CHAPTER V

DISCUSSION

The present study examined gait pattern of obese and normal weight women during overground, treadmill 0%, and treadmill 10% walking. Temporospatial variables and joint kinematic displacements were analyzed and compared between the two groups. Gait kinematics of obese participants have been reported for children and adult men, however, to the author's knowledge, no study has reported the gait pattern for obese women. Treadmill walking is often used as means of exercise training and part of weight management regimen. Nevertheless, the effects of treadmill and slope on gait kinematics have not been examined in women with high body mass index.

The averaged walking velocity for participants in this study was comparable to the values reported for women of similar age in previous studies. Prince and colleagues (25) reported a walking speed of 1.28 m/s in women with mean aged 40.4 years. In Bohannon's study of normal weight women between the ages of 40 and 60 years, a comfortable gait speed was reported to be 1.39 m/s (26). In this study, preferred walking speed of the obese subjects did not differ from that of normal weight subjects. The velocity of the obese women in this study was similar to that reported in children. In addition, a wide range of walking speed was found for both obese (range 0.75-1.41 m/s) and normal weight subjects (range 1.02-1.41 m/s). However, most previous studies reported significant slower comfortable walking speed for obese group compared to normal weight control. Hill and Parker (4) reported a walking velocity of 1.19 m/s for obese children and 1.29 m/s for normal weight children. For adult males, Spyropoulos and colleagues (6) reported the mean walking velocity for obese group to be 1.09 m/s, while a significantly higher speed of 1.64 m/s was reported for normal weight men.

One of the most important factors affecting individual's preferred walking speed is his or her level of energy expenditure. For normal weight adults, walking at approximately 1.4 m/s was found to be associated with minimum energy consumed per unit distance. Previous studies reported slower walking velocity for obese adults depending on degree of obesity. For this study, the obese had a mean BMI of 32.78 indicating obesity class II (moderate obesity). In Browning and Kram's study (27), the obese participants preferred to walk at similar speed to the normal weight participants at which their gross energy cost per distance was almost minimized. However, greater net metabolic rate was required for the obese for walking than the normal weight participants. Therefore, a relatively greater aerobic effort was imposed in the obese participants compared to the normal weight participants.

None of the energetic tests was not directly measured from the participants in this study to determine their metabolic rate and energy cost. However, information from the study's health and physical activity questionnaire indicated that the obese participants are as physically active as the normal weight group. Most obese participants reported that their activities at work involved mostly walking and some prolonged standing tasks such as giving lectures. Although more sedentary type of occupational activities were reported by the normal weight participants as most of them are office workers, most of them are regularly participated in some forms of exercise programs such as jogging, aerobic dancing. Although, the obese participants tended to have slower walking speed this was attributed to both their lower cadence and shorter step length. It may assist the maintenance of body balance in obese group (4, 6).

Temporospatial variables

In previous studies, for level ground walking, comparisons of both step and stride lengths between normal weight and obese participants in children and adult men have been made. It was reported that either children or adult males with obesity problem demonstrated significantly shorter stride length and lower cadence compared to their normal weight controls (4-6). However, cadence and step length have been found to be influenced by other factors including body height of the subject and speed of walking which were not well-controlled in previous studies.

In this current study, shorter step length was demonstrated by the obese group during treadmill walking. Differences in temporospatial variables between walking on level surface and on treadmill in the present study are in agreement with previous studies including a higher cadence and shorter step length compared to walking on overground (28). Murray and colleagues (28) reported that during treadmill walking, step length was reduced and cadence was increased compared to overground walking. Greater cadence while walking on treadmill may be due to a sense of urgency to place the swing limb onto the treadmill while the stance limb was continuously pulled backward the body. Both groups showed similar gait adjustment strategy to maintain the same preset walking speed by reducing step length and increasing cadence. However, a greater decrease in step length was demonstrated by the obese participants (9, 28).

For this study, step length was not affected when changing from treadmill 0% walking to treadmill 10% walking for both groups. The result is in agreement with Lay and colleagues who reported no significant grade effect in stride length for healthy young individuals (29). In contrast, Leroux and colleagues (10) found greater stride length when walking on upslope treadmill. However, Leroux and colleagues (10) also reported an increase in stride duration that may in part affect an increased stride length during upslope walking.

