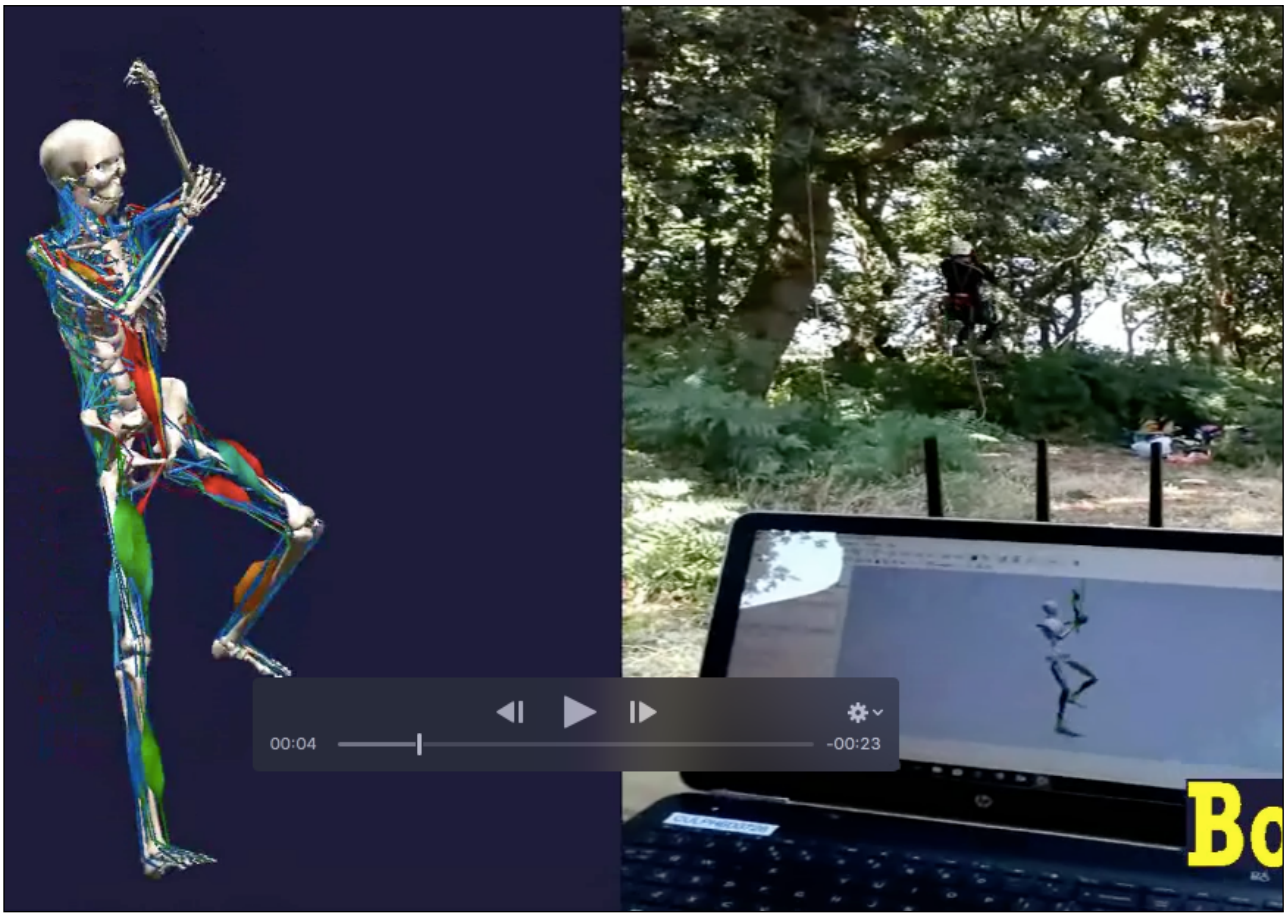
Arboreal Biomechanics

Project Update Report

A Laver - 16 June 2019



Introduction

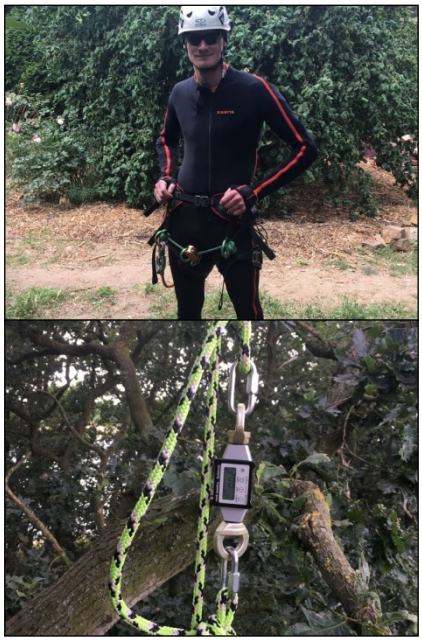
Optimised techniques for arboreal activities

Recent advances in biomechanical motion analysis equipment have enabled the measurement of three-dimensional human movement within environments previously inaccessible. Previously motion analysis was performed using optical tracking equipment which, whilst accurate, was unsuitable for use outside and excluded its application to tree climbing. However, motion capture equipment is now available which uses inertial tracking sensors and can operate in more realistic scenarios such as within the canopy of a tree. With this kit we aim to map tree climber movements as they climb. The data will then provide a body map showing the skeleton and muscle structure of the climber. We plan to record different access and climbing methods to analyse the effect on a climber's body. We then plan to look at tasks in the tree and work positioning options when undertaking those tasks. Having captured this information we can target a study, working with climbers of mixed experience to see if they adapt their method to compensate for the stresses and strains of the method or task. We hope this will guide us to recommend the best climbing methods for climbers to learn and master, to keep them fit and healthy, and remain in the industry for a full and long career.

