation in both static and dynamic settings [1]. The inconsistency between video analysis and related pictures is a significant difficulty with dynamic motion stimulus approaches, making it more difficult to assess lumbar curvature during movement. The use of a 3D motion capture device offers a viable method for spinal dynamics investigation in real-time. This work intends to improve the efficacy of clinical examinations compared to conventional diagnostic approaches by estimating lumbar compression across various activities, specifically through a simple marker displacement method.

Methods

The study included twenty young, healthy female volunteers (age (22.66 ± 1.67), height (156.63 ± 3.58 cm)) without any history of accidents or anatomical abnormalities. Participants with lower back pain, spinal fractures, postural deformities, and scoliosis were excluded from this study. A 3D motion capture system (Qualisys, Oqus 5.0, Miqus 3.0, Sweden) was integrated with a data acquisition system and computer to obtain the kinematic data. A 6 m long walkway was used for experimenting. This research used a high-heeled shoe with a heel size of 5.5 cm and different foot sizes. The Istituti Ortopedici Rizzoli (IOR) full-body marker set was used to study the effect of high-heel shoes on the spine at static and dynamic conditions. Six markers placed in the spinal region, LV1 (1st lumbar vertebrae) and LV5 (5th lumbar vertebrae), were used to measure displacement [2] in the lumbar region (LV1 to LV5) to compare the amount of compression in the spine under static and various subphases of stance phase (heel strike (HS), loading response (LR), midstance (MS), heel off (HO), and toe-off (TO)) for BF and HH walking.

Results and Discussion

The results of this study indicate a reduction in lumbar displacement when wearing HH. Under both static and dynamic conditions (Figure 1), there is a decrease in displacement during normal standing (2.72%) and across different subphases of the stance phase (HS – 0.29%, LR – 0.85%, MS – 1.25%, HO – 3.5%, and TO – 6.53%) for HH walking. This reduction in displacement is directly related to the compression experienced in the spine and lumbar area. The shift in the base of support in the anterior direction and a modification in ankle orientation increases the chance of falling while wearing HH. As a compensatory mechanism and to maintain body balance, the erector spinae and cervical paraspinal muscles become more active [3]. However, prolonged activation of these muscles can lead to spinal compression, reduced mobility, and muscle fatigue. Over time, this strain contributes to swelling, tissue degeneration, and restricted spinal movement. The excessive engagement of the erector spinae is a key factor in decreased lumbar angle and spinal compression associated with HH use.

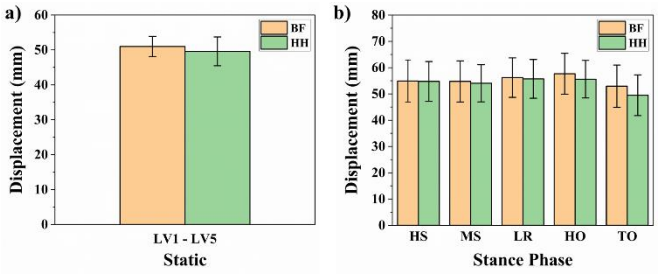

Figure 1: The average displacement (mean ± SD) over trials and subjects in the lumbar region (LV1-LV5) under a) static and b) dynamic (subphases of the gait cycle) conditions between BF and HH walking.

Conclusions

This study shows that wearing HH leads to compression in the lumbar region. The degree of compression in the lumbar varies in each phase of the stance phase (gait cycle).

References

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