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Foot and ankle muscle strength in people with gout: A two-arm cross-sectional study

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ABSTRACT

Background: Foot and ankle structures are the most commonly affected in people with gout. However, the effect of gout on foot and ankle muscle strength is not well understood. The primary aim of this study was to determine whether differences exist in foot and ankle muscle strength for plantarflexion, dorsiflexion, inversion and eversion between people with gout and age- and sex-matched controls. The secondary aim was to determine whether foot and ankle muscle strength was correlated with foot pain and disability.

Methods: Peak isokinetic concentric muscle torque was measured for ankle plantarflexion, dorsiflexion, eversion and inversion in 20 participants with gout and 20 matched controls at two testing velocities (30°/s and 120°/s) using a Biodex dynamometer. Foot pain and disability was measured using the Manchester Foot Pain and Disability Index (MFPDI).

Findings: Participants with gout demonstrated reduced muscle strength at both the 30°/s and 120°/s testing velocities for plantarflexion, inversion and eversion ($P < 0.05$). People with gout also displayed a reduced plantarflexion-to-dorsiflexion strength ratio at both 30°/s and 120°/s ($P < 0.05$). Foot pain and disability was higher in people with gout ($P < 0.0001$) and MFPDI scores were inversely correlated with plantarflexion and inversion muscle strength at the 30°/s testing velocity, and plantarflexion, inversion and eversion muscle strength at the 120°/s testing velocity (all $P < 0.05$).

Interpretation: People with gout have reduced foot and ankle muscle strength and experience greater foot pain and disability compared to controls. Foot and ankle strength reductions are strongly associated with increased foot pain and disability in people with gout.

1. Introduction

Gout is a common form of inflammatory arthritis in adults and is caused by the deposition of monosodium urate (MSU) crystals in articular and peri-articular structures (Choi et al., 2005). Gout typically presents as episodes of acute inflammatory arthritis interspersed with intercritical asymptomatic periods (Martinon, 2006). In the presence of prolonged hyperuricaemia, chronic gouty arthritis may develop with degenerative joint damage, soft tissue inflammation, tophus formation and altered structural integrity of tendons and ligaments (Dalbeth et al., 2010; Martinon, 2006). The structures of the foot and ankle are frequently affected in people with gout (Grahame and Scott, 1970; Hench, 1941). Furthermore, imaging studies have demonstrated particular patterns of foot involvement in gout in which the most common sites for MSU deposition are the first metatarsophalangeal joint, ankle joint and tendons surrounding the ankle including the peroneal and Achilles tendons (Dalbeth et al., 2013; Kim et al., 2013; Mallinson et al., 2014).

People with gout report difficulty walking and experience high levels of foot pain, disability and impairment (Prowse et al., 2013; Rome et al., 2011a,b, 2012). Previous studies have also shown that people with gout demonstrate apropulsive gait patterns with reduced walking speed and cadence (Prowse et al., 2013; Rome et al., 2011a). Despite the importance of lower limb and foot muscle strength requirements in major daily life activities, including walking, the strength of

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foot and ankle muscles in gout is poorly understood. Quantifying muscle strength may be useful in establishing the biomechanical impact of gout, providing further insight into the associated impairments and disabilities, characterising the natural progression of the disease, and consequently aid in monitoring the efficacy of therapies in a clinical setting.

The primary aim of this study was to determine whether there were significant differences in foot and ankle muscle strength for ankle plantarflexion, dorsiflexion, inversion and eversion between people with gout and age- and sex-matched controls. The secondary aim was to determine whether foot and ankle muscle strength was associated with foot pain and disability in people with gout and age- and sex-matched controls. It was hypothesised that those with gout would exhibit decreased muscle strength, and that decreased muscle strength would be associated with higher levels of foot pain and disability.

2. Methods

A two-arm cross-sectional study was undertaken at the Auckland University of Technology (AUT), New Zealand. Twenty participants with gout were conveniently sampled from patients registered with the Rheumatology Department at Auckland District Health Board, New Zealand. All patients met the 1977 preliminary American Rheumatism Association classification criteria for gout (Wallace et al., 1977). Twenty age- and sex-matched controls were recruited from AUT University through poster advertisements and staff newsletters. Ethical approval was obtained from AUT Ethics Committee (AUTEC 13/100). Participants were excluded if they had a history of lower limb amputation, recent surgery or injury to the foot or ankle, or other rheumatic condition. Gout participants were also excluded if they were experiencing an acute flare at the time of assessment as determined by a registered podiatric clinician. Demographic information including age, sex, ethnicity, body mass index (BMI), current medications and co-morbidities was recorded for all participants. Disease duration and gout clinical characteristics, including flares in preceding 3 months, and the presence and number of subcutaneous tophi, were recorded for the gout participants.

Patient-reported foot pain and disability was assessed using the Manchester Foot Pain and Disability Index (MFPDI) (Garrow et al., 2000). This 19-item index measures foot-related items associated with functional limitation, pain, and physical appearance. Statements relating to each item were answered 'none of the time' (scored as 0), 'on some days' (scored as 1) and 'on most/every day(s)' (scored as 2) in the past month. A total score out of 38 was calculated for each participant.