Arborists always complain of suffering from musculoskeletal injuries caused by repetitive stretching and supporting large loads in contorted postures. The prolonged use of these techniques can result in muscle sprains and degenerative joint problems. This project will investigate correlations between working practices and chronic injury rates to provide an evidence basis for the recommendation of safer working practices and improved healthcare for arborists. This in turn, we would hope, will provide better training and development of techniques for future generations, prompting a longer working life and reduce the drain on our skilled workforce.

The project set out to establish whether there are significant differences between an arborists trained in traditional double rope DRT (moving rope), improved friction management DRT and modern developing SRT stationary rope techniques. Climbing tasks will include but are not limited to: assess against the stem, free hanging rope assess, movement in the canopy to pruning target, pruning cuts with a saw and decent from the tree. We hope to look at chainsaw work in time.
Coventry University's biomechanics group has experience of applying motion capture methods across a broad spectrum of applications from sports performance optimisation, through product design to medical device analysis. The biomechanics group has developed software which is capable of analysing human motion and calculating the forces and torques developed within a person's body during a diverse range of activities. Correlations will be calculated between loads occurring at major joints within the arborists' bodies and the rate of musculoskeletal injuries.
Supporting this work we have researched online survey data from working arborist, to ascertain current working methods, the injuries they have suffered and whether they have made or sort changes to reduce compounding injuries or problems. So far all evidence has

