Investigating the relationship between tibial width, length, total height and bodyweight

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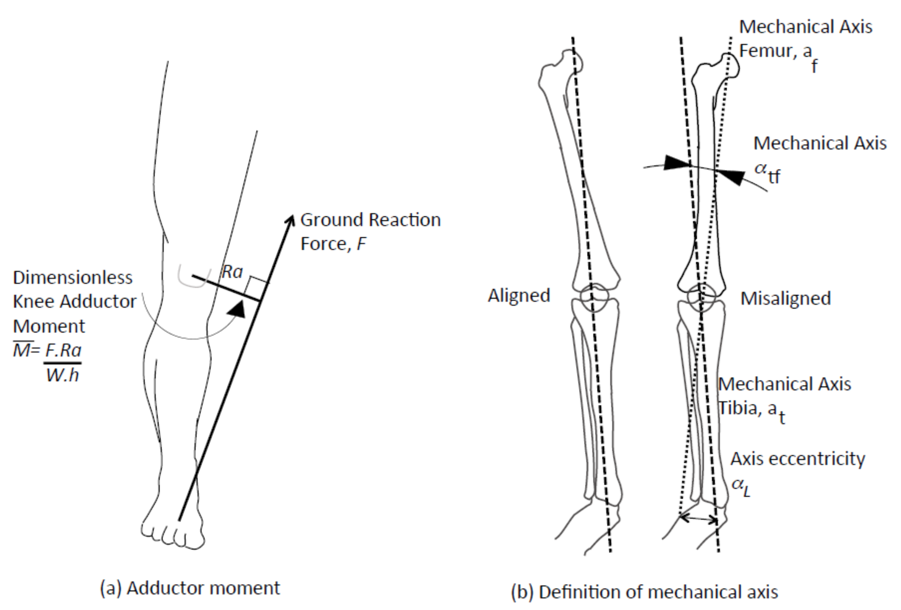
Introduction

Knee osteoarthritis is rising in prevalence with more knee replacements being carried out than ever[1]. There is a specific patient group however, who develop medial compartment osteoarthritis due to having a varus deformity of their knee (see figure 1).

Due to this biomechanical deformity, a moment arm is created within the knee during walking and other movements causing adduction of the knee. (see figure 1)



This adductor,moment if too large, creates increased loading on the medial compartment of the knee, leading to osteoarthritis[2]. The higher the adductor moment, the greater the loading is upon the medial compartment of the knee, increasing the chances of developing osteoarthritis[2].

In order to correct this, various conservative treatment methods can be used[3] or an operation called a high tibial osteotomy is used in order to correct the biomechanical deformity[4].

Figure 1: Diagramatic representation of the main alignment measurements when calculating adductor moments in knees.
(a) Demonstrating the formula for calculating the adductor moment in relation to the ground reaction force. (b) Demonstrating the relationship between mechanical axis of tibia and femur within aligned and misaligned knees. (Source: McClelland *et al.,*[6])

Prodromos *et al.*,[5] defined a high adductor moment at the knee as being equal to or greater than 4% of bodyweight x height. Prodromos *et al.,*[5] went on to describe the poorer outcomes for patients with a high adductor moment pre-operatively when undergoing correction via a high tibial osteotomy.

The study by McClelland *et al.*,[6]however, showed that there was no significant difference in long-term outcome between patients with a pre-operative high adductor moment when compared to patients with a low adductor moment after undergoing high tibial osteotomy.

During discussion with surgeons, it has been suggested that the width of a patient's knee would possibly be a more appropriate dimension to use when calculating the adductor moment within the knee. This, as opposed to using a patient's total height. The authors then investigated whether there was any link between tibial width and tibial length, alongside any link between tibial width and total height. Therefore, the aim of this study was investigate whether there was in fact any correlation between an individual's height or weight to the width of their knee.

