**Minimization of Distal Joint Torque Through Proximal Playing Strategies by Using Digital Simulation ~~Incorporating Dynamic Trunk Motion in Piano Performance: A Biomechanical Strategy to Prevent Musculoskeletal Disorders~~**

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**Keywords**

Piano performance, Musculoskeletal disorders, Optimal Control theory, Trunk Motion

Abstract

Playing-related musculoskeletal disorders (PRMDs) are common among pianists, posing significant challenges to their health and performance capabilities. Using optimal control theory, the goal of this study was to evaluate the biomechanical effects of proximal playing strategies during simple piano tasks, focusing on the reduction of distal joints torque, where common PRMDs are found. A 3D torque-driven upper body biomechanical model with 10 degrees of freedom was developed using Bioptim. We simulated two types of touch (struck, pressed) during isolated loud keystrokes while using a dynamic trunk (DT) vs a static trunk (ST) playing strategy. A weighted torque minimization cost function was applied to the model joints to greatly reduce distal joints torque (MCP and Wrist) during both playing strategies and touch types. DT strategy reduced cumulative squared torque at distal joints, with a 30% reduction for struck and 20% in pressed touches. In ST conditions, the shoulder joint exhibited greater mechanical work, suggesting a compensatory mechanism for the absence of trunk contribution ~~and potentially increasing the risk of muscular fatigue~~. The wrist also showed a compensatory shift from controlled to active movements when trunk movements were excluded. This study indicates that the DT approach may reduce torque on distal joints, which are more susceptible to PRMDs, by altering the workload distribution among upper body joints.