Brief Communication

Scientific understanding of the loading response in elderly subjects

Mudassar Ahmed, MSc, BS.

Gait or walking is the act of repeated events of lower limb motion, which moves the body forward, while maintaining the body's upright stability. A gait cycle is the term given to the single sequence of these events by using only one limb. During this sequence, one limb remains in contact to maintain stability with the surface while the other limb takes the body forward. Functions of the limbs are reversed, and in this way the body reaches the desired position. In the views of Hausdorff[1] gait or walking is a semi automated motor task controlled by the cortical organization. Forward propulsion of the body from one position to the other depends upon the interrelated activities of various lower limb joints. Depending on the relationship between the foot and the surface, gait is normally divided into 2 phases. The time duration when the foot is in contact with the surface is termed the stance, and the duration when it is in space is named swing. The normal gait cycle consists of 60% stance phase, and 40% swing phase.[2] During the gait cycle, various lower limb joints perform 3 functional tasks of the selective synergistic motions that serve to fulfil a functional goal. The first significant objective of the gait cycle is the weight acceptance, which includes initial contact, and a loading response. The second task of the gait cycle is to support the upper body on a single limb, and it is comprised of mid stance and terminal stance. Limb advancement is the third functional component of gait cycle, which includes pre-swing, initial swing, mid swing, and terminal swing. For reference purposes, the gait cycle can be started from any of its events as the starting point but initial contact is normally considered as the initial starting event of the gait cycle.

The stance phase starts when the foot makes initial contact with the surface. This phase begins after the initial contact and continues until the foot is ready to be lifted off the ground for swing. Imperative events of the stance phase include weight acceptance and loading response. This 2% phase of the gait cycle accommodates for 60% of the body weight. It is the important phase of the gait cycle as it serves the most important functions of walking. Shock absorption and weight bearing stability are the major tasks of loading response.

Gait and its different phases are analyzed in terms of kinetics and kinematics of the joints involved. Kinetics are the internal and external forces, which cause various gait events to happen, while kinematics are the actual event of gait cycle. The behavior of loading response is analyzed by the motion analysis system, which focuses on the joint magnitude and timing issues in association with the force plate recordings. To measure the physiology of loading response, dynamic electromyography, which identifies relative intensities of the muscles, is used.

During early events of the loading response, the ankle joint is at 90 degrees. At this point, the initial impact vector forces are vertical giving stability, but no mobility. Therefore, the ankle functions as a heel rocker during the loading response to keep the body propelling forward. The tibia starts rolling over the round surface of the calcaneum and places the body vector posterior to the ankle joint. This whole heel rolling apparatus is called heel rocker. This heel rocker mechanism prepares the limb for weight acceptance and shock absorption.[2] This forward propulsion of the tibia during the loading response is perhaps the most important function of the gait cycle. This heel rocker effect is reduced by 10^0 plantar flexion at the ankle joint during the late phase of the loading response. Various authors[4] have studied the effect of loading on the ankle joint using various analysis systems.

Force plates and a pressure sensitive insole system are needed to analyze weight distribution and pressure areas of the foot during the loading response. Reliability of these insole pressure sensitive dynamic pressure distribution detector systems and force plates has been reported by various authors.[3] Before loading response, a close packed position of the knee joint gives stability to the lower limb, but this stability is disturbed by the sudden weight acceptance during loading response. Hence, the knee goes into flexion to provide a shock absorber mechanism until the foot is flat on the ground. An absent loading response in the elderly population is characteristic of absent knee flexion movement during the stance phase. Perhaps this knee flexion movement is necessary for the loading to occur at the joint. At this phase, knee flexion is controlled by the eccentric activity of the quadriceps muscles.

Evidence suggested that eccentric quadriceps training improves control at this knee flexion torque. Peak knee flexion is also found to be increased with increasing gait speed. Some other authors[4] also noticed a similar increase in the knee flexion range of motion by increasing the gait speed. This may be because during the loading phase, a sudden weight is imposed on the stance limb, and the knee needs to act as a shock absorber to counter the situation. Therefore, forward motion of the tibia brings the body vector posterior to the knee joint and creates a knee flexion torque during the loading response. Hamstring activity flexes the knee through approximately 15^0, while the quadriceps works eccentrically and limits knee flexion, and thus helps for shock absorption. If knee flexion torque is meant for shock absorption, then this flexion torque might not be present during the swing phase. However, evidence supports a demand for knee flexion during the swing phase as well as during the stance phase. This shows the involvement of some other undiscovered factors during the loading phase of gait in healthy adults.[3]

The hip joint is in the 30% flexed position during the early period of the loading response. This anterior body vector creates demand for more flexion at the hip joint while hip extensor muscles contribute to maintain the stability at this stage. The hip joint moves through its complete available range of motion during the gait cycle, but a reduced hip extensor torque is noticed in the elderly population. Some other researchers[5] also found this reduced hip extension due to the presence of hip flexion contractures or tightness. Since gait is the only daily activity that moves the hip joint through its full extension range of motion, this hip flexor tightness, or contracture in the elderly population might be related to decreased walking ability or some other undiscovered factors. Since stretching is evidenced to increase the flexibility of hip flexors in the elderly, hip flexor stretching is advised to increase extensor range to facilitate hip flexors and to make walking easier.

A passive extensor effect by the heel rocker and vector realignment at the hip joint, after the loading response, ceases activity of the hip extensors. Therefore, the hip and knee muscles relax after accomplishing their tasks at the end of the loading response. Overall gait performance can be best represented and analyzed by spatial and temporal variables. Spatial variables are those that tell about length variables of gait like step and stride lengths. Temporal parameters deal with different gait variables in terms of time measures like swing, stance, and step length time.[4] Asymmetrical loading in elderly subjects is an indicator of poor temporal gait characteristics.[5] Therefore, gait velocity can best represent the overall gait performance.

Kim and Eng[4] found the symmetry in normative gait both spatially and temporally. It has been noted that temporal gait components are in a linear relationship with walking speed. Evidence also suggests that overall temporal parameters are related to gait symmetry and not the velocity. Such opposing results may be due to the small sample size of these studies and the actual analysis process. Petterson[5] studied the relationship between these 2 important aspects of the gait cycle; gait velocity and gait symmetry. Some subjects were allowed to use a cane while walking while others were not, so results were opposing to the previously known facts on gait speed and symmetry.

Loading response is the most imperative element of the gait cycle as 60% of the body weight is stabilized and handled by this 2% part of the gait cycle. Lack of the loading response in elderly subjects is characteristic of the absent knee flexion movement. Diagnosing the cause of abnormality in the loading response phase of the gait cycle could help to better understand the biomechanical changes taking place in the lower limb joints as a result of the natural ageing process or any neurological degenerative disease. Shock absorption, energy conservation, and weight acceptance are the core functions taking place during the loading response. Mechanisms responsible for these vital functions are still not fully understood therefore, future research is needed in this area. Understanding the mechanics of lower limb joints in elderly patients might help in diagnosing the outcomes of any specific disease and this may help in the treatment planning.

Received 6th May 2008. Accepted 24th December 2008.

From the Department of Health and Bioscience, University of East London, London, United Kingdom. Address correspondence and reprint requests to: Mudassar Ahmed, Physiotherapist, 239 Monega Road, Manor Park, London E12 6TU, United Kingdom. Tel. +44 7929458423. E-mail: mudassar@csppak.org

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