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Review article

Possible changes in energy-minimizer mechanisms of locomotion due to chronic low back pain - a literature review

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ABSTRACT

One goal of the locomotion is to move the body in the space at the most economical way possible. However, little is known about the mechanical and energetic aspects of locomotion that are affected by low back pain. And in case of occurring some damage, little is known about how the mechanical and energetic characteristics of the locomotion are manifested in functional activities, especially with respect to the energy-minimizer mechanisms during locomotion. This study aimed: a) to describe the main energy-minimizer mechanisms of locomotion; b) to check if there are signs of damage on the mechanical and energetic characteristics of the locomotion due to chronic low back pain (CLBP) which may endanger the energy-minimizer mechanisms. This study is characterized as a narrative literature review. The main theory that explains the minimization of energy expenditure during the locomotion is the inverted pendulum mechanism, by which the energy-minimizer mechanism converts kinetic energy into potential energy of the center of mass and vice-versa during the step. This mechanism is strongly influenced by spatio-temporal gait (locomotion) parameters such as step length and preferred walking speed, which, in turn, may be severely altered in patients with chronic low back pain. However, much remains to be understood about the effects of chronic low back pain on the individual's ability to practice an economic locomotion, because functional impairment may compromise the mechanical and energetic characteristics of this type of gait, making it more costly. Thus, there are indications that such changes may compromise the functional energy-minimizer mechanisms.

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Possíveis alterações no mecanismo minimizador de energia da caminhada em decorrência da dor lombar crônica - revisão de literatura

Palavras-chave:
Dor lombar
Locomoção humana
Caminhada
Biomecânica
Consumo de energia

RESUMO

Um dos objetivos da marcha é deslocar o corpo no espaço da forma mais econômica possível. Porém, pouco se sabe como os aspectos mecânicos e energéticos da caminhada são afetados pela dor lombar. Ainda, caso haja prejuízos, é pequeno o conhecimento de como as características mecânicas e energéticas da caminhada se manifestam nas atividades funcionais, principalmente nos mecanismos minimizadores de energia da locomoção. Este estudo teve por objetivos: a) descrever os principais mecanismos minimizadores de energia da locomoção; e b) verificar se há indicativos de prejuízos nas características mecânicas e energéticas da caminhada decorrentes da dor lombar crônica (DLC) que possam comprometer os mecanismos minimizadores. Estudo caracterizado como revisão narrativa de literatura. A principal teoria que explica a minimização do dispêndio energético durante a caminhada é a do pêndulo invertido pelo qual o mecanismo minimizador converte energia cinética em energia potencial do centro de massa e vice-versa durante a passada. Esse mecanismo é fortemente influenciado por parâmetros espaços-temporais da marcha, tais como comprimento de passo e velocidade preferida da caminhada, que, por sua vez, podem estar severamente alterados em pacientes com dor lombar crônica. Contudo ainda há muito que se entender sobre os efeitos da dor lombar crônica sobre a capacidade do indivíduo de praticar uma marcha econômica, pois os prejuízos funcionais podem comprometer características mecânicas e energéticas dessa modalidade de marcha e torná-la mais dispendiosa. Desta forma, há indicativos de que tais mudanças funcionais possam comprometer os mecanismos minimizadores de energia.

Introduction

The adoption of locomotion on two legs as an exclusive form of march was an important marker of human evolution, and energy saving, in this type of locomotion, is one of the main reasons for the establishment of bipedalism.[1–3] However, the bipedal locomotion cannot always be considered as a simple task. The trunk, essentially unstable for its multijoint characteristics, maintains its stability by muscular action that constantly modifies itself to ensure the needed posture to movements.[4] Therefore, the ability of locomotion depends on a complex interaction of patterns of coordinated movements of the hip, pelvis and lumbar spine, which, when harmonic, determine the normal biomechan-ical gait pattern.[1,5]

Walking is a form of locomotion that stands out by influencing multiple aspects in the physical, social and evolutionary spheres of human existence.[6] An anthropological and evolutionary vision makes us think that, if the modern man can walk quietly and use this ability to perform his daily activities, in the past perhaps this was not so simple for our ancestors - probably bipedal locomotion was used for escape, producing tiredness and fatigue. Bipedal locomotion was used to permit man's flight, causing greater exhaustion and fatigue. Throughout the evolutionary period, certain anatomical changes were occurring slowly over thousands of years, to allow the fixation of this mode of march and promoting adaptations of human locomotor system that provide us with perspectives on musculoskeletal disorders found in the current clinical scenario.[7]

The biped march encompasses many aspects that go beyond a simple act of placing one leg in front of the other. It can be understood as a cyclic movement with loss and recovery of the balance, due to the constant change of position of the body center of mass promoting body instability. Such instability is compensated by leg movements, ranging from a stance phase, which can be single-leg or bipedal, and a swing phase, in which the leg is free in the air. Thus, at the end of the swing phase, the center of mass lies in a posterior relation to the anteriorly extended leg and begins to rise, due to the kinetic energy, at the beginning of the stance phase, after the heel contact with the ground (i.e., heel-strike). During the first half of the step, the kinetic energy decreases as the center of mass gains height, with consequent increase of potential energy which reaches its peak in the middle of the one-leg support phase. In the second half of the step, the opposite occurs; the center of mass loses height and the potential energy is converted into kinetic energy. The reconversion between the mechanical energies connected to the center of mass during walking plays a crucial role in the individual's ability to walk as economically as possible, and is influenced by a number of spatio-temporal gait variables, such as step length and gait speed.[8–11]

The impairment of the normal gait cycle and the loss of characteristics of energy conservation between trunk and limb movements result in greater energy expenditure. Patients with diseases that compromise the ability to walk tend to develop compensatory gait patterns to minimize the additional energy expenditure.[9]