INTRODUCTION
In the recent decades, computer-controlled, variable-damping prosthetic ankle-foot and knee have been introduced. Advantages of variable-damping designs over mechanically passive prostheses may include adaptation to various walking speeds and enhanced stability. Foot dampers may play a significant role in the impact transfer of vertical ground reaction force to the knee and hip joints. Some researchers have worked on viscoelastic models of prosthetic foot, comprising of dampers and springs.

Given the growing number of variable-damping components and the broad number of potential outcomes, a systematic review is needed to assess the advantages of damped knee and ankle units over non-damped prostheses. The purpose of this study was, therefore, to provide an overview of the biomechanical outcomes associated with the use of prosthetic knee and ankle with damping mechanisms in individuals with lower limb amputation.

METHOD
A systematic search was performed through PubMed, Science Direct, Web of Science, Cochrane, and Scopus databases from June 1994 to June 2014. The following keywords and their combinations were used for the search: amputee, lower limb, transfemoral, transtibial, above knee, below knee, foot, knee, ankle-foot, prosthesis, artificial limb, hydraulic knee, hydraulic ankle, pneumatic knee, pneumatic ankle, damping, gait analysis, motion analysis and walking. The cited references were also investigated to extend the search.

The level of evidence of each article was assessed using a 13-element checklist developed by Van der Linde et al. for evaluating non-randomized control trials (Van der Linde, 2004). This checklist was originally adapted from two other checklists for quality assessment of randomized controlled trials and included 13 criteria divided into three categories for assessing the selection of patients (A1-A4), intervention and assessment (B5-B9) and statistical validity (C10-13). A criterion scored 1 if the answer was yes or valid and scored 0 if the answer was no or invalid. The criterion scored 0 if it was not applicable. Two reviewers performed the quality assessment independently. Afterwards, the studies were classified as A-level, B-level, or C-level based on total score and positive scores from certain key categories.

RESULTS
The initial search resulted in a total of 243 abstracts, among which 66 papers were duplicated. After applying the inclusion criteria, 16 papers remained for the full text review. Additionally, a reference search of the papers resulted in 10 more papers among which only 4 abstracts met the inclusion criteria. Finally, 20 studies were assessed.

Fourteen of the 20 studies scored enough to be classified. Use black and white graphics. Among those, 1 scored as A-level, 8 as B and 5 as C. The main difference between B- and C-level studies was the positive score on the adaptation time with the prosthesis criterion. Ten studied knees and four studied ankles and ranged from 5 to 28 subjects.

DISCUSSION
The A-level study for prosthetic knees (Boonstra et al., 1996) compared an Otto Bock 3R20 mechanical swing phase control knee to a Teh Lin pneumatic swing-phase control knee and found increased walking speed and decreased knee joint range of motion with the latter. However, other B- and C-level studies found no differences in similar outcomes with similar knees. The one B-level study assessing ankle/foot mechanisms found no cadence changes but decreased loading rates for an Echelon foot versus an ESAR foot (Portnoy, 2012).

CONCLUSION
Minor differences were documented with the damped prosthetic knee and ankle joints compared to those without a damper. Additionally, considering the level of studies based on this review, more studies are needed to prove the differences among the various available joints. Overall, the walking speed showed the highest difference when dampers were applied to the leg. Moreover, the few available studies on the prosthetic ankle only were conducted on transtibial amputees. Future work is needed to compare the outcomes with transfemoral amputees as well and to evaluate how the combination of damped knee and ankle joint would affect amputee performance.

CLINICAL APPLICATIONS
Prescription of knee and foot/ankle components becomes more challenging as devices become more complex. Ongoing research is needed related to biomechanical outcomes in order to properly match component capability to patient need.

REFERENCES