AGE BASED LOWER BODY JOINT ANALYSIS OF MALE ENDURANCE RUNNING PERFORMANCE

Ceri Diss[1], Marianne Gittoes[2], Richard Tong[2] and David Kerwin[2]

Department of Life Sciences, University of Roehampton, London, UK[1]
Cardiff School of Sport, Cardiff Metropolitan University, Cardiff, UK[2]

The purpose of this study was to examine the age based changes in joint angles and moments throughout the stance phase of running. A biomechanical analysis was conducted on the running gait of endurance athlete from three different age groups. Reduction in ankle and knee flexion and moments was an age response to running gait. To reduce the rate of decline in running performance seen with age the training strategies employed should be ankle and knee joint focussed.

KEY WORDS: stance phase, moments, angles, continuous analysis.

INTRODUCTION:Wang (2008) reported that an inferior jump performance by older participants was attributed a reduction in lower limb kinetics. As a result of ageing it is possible that the underpinning mechanisms contributing to maximising force production is compromised, which has potentially detrimental effects on dynamic performance.
Peak moments have been reported to significantly ($p < 0.05$) differ between young and old participants when performing an isometric plantar flexion (Challis, 2006). The reduction in maximum isometric joint moment was attributed to the simpler moment profile demonstrated by the older participants. The findings suggest that in a dynamic movement such as running the lower body joint moments would diminish with age.
Fukuchi and Duarte (2008) examined the discrete joint angles betweenthe young and elderly gait when running at the same speed. The ankle’s flexion angles were very similar between the two groups but the knee flexion angle at initial contact with the ground was 10^o for the elderly compared to 5^o for the young athletes.
Understanding movement dynamics can take many different approaches (Hamill, Haddad & McDermott, 2000) and traditionally running gait has been explored using discrete methods. Gittoes and Wilson (2010) examined the lower body joint in phase coupling throughout the stance phase of sprinting and reported an increase in coupling at take off compared to touchdown. Therefore to examine further the effect of age on running gait performance a continuous method is warranted. The aim of the study was to develop an understanding of the age based lower body joint angles and moment throughout the stance phase of running for the purpose of developing training strategies that reduce the rate of decline in running performance which is associated with age.

METHODS: Male participants (N=24) who were county standard endurance athletes took part in the study andwere assigned to three distinct age groupings; 26 to 32 years (S32, N = 8), 50 to 54 years (M50, N = 10) and 60 to 68 years (M60+, N = 6). Six running trials were performed by each athlete during which lower limb marker coordinate and ground reaction force data were collected using a nine camera infra-red system (Vicon 612, 120 Hz) synchronized with a force plate (Kistler, 1080 Hz). The x, y and z coordinate time histories for each marker were smoothed using Woltring's cross-validated quintic spline routine (MSE = 15 mm^2). The spatial model developed by Davis et al. (1991) wasused to locate the sagittal plane coordinates for the ankle, knee and hip joint centres, which were used to calculate the segments of the lower body. The angle between two segments was used to calculate the sagittal plane flexion/extension angles for the ankle,knee and hip joints. The convention defined full extension as 0^o.Sagittal plane joint reaction forces and joint moments were calculated using standard inverse dynamic analysis (IDA).Joint moments were normalised to body weight (BW) and leg length.

The stance phaseof the running gait cycle was defined between the times when the vertical force was >8N and <8N. All data sets were then converted to 100% of stance rather than to time in seconds. To interpolate each data set from 0 to 100 points a cubic spline was employed using MathCad (Adept Scientific) software. The mean of each measure for each athlete was calculated throughout stance and subsequently the mean (±standard deviation) for each group.
The root mean square difference, which was normalised as a percentage of the difference between the maximum and minimum values from both data sets, was computed for the continuous profiles throughout the stance phase between each age group.

RESULTS:

Table 1
Normalised Root Mean Square difference between each age group

	Normalised Root Mean Square Difference (%)		
	Ankle	Knee	Hip
		Angle	
S32 v M50	13	10	9
S32 v M60	19	18	7
M50 v M60	13	24	15
		Moment	
S32 v M50	19	15	17
S32 v M60	23	25	12
M50 v M60	9	32	12

The normalised root mean square difference quantitatively compared the joint response between each age group throughout the stance phase. For the ankle joint the M60 group had the greatest difference compared S32, however for the knee joint the biggest variation was between M50 and M60.For the hip joint the M50 group had the largest difference when compared the M60 (angle) and S32 (moment).

Figure 1 illustrates the ankle dorsi flexion,which occurred in the first 50% of stance for all age groups with S32 and M50 groups achieving maximum dorsi flexion after the time when the displacement of the centre of mass was minimal. The knee angle at touchdown and toe off were similar between the groups with the M50 group demonstrating the greatest extent of knee flexion throughout stance. The M60 group had the least amount of flexion during stance and the lowest moment continuous profile.
The hip angle profiles illustrate different angular displacement for each group up to the minimal displacement of the centre of mass after which the curves diverge as the hip extended up to toe off for each group. The normalised hip moment increased after touchdown where the S32 group generated the greatest moment compared to the M50 and M60+ groups. The minimal displacement of the centre of mass occurred 8/9% later in the stance phase for the M60 group who also had a longer contact time compared to S32 and M50.

