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Short communication

Ankle joint function during walking in tophaceous gout: A biomechanical gait analysis study

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ABSTRACT

Background: The foot and ankle are frequently affected in tophaceous gout, yet kinematic and kinetic changes in this region during gait are unknown. The aim of the study was to evaluate ankle biomechanical characteristics in people with tophaceous gout using three-dimensional gait analysis.
Methods: Twenty-four participants with tophaceous gout were compared with 24 age-and sex-matched control participants. A 9-camera motion analysis system and two floor-mounted force plates were used to calculate kinematic and kinetic parameters.
Results: Peak ankle joint angular velocity was significantly decreased in participants with gout ($P < 0.01$). No differences were found for ankle ROM in either the sagittal ($P = 0.43$) or frontal planes ($P = 0.08$). No differences were observed between groups for peak ankle joint power ($P = 0.41$), peak ankle joint force ($P = 0.25$), peak ankle joint moment ($P = 0.16$), timing for peak ankle joint force ($P = 0.81$), or timing for peak ankle joint moment ($P = 0.16$).
Conclusions: Three dimensional gait analysis demonstrated that ankle joint function does not change in people with gout. People with gout demonstrated a reduced peak ankle joint angular velocity which may reflect gait-limiting factors and adaptations from the high levels of foot pain, impairment and disability experienced by this population.

1. Introduction

Gout is a common form of inflammatory arthritis in adults and is a chronic disease of urate crystal deposition in articular and peri-articular structures [1]. Clinically, gout is characterised by painful flares of acute monoarthritis interspersed with asymptomatic periods and can progress to a chronic arthritis with tophus formation [2]. Tophaceous gout, characterised by deposition of monosodium urate crystals (MSU) is associated with pain, inflammation, joint deformity and/or joint destruction, bone erosions and alteration to tendon and ligament structure and function [3,4]. Dual-energy computed tomography has shown that the foot and ankle contain the largest volume of MSU crystal deposition with between 37% and 68% of people with gout demonstrating some degree of crystal deposition within joints and soft tissue structures of the foot and ankle [5–8]. Stewart [9] reported that people with gout were found to have reduced foot and ankle muscle strength and experience greater foot pain and disability compared to controls using isokinetic dynamometry. Despite the importance of lower limb and foot muscle strength requirements in major daily life activities, including walking, there is limited knowledge of kinematic or kinetic characteristics of ankle function in people with gout. The aim of the study was to determine the kinematic and kinetic characteristics of the ankle joint in people with tophaceous gout in comparison with age-and sex-matched control participants.

2. Methods

Participants with tophaceous gout were recruited from a rheumatology clinic at the Auckland District Health Board, Auckland, New Zealand. Participants were eligible for study inclusion if they were:

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Table 1
Demographic and clinical characteristics.

		Tophaceous gout (N = 24)	Control (N = 24)	*P*
Age, years		61.9 (12.0)	61.7 (12.3)	0.95
Male, n (%)		22 (92)	22 (92)	0.99
Ethnicity	European, n (%)	14 (58)	23 (96)	< 0.001
	Māori, n (%)	1 (4)	1 (4)	
	Pasifika, n (%)	6 (25)	0 (0)	
	Asian, n (%)	3 (13)	0 (0)	
BMI, kg/m^2		31.1 (4.1)	26.3 (5.1)	< 0.01
Disease duration, years		17.4 (11.9)	–	–
Age at first episode, years		44.3 (18.8)	–	–
Flares in preceding 3 months		1.23 (1.45)	–	–
Hypertension, n (%)		17 (71)	7 (29)	< 0.01
Cardiovascular disease, n (%)		8 (33)	2 (8)	0.03
Type 2 diabetes, n (%)		7 (29)	2 (8)	0.07
Diuretic use, n (%)		9 (38)	9 (38)	1.00
Urate lowering therapy, n (%)		23 (96)	–	–
Colchicine use, n (%)		14 (58)	–	–
Prednisone use, n (%)		6 (25)	–	–
Foot tophus count		2.17 (3.33)	–	–
Total tophus count		7.21 (7.35)	–	–
HAQ-II		0.56 (0.52)	0.17 (0.31)	< 0.01
Foot pain, 100 mm VAS		28.50 (32.28)	4.13 (11.27)	< 0.01
Global pain, 100 mm VAS		27.00 (53.00)	0.00 (15.00)	< 0.01
Global health, 100 mm VAS		25.50 (38.00)	2.50 (14.00)	< 0.01
Serum urate, mmol/l		0.37 (0.11)	–	–
Walking velocity, m/s		1.02 (0.19)	1.23 (0.13)	< 0.01

