Clin Orthop Relat Res (2016) 474:2064–2066 / DOI 10.1007/s11999-016-4965-2

Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®

Published online: 8 July 2016

CORR Insights

CORR Insights®: Hip, Knee, and Ankle Osteoarthritis Negatively Affects Mechanical Energy Exchange

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Where Are We Now?

Energy expenditure measurement is considered a reliable method for quantitatively assessing gait disability [4]. Few studies have examined the effects that lower limb osteoarthritis (OA) has on the joints, specifically the hip, knee, and ankle joints for patients 45 years of age or older [2, 8]. Lower limb OA can affect the hip, knee, and ankle and is associated with joint pain, ROM limitation, and fatigue [1, 2].

When walking on an assumed stiff leg, the center of mass follows the cycle of an "inverted pendulum." Think of a pendulum that has its center of mass above its pivot point. A person with an upright position will constantly make adjustments to maintain balance during standing, walking, or running. The inverted pendulum model has been used to describe the transformation between potential energy and kinetic energy for propulsion [5, 6]. When this exchange is efficient, it will take less energy to walk. However, the exchange expends more energy, which could explain why patients with OA develop fatigue [7–9].

Lower extremity OA reduces the exchange of potential and kinetic energy, increasing the muscular work required to control movements of the center of mass [12, 14]. The fatigue and limited physical activity reported in patients with OA of the lower extremity could be associated with increased mechanical work of the center of mass.

Queen and colleagues have a novel view on the energy exchange between potential and propulsive energy of the center of mass during walking. An orthopaedic surgeon identified all participants of the study as having end-stage radiographic disease, and all were considered candidates for joint replacement surgery. After adjusting for walking speeds, the results indicated that those showing no signs of OA had greater recovery than those with hip OA and ankle OA.

The primary force of progression is an individual's body weight. Progression over the stance limb is assisted by a rocker action by the foot and ankle. Another progressive force is provided by the swinging limb [10]. The role of the knee is passive with a linkage of ankle and hip joints.

This CORR Insights® *is a commentary on the article* "Hip, Knee, and Ankle Osteoarthritis Negatively Affects Mechanical Energy Exchange" *by Queen and colleagues available at*: DOI: 10.1007/s11999-016-4921-1.

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This *CORR* Insights® comment refers to the article available at DOI: 10.1007/s11999-016-4921-1.

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Where Do We Need To Go?

Currently, we know the energy recovery rate of each joint involvement due to end-stage OA, and we generally understand the center of mass fluctuation [3, 13]. However, we have to investigate the total energy consumption affected by arthritis of the major joints in the lower extremity [11]. Is there any difference of total energy among the several conditions derived from single or multiple joint involvement? The center of mass fluctuation is not limited to the vertical direction. A lateral shift of the center of mass and its control in stance phase also is important, as the center of mass depends upon the laterality of joint involvement and on gait symmetry. Of course, movement in the horizontal plane does not cause a fluctuation of the energy transformation. But, this is an essential point—we need a different point of view from energy transformation between potential energy and kinetic energy for propulsion in sagittal plane.

How Do We Get There?

In their study, the authors mentioned that a "disruption in energy exchange is associated with changes in the timing and magnitude of the center of mass energy fluctuations." Future studies should examine how the center of mass sways in each case of joint involvement, as well as how a center of mass change regulates energy saving during gait phases.

Queen and colleagues calculated the recovery rate of energy transformation through one cycle of gait. Future studies should conduct a more precise analysis that examines (1) stance or swing phases of the affected side, and (2) ascending or descending phases of the center of mass in a stance period. If we know which phase has difficulty in transforming energy, rehabilitation interventions could be more effective at mitigating the energetic burdens of disability during ambulation. Focused gait retraining could potentially improve walking mechanics and decrease fatigue in this patient population.

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