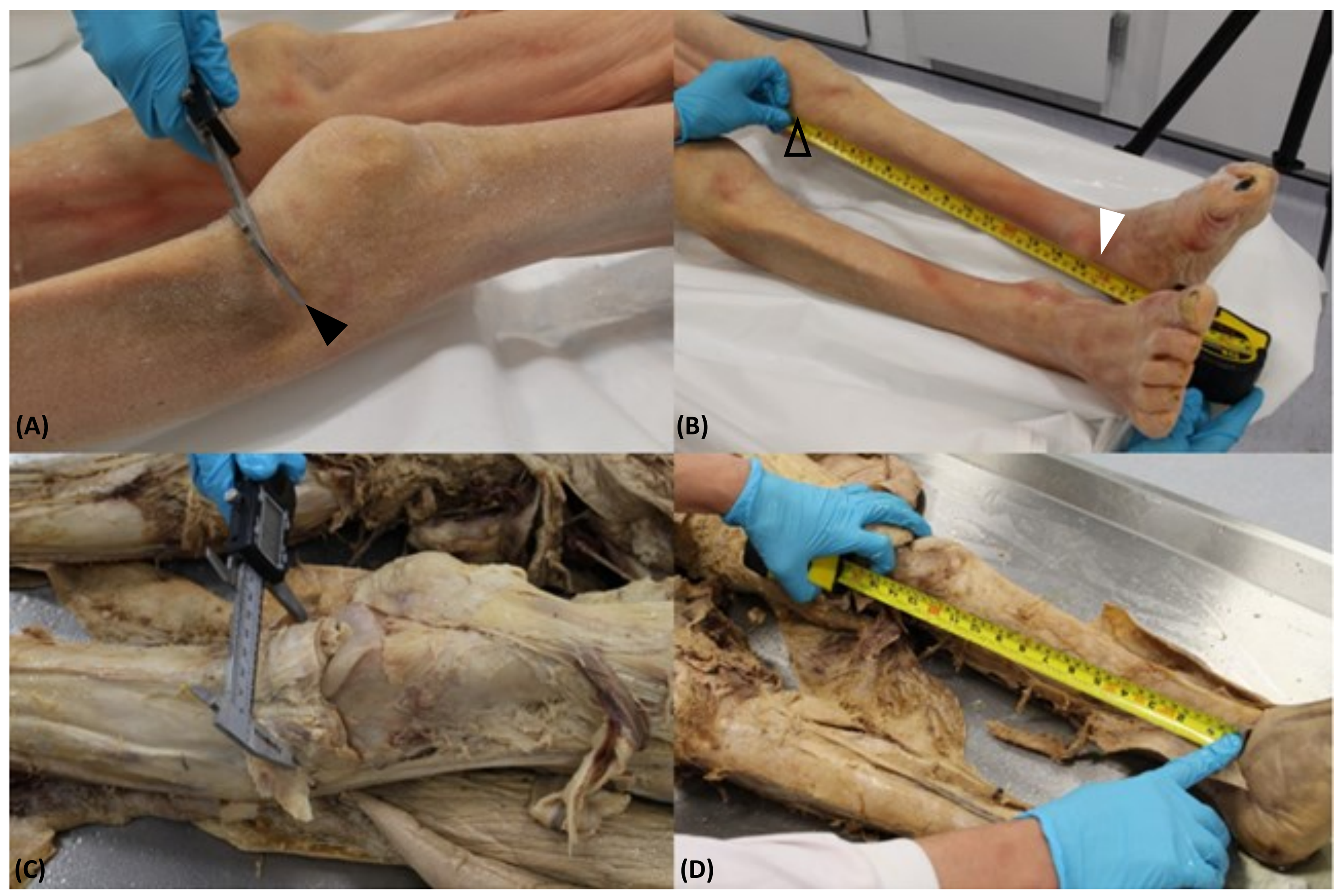


Figure 2: Demonstrating measuring process in cadaveric arm of study. Solid arrowhead indicates tibiale laterale on lateral tibial condyle. Clear arrowhead indicates tibiale mediale on medial tibial condyle. White arrowhead indicates sphyrion tibiale on medial malleolus. (A) Demonstrating measurement of tibial width of cadavers prior to dissection (B) Demonstrating measurement of tibial length of cadavers prior to dissection (C) Demonstration of measurement of tibial width post dissection of soft tissue and tibial cortex exposed (D) Demonstration of measurement of tibial length post dissection.

Materials & Methods

The methods of this study had prior ethical approval from the S-SPEC ethical board at Keele University (S-SPEC number 16-13). Written consent was obtained from living subjects prior to measurements, cadaveric subjects had prior written consent that their bodies were to be used for scientific and educational purposes. These cadavers and any material related to them were handled in accordance of the Human Tissue Act (2004).

The study involved two separate arms of data collection. The first involved work on 11 cadavers, embalmed in formalin, measuring the tibial length and width with the skin intact and after dissection. This was in order to discern any measuring error caused by soft tissue when compared to exposed bone.

Figure 3: Demonstrating measuring process of total body height in living subjects. Head positioned level in Frankfort plane during measuring process[7].