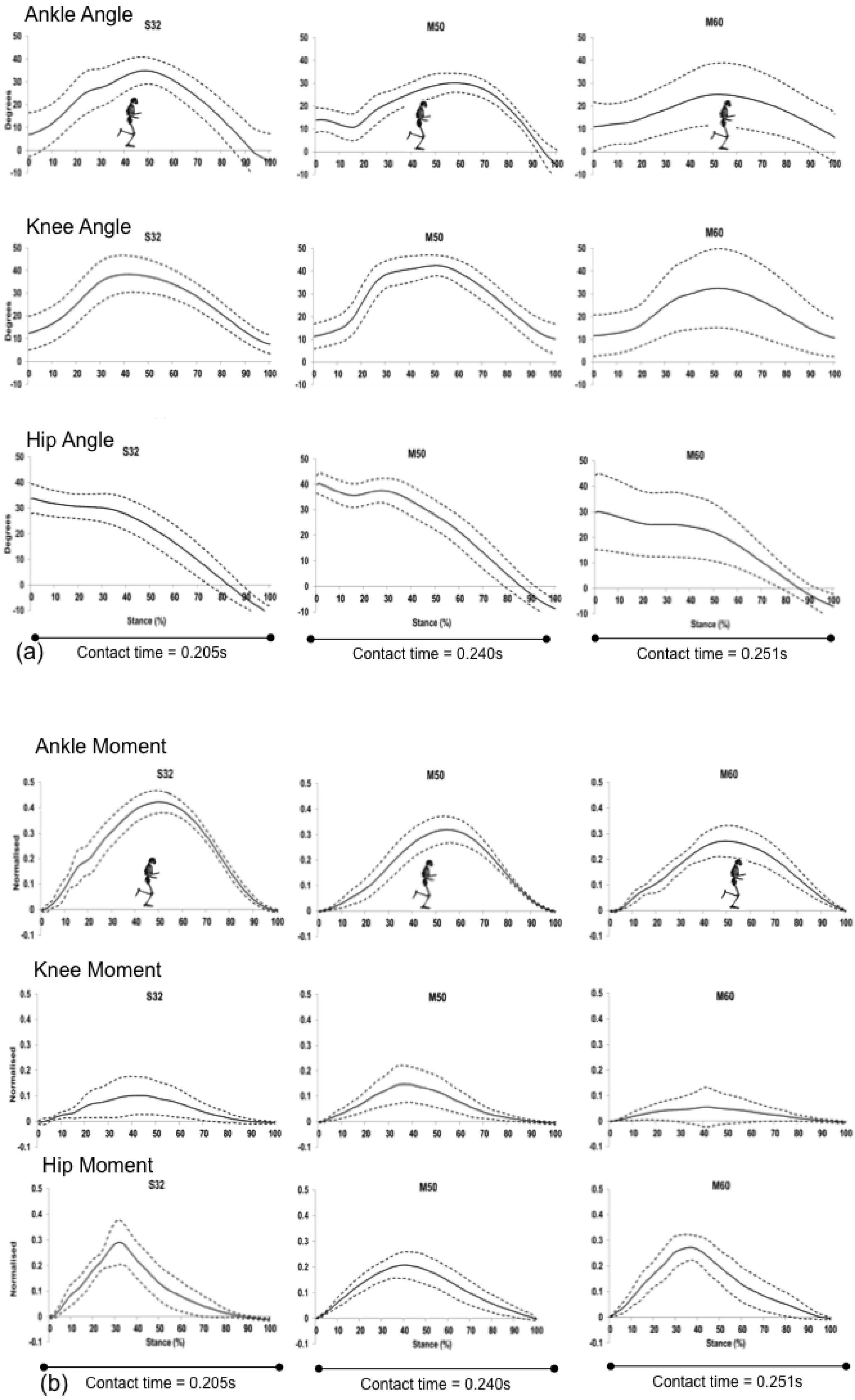

Figure 1 The mean (±standard deviation) for the lower body joint flexion/extension angles (a) and moments (b) throughout the stance phase of running for each age group. The skeleton figure indicates the time when the resultant vertical and horizontal displacement of the centre of mass was minimal.

DISCUSSION: The age based response of a reduced ankle joint's range of motion demonstrated by the M50 and M60+ groups (and the longer stance time) may be to ensure that the foot is flat to the floor by moving the ankle joint through a minimal range compared to the S32 group in an attempt to improve stability prior to the propulsive phase of stance.The greater normalised ankle moment generated by the S32 group compared to the M50 and M60 groups was a result of a combination of measures one of which was the ankle joint's vertical and horizontal force generation. The forces generated at the ankle joint would be a function of the lower leg muscles, particularly the gastrocnemius and soleus muscles, which was an age-based response of the endurance athletes potentially caused by the reduction in muscular force generation.
The normalised root mean square difference revealed that the S32 group's overall profile was similar for the M50 group for the measures of ankle and knee angular displacement and normalised knee moment. When comparing the ankle, knee and hip moments, the peak knee extensor moments were much lower compared to the ankle and hip for all the groups. Bezodis *et al.* (2008) reported that for elite sprinters, the normalised peak knee extensor moments were low with values of 0.092 ± 0.033 which occurred whilst the knee was still flexing. The authors suggested that the power generation during sprinting was generated by the ankle and the hip joints, which compensated for the low knee kinetic magnitudes. For the M60+ group the continuous profiles throughout stance for the ankle, knee and hip normalised moments for endurance runners supports Bezodis *et al.'s* (2008) findings.For the hip joint similar continuous profiles were found between the S32 and M60+ group. Therefore the age-based changes in the joint angles and moments generated potentially become joint specific with age.

CONCLUSION: To minimise the detrimental effects of ageing on running performance, an enhanced execution of the ankle and knee joint biomechanical function may be beneficial in older athletes. Coaching strategies customised to the age of the athlete and the skill being performed may therefore be advocated to maintain or enhance dynamic performance.

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