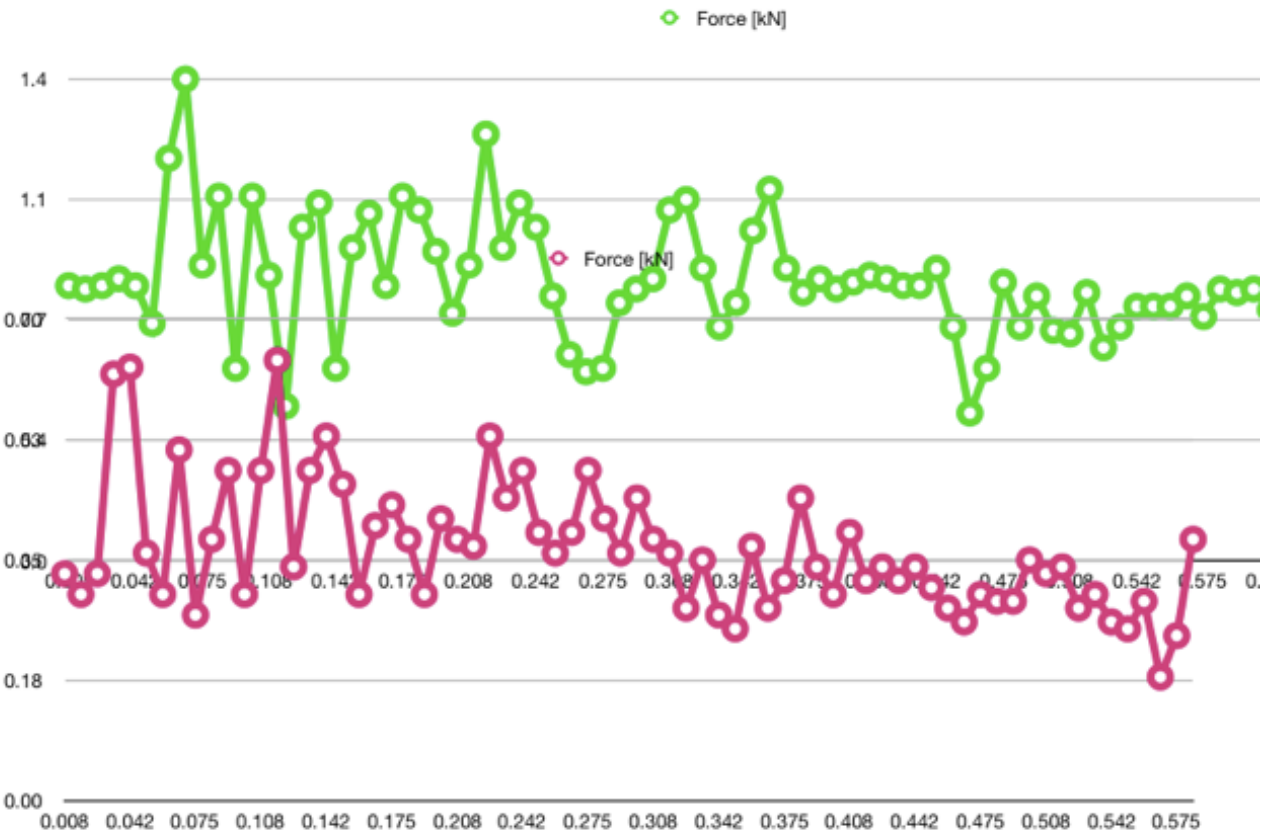
been anecdotal and we hope to gain some meaningful data to better understand the current problem and tree-worker climate.



Summer testing 2018

We scheduled two days of testing with Barbara May and James Shippen from Coventry University along with a climbing team. The first morning was spent testing the data capture equipment: setting it up to ensure it did not comprise the climber ability to move freely or the functional and safe use of climbing equipment. The afternoon was then spent in bench-marking climbing ascent methods and techniques to start building-up a data set to study. That evening we all met for a meal to plan for the following day, we had proven the concept

worked well and could see the results on screen. Day two we expanded the data sets and looked at movement in the crown while branch walking.