Changing from overground to treadmill walking had smaller effect on the percent of stance cycle for normal weight. For obese participants, percent of stance cycle increased 1.25% and 1.10 % for treadmill 0% and treadmill 10%, respectively, compared with overground walking, whereas an increase in percent of stance cycle was less than 1% for normal weight participants. Similar to findings in Murray and colleagues' study (28) for normal weight subjects, longer percent of stance cycle was reported during treadmill walking compared to overground walking. Greater proportion of time spent in stance of treadmill walking could be explained by requirement to maintain stability while walking on constantly moving platform.

Percent of stance cycle, did not differ between groups at overground walking, however, the obese group spent longer relative time on stance during treadmill walking regardless of slope. Similar findings have been reported for obese children and obese men. The obese children and men had greater percent of stance cycle, longer double support phase and lesser percent of swing cycle compared to their normal weight controls (4-6). Prolonged period of stance phase may be compensation for more instable gait in the obese subjects (4, 6).

Another possible explanation for prolonged period of stance revealed in gait cycle of obese participants may be to ensure adequate push off force was generated to overcome inertia from the mass of stance limb. Spyropoulos and colleagues (6) found that ankle position of obese participants was in neutral position at end of stance phase giving a disadvantage position for a forceful take off. In other words, the obese participants did not move into an adequate ankle plantarflexion later at end of stance phase compared to normal weight participants. Therefore, being in the stance period longer may help generate adequate push off force for obese individuals.

Joint kinematics displacement

Patterns of joint kinematics of the normal weight group for this study were similar to those previous reported (6). The obese group had similar joint kinematics pattern to that of normal weight group, however, differences in the magnitude of joint displacements were clearly shown.

Changing from overground to treadmill walking had minimal effect to hip and knee joint angles for the normal weight group during initial contact. Similar to the results for the normal weight of this study, Murray and colleagues (28) reported no significant differences between overground and treadmill 0% walking for hip angle at initial contact. In contrast, Alton and colleagues (9) found greater hip flexion at treadmill 0% compared to overground walking. Greater hip flexion found in Alton and colleagues' study (9) may caused by an increase forward tilt of trunk for treadmill condition.

Differences in joint kinematics between both groups for the three walking modes were found for maximum hip and knee flexion angles during swing phase. The obese group demonstrated less maximum hip and knee flexion during swing phase than the normal weight group. Several factors are likely to play a role in the reduction of joint displacement of the obese including excessive body weight, decreased muscle strength and a reduction of percent swing time. First, with greater thigh and shank segmental mass, an increase in moment of inertia will occur. Therefore, with an attempt to reduce the effect of an increased moment of inertia, the obese participants reduced their angular displacement of hip and knee flexion during swing phase. Secondly, the less magnitude of joint displacement may be a result of inadequate muscle strength to successfully overcome moment of inertia and raise the limbs. The increased mass associated with obesity also contributes to a relative reduction in muscle strength in the obese (30). From previous studies, the obese adults had greater absolute strength and power of muscle of the trunk and lower extremities. However, when adjusted the body mass or lean body weight, the obese participants had reduced muscle strength and power compared with the normal weight participants (31, 32). Inadequate muscle strength may limit proper hip and knee control. Third, the decreased percent of swing cycle for obese group may affect the possible hip and knee angular displacements. a decreased relative time spent in swing in couple with the need to take the next step quickly on treadmill may lead to decrease hip flexion during swing phase for the obese group (6).

During initial contact, less hip and knee joint angles in obese participants compared to normal weight controls were found during treadmill conditions. Decreases in joint displacements from the late swing phase of the previous gait cycle may continue to affect the hip and knee joint angle at initial contact. DeVita and Hortobágyi (33) found lesser the moment of force for knee joint angle and similar the moment of force for hip joint angle during stance phase in obese participants than in normal weight participants. Obese participants reorganize their neuromuscular function to lower knee joint torque and same hip joint torque. This response was protective mechanism of the hip and knee joint during walking for obese participants (33).

