EFFECTS OF A HEAVY BACKPACK ON LOWER EXTREMITY JOINT MECHANICS DURING GAIT

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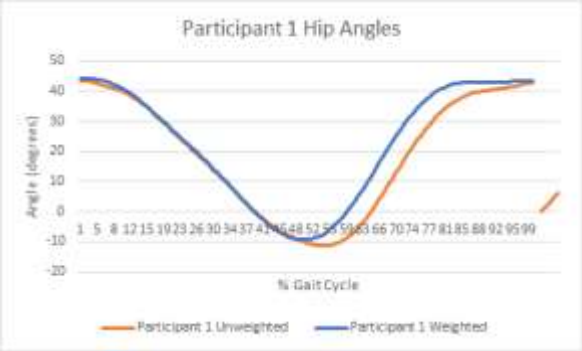
BACKGROUND: "According to the U.S. Consumer Product Safety Commission, backpack-related injuries send an estimated 5,000 children a year to emergency rooms. More than 14,000 children are treated annually for injuries."(1) Several sources report that carrying too much weight can be detrimental to several joints throughout the body. (4,5,6,7) Changes in the lumbar spine resulting from such weight have been well reported in literature, however there is limited research on the effects of a heavy posterior weight on the lower extremity joint mechanics during the gait cycle. (3,4,5,6,7) There is evidence to support that the weight of a heavy backpack can result in increased hip and knee flexion in walking. (5,7) An increase in ankle plantarflexion can also be expected at push off in order to compensate for the extra weight required to propel forward. (2,3,7) Also, decreased stride length is expected with the addition of the backpack as a compensatory mechanism related to decreased single limb support time. (2,7)

PURPOSE: The purpose of this experiment was to determine how the weight of a heavy backpack affects stride length and gait mechanics in the sagittal plane.

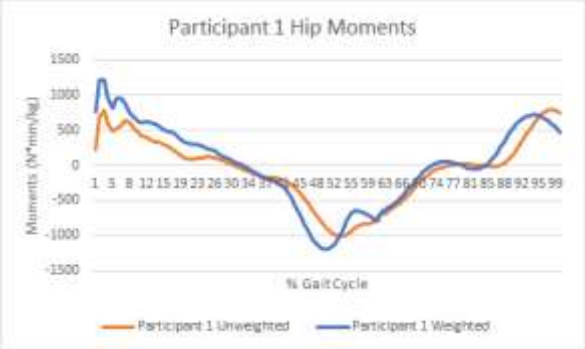
METHODS: During the study, two participants walked at a self-selected pace under two conditions, with each participant acting as their own control. The control condition consisted of each participant ambulating across the force plate without a backpack. The second condition was the experimental condition in which each participant ambulated across the force plate with a Northface Borealis backpack weighing 11.4kg. An 8-camera Vicon® system (120 Hz) was used to capture 16 reflective markers placed from the hip to the heel bilaterally while the participant ambulated across force plates to evaluate lower extremity joint angles, moments and stride length. Each participant ambulated at their normal walking speed across the force plate until 3 satisfactory trials were obtained.

RESULTS: As hypothesized, while wearing a backpack, results showed increased hip flexion, knee flexion, and ankle plantarflexion angles. Hip flexion increased 4% during midswing from 45.03° to 46.77°. Knee flexion increased .084% during midswing from 62.24° to 62.77°. Ankle plantarflexion increased 21% throughout stance phase from 10.24° to 12.89°. Results also showed a 7% decrease in stride length in order to overcome the posterior weight of the backpack as hypothesized. In addition, with the backpack weight, hip flexion, knee flexion and ankle dorsiflexion external moments increased. External hip flexion moments increased 150% during stance phase from 1313.99N*mm/kg to 1356.37N*mm/kg. External knee flexion moments increased 8.8% during terminal stance/pre-swing phases from 555.99N*mm/kg to 609.80N*mm/kg. External ankle dorsiflexion moments increased by 9% throughout stance phase from 1550.39N*mm/kg to 1704.26N*mm/kg.


Participant 1 Hip Angles
Angle (degrees)
% Gait Cycle
Participant 1 Unweighted
Participant 1 Weighted


Participant 1 Knee Angles
Angle (degrees)
% Gait Cycle
Participant 1 Unweighted
Participant 1 Weighted


Ankle Angles
Angle (degrees)
% Gait Cycle
Participant 1 Weighted
Participant 1 Unweighted


Participant 1 Hip Moments
Moments (N*mm/kg)
% Gait Cycle
Participant 1 Unweighted
Participant 1 Weighted


Participant 1 Knee Moments
Moments (N*mm/kg)
% Gait Cycle
Participant 1 Unweighted
Participant 1 Weighted


Participant 1 Ankle Moments
Moments (N*mm/kg)
% Gait Cycle
Participant 1 Unweighted
Participant 1 Weighted

CONCLUSION: While the increased angles in hip and knee flexion, along with a decreased stride length match our original hypothesis, the increase in dorsiflexion did not. Our research found both ankle dorsiflexion and plantarflexion increased, but at different points of the gait cycle. We hypothesize that this increase in ankle dorsiflexion during stance phase may be due to the force of the posterior weight pushing the ankle into more dorsiflexion. Additionally, this increase could be to allow for more plantar flexion range of motion during push-off to adjust for the increase in mass required to propel forward. From this study we conclude that increased posterior weight leads to abnormal body mechanics and changes in moments which can lead to serious injury. The results from this study can guide health care professionals to promote patient education on the importance of a lighter backpack weight and screen patients for musculoskeletal risk factors to prevent injuries. Further research should be done to evaluate the effects of a heavy backpack on lower extremity gait mechanics with a larger sample size.

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