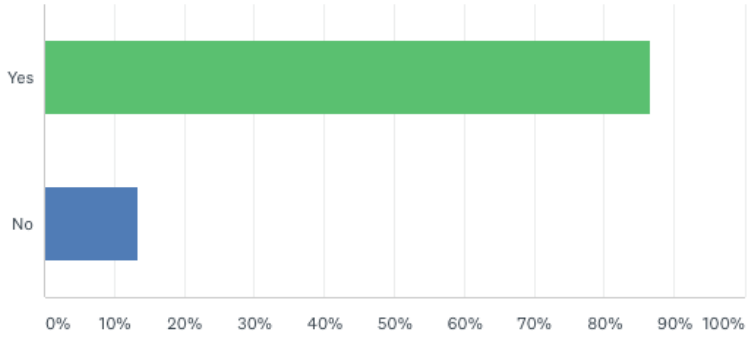
The graph below shows loads on the climbing-line for SRT in green and MRT in red. We captured this data for all methods tested. In analysis we found we had one big issue. Up until this point the software and hardware, has been used to study people in contact with the ground. A tree climber moving up a rope has their weight in the rope, harness, hands and feet with passing contact with the tree. Tracking these transferred loads to give a full accurate picture of the muscle loading and torques in the joints is a major hurdle we need to overcome. From the captured data sets we can now model the methods and compare these using nominal loads. This will rely on the observation and experience of a climber to inform us where the connected load distributions are felt whilst moving around the system and body. This is going to demonstrate the theory but is not going to give us full reportable science just anecdotal interpretation.

Via key tree-care industry questions, with over 325 responses and a good broad data set, we have made some clear discoveries the full results of which will be publish later this summer. The main conclusions we can draw from this survey, is tree climbers do indeed suffer from muscular and skeletal injuries, there are also patterns of common areas where

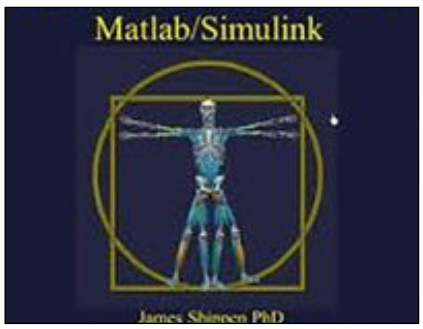
people get injured. We are considering these results and we may try a follow-up survey to see if we can dig deeper in to these issues.

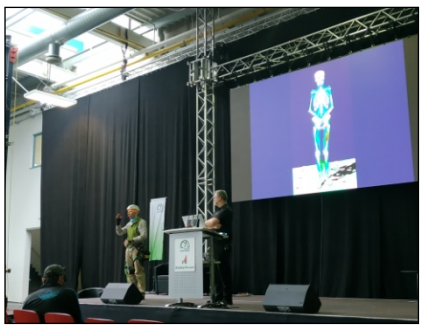
Have you ever suffered any muscular or skeletal injuries or pain caused by climbing actives.