The second arm of the study involved measurements taken from 33 live volunteers, in order to provide a healthy control population. Healthy was defined as an individual with no previous history of major knee injuries or trauma (i.e. cruciate ligament ruptures or meniscal tears) and no known history or diagnosis of osteoarthritis.

Figure 4: Demonstrating measuring process of tibial width and tibial length in living subjects. (A) Measurement of tibial width across tibial condyles (B) Demonstrating position of subjects leg during measuring process (C) Measurement of tibial length in living subjects from tibiale mediale to sphyrion tibiale.

The living study subjects were asked to provide certain demographics: date of birth, gender and weekly activity levels. With each cadaver, the same demographics were taken from the Keele Anatomy Facility bequethal records. These also included the cadavers' height & weight (Note: height and weight values were taken prior to the embalming process.)

The investigators measured the living subjects' height, weight and body fat %. The tibial length and width was measured in both living and cadaveric groups. Tibial width was measured between the mediale tibiale (the most superior point on medial border of the tibia)[7] and tibiale laterale (the most superior point on the lateral border of the tibia)[7]. Tibial length was measured from tibiale mediale to the sphyrion tibiale (the most distal part of the medial malleolus)[7].

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Results & Discussion

Following data collection a full data analysis was carried out. However only the correlation between tibial width and height and the correlation between tibial length and height have been shown here.

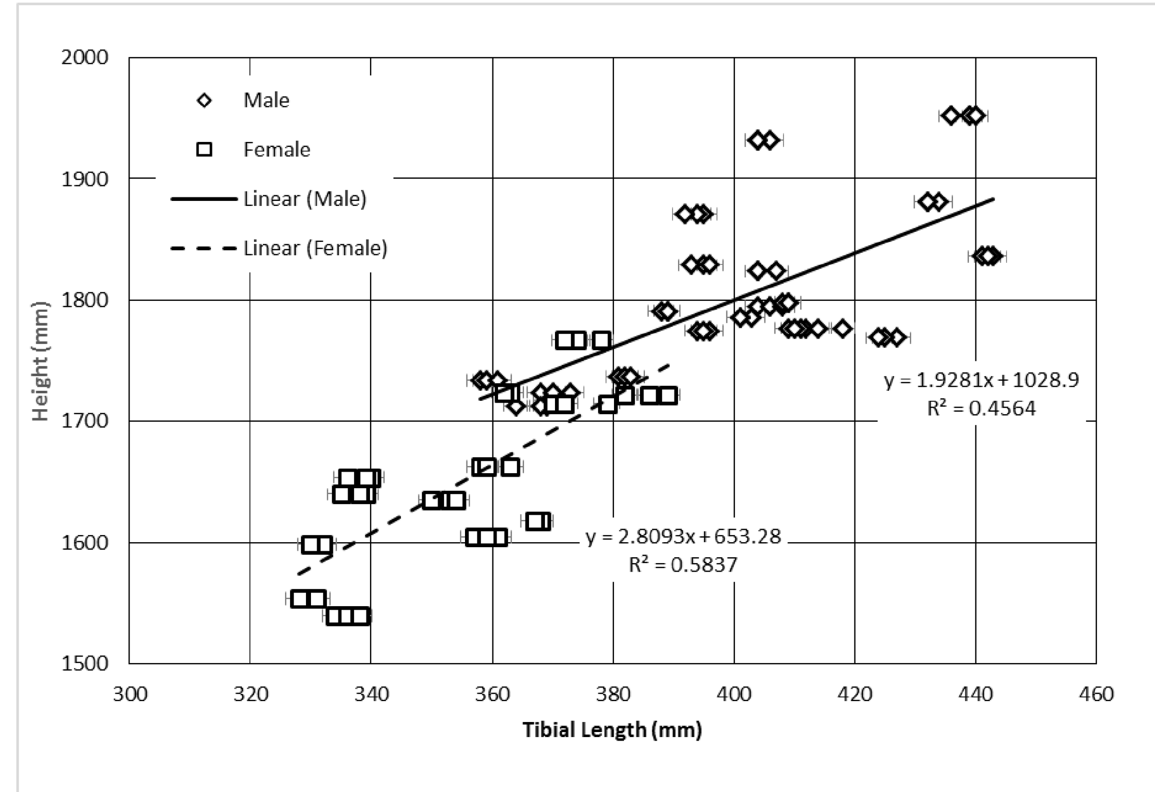

Figure 5: Comparison of tibial length and total body height in male and female subgroups of living cohort. In the male group $R^2 = 0.4564$ and in the female group $R^2 = 0.5837$. Trend lines indicate relationship. (Error bars in x-axis indicate combined error of measurement without soft tissue error; error bars in y-axis indicate standard error of measurement for height measuring apparatus).