Peak isokinetic concentric muscle strength was tested by a single researcher for four conditions: ankle plantarflexion, dorsiflexion, inversion and eversion using the Biodex System 3 Dynamometer (Biodex Medical Systems, Shirley, New York). Isokinetic dynamometry has been shown to be a reliable tool for measuring peak torque at the ankle joint (Aydoğ et al., 2004; Hartmann et al., 2009). For all testing conditions, participants were seated in the adjustable chair of the dynamometer with the hip angle set at 70° to 85° flexion. The leg to be tested was elevated by a support arm under the knee which was flexed at 30° to 45°. To stabilise this position, straps were fit around the participant's torso, waist, and thigh. The participant's ankle was placed on a footplate, with the heel supported in a rubber heel cup at 90° flexion and the forefoot secured with two Velcro straps.

Prior to isokinetic testing each participant undertook a 5 min warm up that involved walking at a self-selected pace. Participants were then seated in the Biodex device and the maximal range of motion was established for each test condition. In addition, to negate the effect of gravity on torque, each limb was weighed and the data corrected by the Biodex software (Holmeback et al., 1999). Prior to testing, each participant received a verbal explanation of each test and was asked to perform four test-specific submaximal contractions to allow them to become familiar with each test procedure. Following the warm up each participant was asked to perform five maximal concentric isokinetic efforts. Verbal encouragement was given throughout testing. Both right and left limbs were tested for each condition at two velocities: 30°/s and 120°/s. Participants were given a 2-minute rest period between each velocity condition. Participants were also given a five-minute rest period between plantarflexion–dorsiflexion testing and inversion–eversion testing. The maximum peak torque was calculated from the five contractions for each test condition and was normalised to the participant's body weight prior to analysis. In addition, the strength ratios of the antagonistic muscle groups (plantarflexion-to-dorsiflexion and eversion-to-inversion) were also calculated.

Descriptive statistics relating to participant demographics and muscle torque were presented as mean (SD) for continuous data and frequency (%) for categorical data. All muscle torque data was reviewed for normality using residuals from a linear model through both visual and formal tests including Kolmogorov–Smirnov and Shapiro–Wilk tests, with the participant group (gout or control) as the independent variable. Adjustments for gender, age group, and ethnicity were considered for each testing condition if they achieved at least 10% on an F test. A single adjusted model was sought for all testing conditions to facilitate interpretation. To determine whether the differences between gout and control groups were significant for each muscle test condition, mixed linear models were used. Models accounted for repeated measures taken from right and left feet of each participant through adopting a mixed models approach in which a participant-specific random effect and participant-nested random effect for foot-side were included. This analysis produces results identical to an analysis of measures averaged for each foot-side that would allow for a between-foot-side correlation, and also allows for any reweighting required due to missing values. For muscle groups which demonstrated significant between-group differences, Pearson correlation coefficients, denoted r, were used to assess for associations between the total MFPDI scores and muscle force. An r value of 0.1 was considered a small effect size, 0.3 a medium effect size, and 0.5 a large effect size (Cohen, 1988). No adjustments for multiplicity were used, but all test-statistics, their null distributions and

Table 1
Demographics & clinical characteristics.

Variable	Control	Gout	*P*
N	20	20	
Gender, male, n (%)	19 (95%)	19 (95%)	0.998
Age, years, mean (SD)	53 (12)	60 (7)	0.056
Ethnicity, n (%)	European 20 (100%) Maori 0 (0%) Pacific 0 (0%) Asian 0 (0%)	European 12 (60%) Maori 1 (5%) Pacific 3 (15%) Asian 4 (20%)	**0.004**
BMI, kg/m^2, mean (SD)	26.7 (4.3)	31.5 (5.9)	**0.006**
Diuretic use, n (%)	1 (5%)	3 (15%)	0.635
NSAID use, n (%)	0 (0%)	12 (60%)	0.998
Prednisone use, n (%)	0 (0%)	2 (10%)	0.998
Hypertension, n (%)	6 (30%)	12 (60%)	0.061
Cardiovascular disease, n (%)	1 (5%)	5 (25%)	0.108
Diabetes, n (%)	1 (5%)	4 (20%)	0.182
Microscopically proven gout	–	4 (20%)	–
Disease duration, years, mean (SD)	–	16 (11)	–
Serum urate, mmol/l, mean (SD)	–	0.37 (0.15)	–
Flares in preceding 3 months, mean (SD)	–	1.1 (1.6)	–
Any subcutaneous tophi, n (%)	–	12 (60%)	–
Subcutaneous tophus count, mean (SD)	–	3.9 (6.1)	–
Urate lowering therapy, n (%)	–	18 (95%)	–
MFPDI, total score, mean (SD)	2.1 (4.3)	12.4 (8.6)	**0.00001**

Bold values are those with a p-value of less than or equal to 0.05.