INTRODUCTION
Falls remain a major health concern among the elderly. Approximately one third of adults over the age of 65 will fall each year. Falls may lead to severe injuries, a decrease in activity, loss of confidence and even death [1]. In order to assess and predict the risk of falls, greater understanding of the underlying mechanisms of falls is necessary. Since most falls occur during dynamic motion, level walking tasks are an appropriate paradigm to assess differences in healthy older adults and fallers. The purpose of this study is twofold: 1) to determine the ability of k-means clustering in identifying fallers and non-fallers retrospectively; and 2) to assess the gait performance of older adults and determine the relative risk of falling among adults who were followed prospectively.

METHODS
Gait analysis was performed on 152 older adults. Among these individuals, 34 have experienced one or more falls in the prior year. During testing, all adults were asked to walk at a self-selected comfortable pace across a 10-meter walkway. Three dimensional marker trajectories were captured using an 8-camera motion analysis system at 60Hz. Ground reaction forces and moments were captured from two embedded forceplates at 960Hz. Gait characteristics were assessed using spatiotemporal and balance control measures. Balance control measures included inclination angles formed by the center of mass (CoM) position and the center of pressure (CoP) [2], as well as the interaction of the CoM and CoM velocity with the base of support (BoS) at heel strike and toe off [3]. Using the fallers and non-fallers as the gold standard, the 152 subjects were assigned into two groups using k-means clustering. K-means clustering is a heuristic algorithm that attempts to associate each sample with the nearest group mean or cluster centroid, with analysis performed in Matlab [2]. All possible combinations of balance control measures (1023 base of support combinations, 31 spatiotemporal combinations and 7 inclination angle combinations) were utilized as grouping variables to assess the sensitivity and specificity of group assignment.

In order to test the ability to group elderly adults and assess the risk of falling, an additional 25 older adults were followed prospectively. Following an initial screen and gait analysis, all subjects were interviewed over the phone every month for 6 months to check for any prospective falls. At baseline, subjects underwent a clinical examination and were asked to walk around an approximately 40-meter long walking walkway for 10 minutes.

Older adults were categorized as healthy or “faller” based on their Euclidean distance to the centroid of each k-means cluster. Relative risk was calculated as the probability of falling among those categorized as a faller versus the probability of falling among adults categorized as healthy. A value of 1 would indicate that the risk classification is not better than randomly guessing, while values larger than 1 indicate that the subjects categorized in the faller group demonstrated a much greater risk of falling than the non-fallers.
RESULTS AND DISCUSSION

Utilizing the k-means clustering algorithm and prior fall history as the gold standard, the ability to group older adults based on biomechanical gait characteristics demonstrated both good sensitivity and specificity. Utilizing different combinations of temporal-distance gait measures as well as CoM-BoS interactions at heel strike and toe off, the ability to predict group membership of healthy adults and fallers had a peak sensitivity and specificity of 0.82 and 0.97, respectively (Figure 1).

![Figure 1](image1)

**Figure 1:** Ability to categorize adults as healthy or fallers based on gait characteristics. Blue squares represent iterations performed using base of support measures; red crosses represent spatiotemporal measures and green triangles clinical measures.

Among the 25 older adults who are being followed prospectively, 12 adults have reported a fall with 5 adults reporting multiple falls. The ability to accurately categorize and predict these older adults who will sustain a fall could significantly reduce costs. Utilizing the k-means clusters of the base of support measures, spatiotemporal measures and clinical measures the relative risk of falling among the older adults who were categorized as fallers compared to those who were categorized as healthy was greater than 1 for mostly CoM-BoS interactions (Figure 2).

![Figure 2](image2)

**Figure 2:** Relative risk of one or more falls and multiple prospective falls of older adults based on base of support measures (squares), spatiotemporal measures (crosses) and clinical measures (triangles).

CONCLUSIONS

Utilizing combinations of clinical and biomechanical measures, it is possible to determine which variables can most effectively predict whether an adult sustained a prior fall with high sensitivity and specificity. Additionally, the ability to properly predict the risk of prospective falls in older adults can allow for individualized treatment and intervention. The ability to categorize fallers as well as predict the risk of both single and multiple falls among older adults was greatest when using biomechanical measures.

REFERENCES