Unless specified, data are presented as mean (SD).

classified with gout according to the 1977 American Rheumatism Association criteria [10]; aged > 18 years old; able to walk 10 m without assistive devices; and had at least one subcutaneous tophus determined by clinical examination at the time of data collection. Tophi were defined as palpable nodules evident within periarticular or subcutaneous tissue, which is a simple and feasible method for tophus assessment [11]. The location of tophi in each foot was also recorded. Participants were excluded if they had a previous rupture of the Achilles tendon, a current musculoskeletal injury to the lower limb, or history of peripheral neuropathy. A sample size of 22 participants per group was estimated based on previous work [12]. A community-dwelling control group of age-and sex-matched participants without gout were recruited by public advertising. The Auckland University of Technology Ethics Committee approved the study (AUTEC 13/100). All participants provided written informed consent prior to data collection. Demographic characteristics were recorded for all participants. Gout characteristics were recorded for the patients with gout. The severity of foot pain, generic pain and global function and activity limitation using the HAQ-II [13] were assessed.

Three-dimensional (3D) gait analysis was undertaken using a nine-camera motion analysis system (Qualysis AB, Gothenburg, Sweden) and two floor-mounted force plates (Advanced Mechanical Technology Inc., USA). Nineteen lightweight reflective markers (12 mm diameter) were attached to both lower legs and feet according to the Oxford Foot Model protocol described by Carson [14]. Three walking trials were conducted barefoot on a 10 m walkway at a self-selected walking velocity. All data processing was conducted in Visual 3D Professional (Version 5.01.18, C-Motion Inc., Germantown, MD, USA). Kinematic and kinetic data were sampled at 240 Hz and 1200 Hz, and filtered at 6 Hz and 10 Hz, respectively, using a 4th order Butterworth recursive filter. Inverse dynamics was used to estimate ankle joint moments and joint reaction forces, by combining kinematic and kinetic data in the single segment foot model. Kinematic and kinetic data were normalised to 100% of the stance phase. Ankle moments, ankle power, horizontal and vertical ground reaction forces were normalised according to each participant's bodyweight.

2.1. Statistical analysis

Demographic, clinical features, disease characteristics and patient-reported outcome measures were summarised as mean (SD). Comparative analysis for between group differences was performed by using analysis of covariance (ANCOVA). In the ANCOVA we adjusted for the baseline variables of walking velocity and BMI which were found to significantly differ between the two groups. The inclusion of these covariates is further justified based on previous studies that have shown differences in both walking velocity and BMI in populations with gout [9,15]. All data were analysed using SPSS v.24 (IBM Corporation) with the significance level set at 5%.

3. Results

Twenty-four tophaceous gout and 24 controls participated in the study. The majority of participants with gout were middle-aged males of European ethnicity (Table 1). Participants with tophaceous gout had a mean (SD) serum urate level of 0.37 (0.11) mmol/l and disease duration of 17.4 (11.9) years. Table 2 illustrates peak ankle joint angular velocity was significantly decreased in participants with gout ($P < 0.01$). No differences were found for ankle ROM in either the sagittal ($P = 0.43$) or frontal planes ($P = 0.08$). No differences were observed between groups for peak ankle joint power ($P = 0.41$), peak ankle joint force ($P = 0.25$), peak ankle joint moment ($P = 0.16$), timing for peak ankle joint force ($P = 0.81$), or timing for peak ankle joint moment ($P = 0.16$).

4. Discussion

Three dimensional gait analysis has improved our understanding of foot and ankle function in people with inflammatory arthritic conditions such as rheumatoid arthritis but has not been reported in gout. We found no differences in ankle ROM, peak force and peak plantar flexor moments and ankle plantarflexor concentric work were similar between the groups. The findings are contrary to previous work that reported