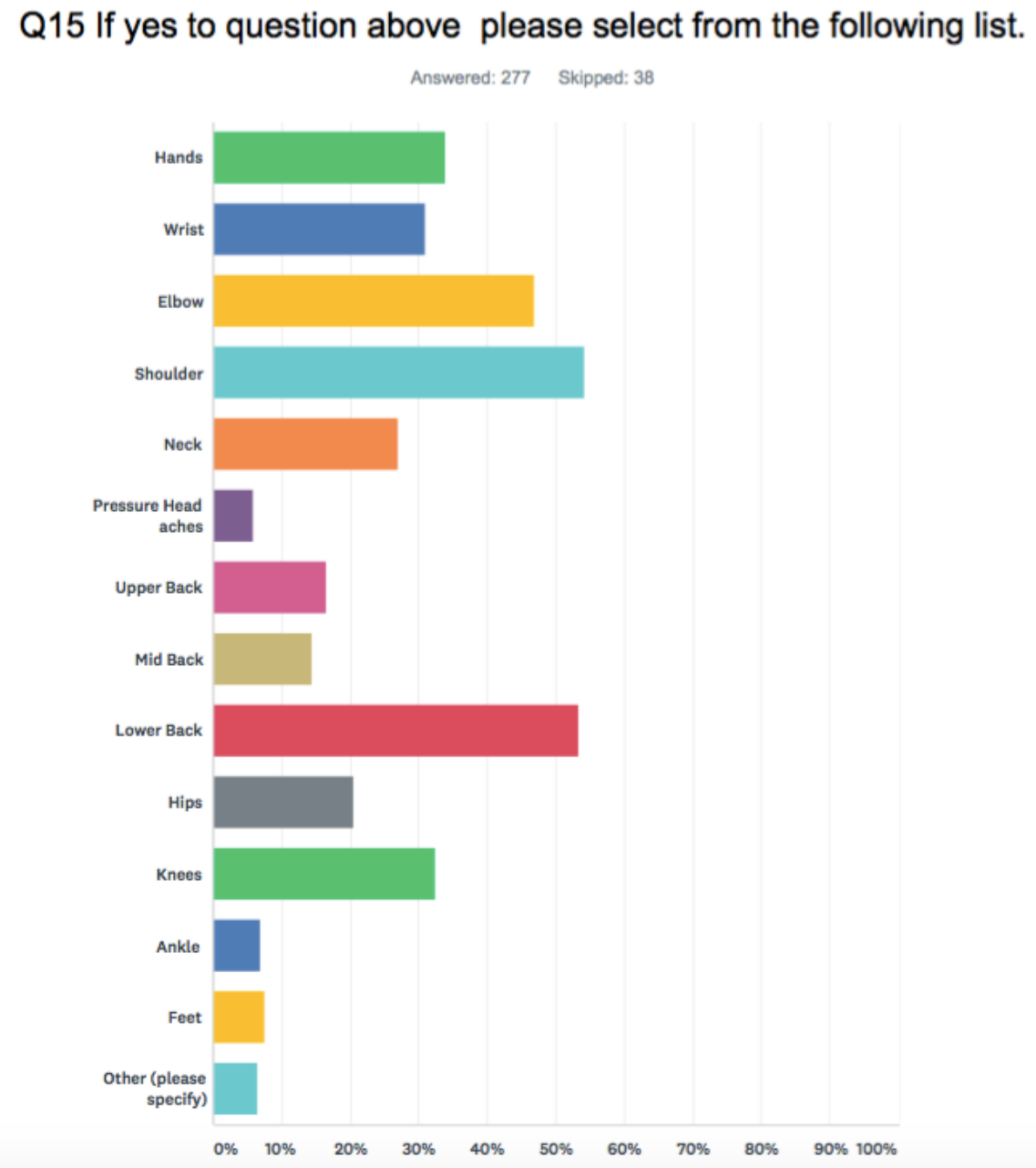
Answered: 315 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	86.67%	273
No	13.33%	42
TOTAL		315







This past May three of the research team were invited to present a work-in-progress session at the German Tree Care conference, Climbers Form in the town of Augsburg. In this 90min session we walked the audience through the results of the survey we had captured at the time, explained what biomechanics is and how the science has developed and how the new technology we are using actually works. We then did a live demo of data capture where the audience could see the movements. I also demoed climbing in MRT and SRT on a tower as a three-dimensional model on the screen. We then showed some of the data captured with the muscles laid on to the model and effects of torques using estimated loads from our load cell data. I will be attending ISA conference in August at Knoxville, to present a condensed 60min talk similar to that given in Germany but without the live demo of the technology.

On-going is work into solving the unknown key loads on the climbers' hands, feet and harness. The load cells currently available for this project even though designed for rope load measurements are just too big to add in to a harness system without changing the climbing system ergonomics to point of removing the real moments and therefore affecting the true picture. To this end I am working on installing small strain gauges to items of climbing equipment and developing small micro processors to capture the data. Once we have some working prototypes of these instruments we can work on software to sync the data to motion capture data in Mat Lab to give us a fuller picture. From here we can then look at new complete data sets of the hot-spot areas where we have identified the greatest risks to the climbers through certain movements or techniques.