INTRODUCTION

As the prevalence of obesity continues to increase at the population level, there is increasing concern about the impact of co-morbidities such as osteoarthritis. Osteoarthritis is a loading-related disease and its development and progression have been linked to excess body weight [1]. Changes in gait biomechanics, particularly at the knee, have been associated with increasing osteoarthritis severity in older adults. Differences in knee flexion excursion, peak knee flexion, peak knee adduction, peak external knee flexion moment, and peak external knee adduction moment have been reported [2,3]. However, it should be noted that these differences in knee variables with osteoarthritis were found in older adults. As the proportion of young people who are obese also rises, it is important to investigate the risk of osteoarthritis development at a younger age. This may be linked to patterns of knee biomechanics during gait. Simple statistical comparisons of discrete knee variables among young adults grouped by body mass index (BMI) found no differences among the groups in a previous report from our study [4]. Any relationship between knee biomechanics and osteoarthritis risk may be more complex in younger adults. Therefore, the purpose of this study was to further examine potential differences in knee biomechanics during gait among normal BMI, overweight, and obese young adults, using support vector machines [5], which are a group of pattern recognition and classification techniques.

METHODS

Healthy young adults aged between 18 and 35 years with BMI ranging from normal to obese were recruited. All procedures were approved by the Institutional Review Board prior to commencing the study. All participants provided written informed consent to participate. Groups were determined by BMI, with 10 participants in the normal BMI group (N: BMI 18 – 24.9), 10 overweight (OW: BMI 25 – 29.9), and 10 obese, 9 obese at preferred walking velocity (OB: BMI ≥ 30). Gait data were collected using standard three-dimensional motion capture techniques. Participants’ lower extremities were instrumented with retroreflective markers and they wore standard laboratory footwear. Marker trajectory data were collected at 120Hz using an optoelectronic motion capture system. Ground reaction force data were collected using force platforms sampling at 1200Hz and synchronized with the motion capture system. Walking velocity was monitored using photoelectric cells and a timer. Participants walked at both their preferred velocity (N: 1.44 ± 0.16 m/s; OW: 1.35 ± 0.13 m/s; OB: 1.21 ± 0.13 m/s) and at a fixed velocity of 1.00 m/s (± 5%), which is a typical walking velocity of older adults with knee osteoarthritis. Data were processed using standard joint coordinate system and inverse dynamics techniques via commercially available software. Data from five trials at each velocity were extracted from the stance phase: knee flexion excursion, peak knee flexion angle, peak knee flexion moment, peak knee adduction angle, and peak knee adduction moment. Data from the trials were averaged for each participant. Support vector machines were trained to discriminate between N and OW, N and OB, and OW and OB groups. Leave-one-out cross validation was conducted to verify the accuracy of discrimination.

RESULTS AND DISCUSSION

Support vector machines were able to successfully predict group membership for the N and OB groups. Peak knee flexion moment and peak knee adduction angle were the distinguishing variables. Using data
for the right knee, the combination of these two variables predicted N and OB group membership with 95% accuracy at preferred walking velocity (Figure 1) and 90% accuracy at 1m/s. The same pair of variables was able to predict membership of the N and OB groups for the left knee, with less accuracy 90% at preferred walking velocity and 85% at 1m/s (Figure 2). Membership of the OW group could not be predicted as well using this variable combination.

Figure 1: Support vector machines identified members of normal and obese groups at preferred walking velocity with 95% accuracy using right knee flexion moment and knee adduction angle.

Figure 2: Support vector machines identified members of normal and obese groups at preferred walking velocity with 90% accuracy using left knee flexion moment and knee adduction angle.

All of the participants in this study were healthy young adults who had not been diagnosed with knee osteoarthritis. The purpose of the study was to explore whether support vector machine analysis was able to predict BMI group membership using gait variables associated with knee osteoarthritis. A main feature of the reported analysis is the clustering of normal weight participants with similar or higher peak knee adduction angle than the obese participants. This is contrary to expectations that obese participants would tend to have greater peak knee adduction angle. Furthermore, knee flexion moment has a smaller range in the normal BMI group compared to the obese group. Similar patterns are evident for the left side. As is the nature of a cross-sectional study, it is unknown which, if any, participants will go on to develop knee osteoarthritis in the future. However, there is a higher prevalence of obesity in candidates for total knee arthroplasty, the end-stage treatment for knee osteoarthritis, compared to the general population. This relationship highlights the association between obesity and osteoarthritis [6]. It would be interesting to further investigate whether these associations lead to a greater risk of future development of osteoarthritis in obese young adults.

CONCLUSIONS

Using classification techniques based on support vector machines, we found that normal and obese BMI groups show different patterns in their knee biomechanics during gait. In particular, the obese group is characterized by a wide range of peak knee flexion moment values, some similar to the normal weight group and some higher. Similarly, there is a large overlap in peak knee adduction angles between the groups, with several obese participants exhibiting lower peak angles than those with a normal BMI.

REFERENCES