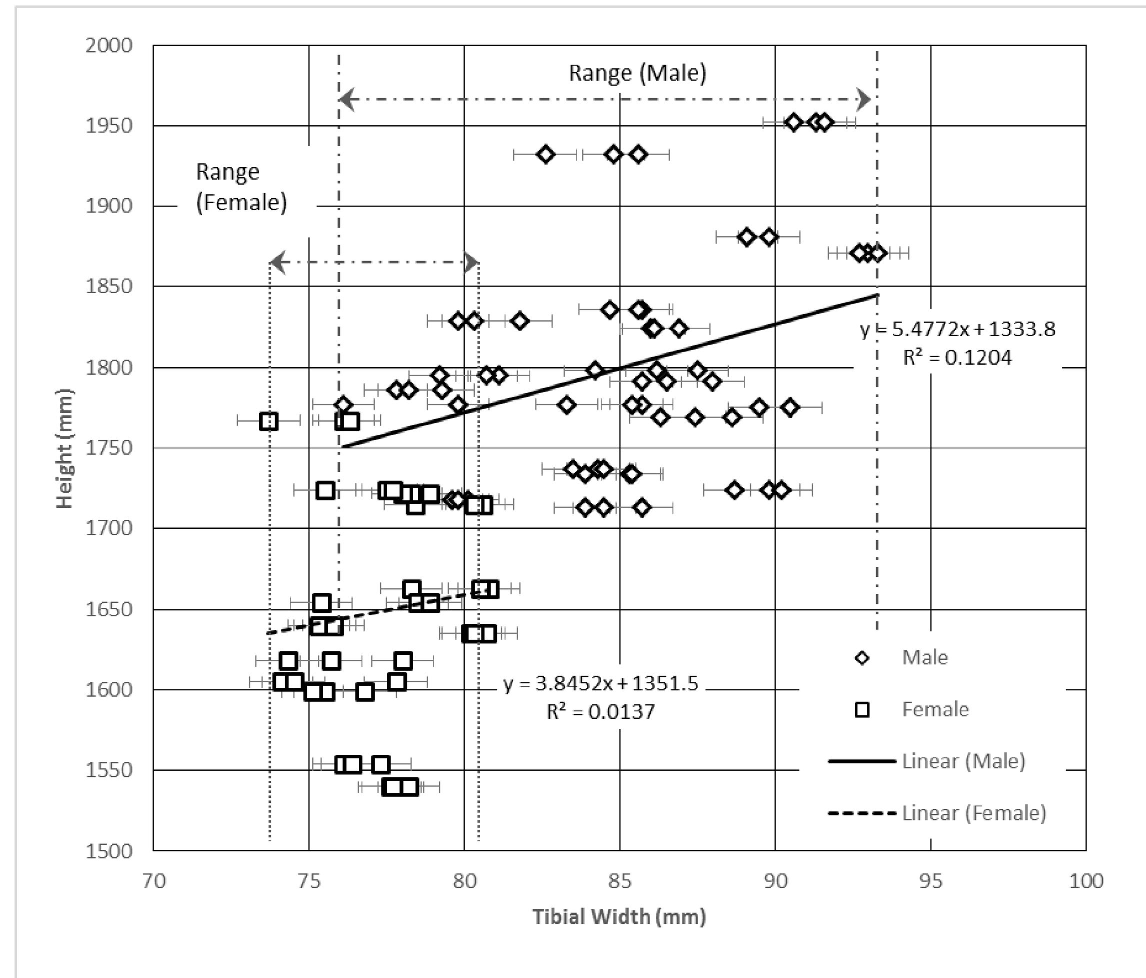

Figure 6:Tibial width compared total body height in male and female groups of living cohort. The male group $R^2 = 0.1204$, in the female group $R^2 = 0.0137$ indicating no correlation. (Error bars in x-axis combined measurement error without soft tissue error; error bars in the y-axis denote standard error of measurement).

The data gathered showed no correlation between tibial width and height. However, as expected and similar to existing data there was a slight correlation between tibial length and height[8,9,10].

When considering this data in context with pre-operative planning for a high tibial osteotomy it confirms the need to revisit the formula for calculation of adductor moment and consider replacing height with a different dimension such as tibial width as tibial width has no correlation with height, weight, or body fat percentage and therefore must be included as its own dimension.

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