In this study, during initial contact, both normal weight and obese groups significantly increased their hip, knee, and ankle angles during upslope treadmill walking compared to level walking. The result is in agreement with previous study which reported an increase in hip, knee and ankle angles throughout the gait cycle at upslope walking for healthy young individuals. For the joint moment data, Lay and colleagues (29) found similar knee and ankle joint moment pattern during upslope walking and level walking. However, the hip extensor moment significantly increased during upslope walking compared to level walking.

During treadmill walking, both normal weight and obese groups had greater hip extension angle at late stance phase. With a prolonged percent stance on treadmill, the stance limb was continuously moved backward further resulting in more extend hip position. However, upslope treadmill walking had a greater effect on obese group for maximum hip extension due to greater percent stance compared to the normal weight.

In this study, uphill slope of treadmill walking was found to give emphasis to gait characteristics of the obese group since more hip flexion is needed to perform the consecutive walking on treadmill. In contrast to previous studies, a decrease in knee flexion angle during swing phase of walking was revealed for this study. As both groups response to upslope walking with an increase in hip flexion which already guaranteed foot clearance, an increase in knee flexion was not required.

Minimal group differences were revealed for the trunk and ankle displacements. Both groups demonstrated similar pattern of trunk and ankle joint movements for the three modes of walking. For both groups, during overground walking, trunk segment moved from a slightly flexed position at initial contact to a slightly extended position during swing phase. Trunk segment was in more upright position for treadmill walking and upslope treadmill walking for both groups. In previous studies, for young normal weight subjects, only slope of treadmill walking had a significant effect on trunk position as difference in trunk flexion was showed between upslope walking and level walking (10) but no difference between overground and treadmill walking at 0% slope (28). Erector spinae muscle is a main trunk stabilizer during treadmill walking. For participants of both groups in this study, being in more upright position during treadmill and upslope walking may help control the body’s center of mass within the base of support.

For this study, ankle joint angle did not differ between groups for three modes of walking. In contrast with a previous study investigating adult males, Spyropoulos and colleagues (6) found that the obese group had greater ankle dorsiflexion during stance phase compared to the normal weight group. The greater ankle dorsiflexion of obese participants was associated to the reduced hip flexion angle at initial contact. This ankle position may assist obese participants to maintaining better body balance. Additionally, the greater ankle dorsiflexion at push off period may in turn result in a reduced push off force, a reduced percent of swing cycle, and a reduced stride length for obese participants.

For this study, both groups had same pattern of ankle position throughout gait cycle when changing between modes of walking. The ankle joint was in more dorsiflexed position during initial contact and swing phase for upslope walking. The result is in agreement with previous study reporting greater ankle dorsiflexion for upslope walking (10). This position of ankle was strategy to maintain consecutive walking steps on uphill slope treadmill.

CONCLUSION

This study examined gait characteristics of middle-aged obese women during overground and treadmill walking using temporospatial variables and lower limb joint displacements. Gait characteristics of middle-aged obese women were compared to those of age-matched normal weight women. It was found that the obese women walked at similar preferred speed as the normal weight women. Step length and gait cadence of obese women were not different from those of normal weight women during overground walking. However, obese women adjusted their stepping pattern when changing to treadmill walking such that percent of stance phase was increased compared to that of normal weight women; therefore, body stability during treadmill walking was ensured. Decreases in maximal flexion angle of the hip and knee joints were found in obese women during the swing phase of upslope walking. Several factors may contribute to the reduced joint displacements of the obese group including excessive body weight, decreased muscle strength and a reduction of percent swing time. Although treadmill walking and upslope treadmill resulted in some significant differences in gait characteristics, the general pattern of lower limb joint kinematics were essentially the same. Previous research also revealed gait adjustments toward protection of increased joint loads in the obese. Therefore, it is appropriate to introduce walking on treadmill as means of exercise for obese women who need to solve their weight problems.

FUTURE STUDY

Some differences in gait characteristics of women with high body mass index compared to women with normal weight were revealed. However, the present study determined joint kinematic profiles for obese individuals during short-termed walking period. In actual situation, individuals with weight problems often participate in prolonged exercise period which may induce muscle fatigue. Therefore, given a disadvantage of having relatively reduced muscle strength, future research may focus on the effects of long-duration treadmill walking on the lower limb kinematics of the obese. In addition, incorporating kinetics data may give insight into the effect of increased mass on joint force during slope treadmill walking.