ISB 2013 BRAZIL
XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

Kinematic changes in the rheumatoid arthritic foot are related to pathologies of foot joints and tendons

[1]Rosemary Dubbeldam, [2]Hetty Baan and [1]Jaap Buurke
[1]Roessingh Research and Development, Enschede, The Netherlands, email: r.dubbeldam@rrd.nl
[2]Ziekenhuis Group Twente, Twenteborg Ziekenhuis, Almelo, The Netherlands

SUMMARY

In rheumatoid arthritis, pathologic changes in structures and in gait kinematics of the foot and ankle occur from onset of the disease. The aim of this study was to explore the relationship between these clinical and kinematic factors at various phases of stance.

Foot and ankle kinematics of 25 subjects with RA was assessed and related to the following clinical factors: Magnetic Resonance Imaging scores of joint swelling and erosions and leg tendon involvement, as well as Joint Alignment and Motion scores. The upper and lower confidence intervals of Spearmans correlation coefficient were used to explore the relationships between clinical and kinematic parameters.

Maximum first metatarsal-phalange (MTP I) dorsiflexion at pre-swing was related to reduced MTP I passive motion, MTP I synovitis and erosion, midfoot synovitis and erosion as well as hindfoot erosion. Midfoot pronation rang of motion during single-stance was related to subtalar alignment and Achilles tendon involvement. Hindfoot eversion range of motion during single-stance was related to subtalar alignment and peroneus longus tendon involvement. Involvement of the tibialis posterior tendon could not be identified as an independent factor influencing foot or ankle kinematics. In conclusion, changes in gait kinematics could be related to structural pathologies. Such findings may provide guidelines for foot and ankle therapies.

INTRODUCTION

Walking problems are a common experience for 40% to 60% of patients with rheumatoid arthritis (RA) [1]. Their foot and ankle gait kinematics have been shown to alter from early onset of the disease compared to healthy subjects [2]. While foot joint and tendon pathologies in RA have been studied, little is know about their relationship with the kinematic changes during gait. A better understanding between these clinical and kinematic factors may support clinical decisions in both conservative and surgical treatment. The aim of this study was to explore the relationship between foot and ankle structural pathologies and corresponding gait kinematics of subjects with RA.

METHODS

Gait of 25 subjects with varying stages of RA disease were recorded by means of 6 infra-red video camera's (Figure 1). Corresponding foot and ankle kinematics was assessed by means of a 5-segment foot and ankle computer model consisting of a hallux, forefoot, midfoot, hindfoot and leg segment [3]. The stance-phase was divided into foot-loading (first double-stance), single-stance, and pre-swing (second double-stance). A previous study showed that changes in maximum first metatarsal-phalange (MTP I) at pre-swing, the midfoot pronation range of motion during single-stance and the hindfoot eversion range of motion during single-stance were pathological changes in RA foot and ankle kinematics compared to those from healthy subjects, independent of walking speed [4].

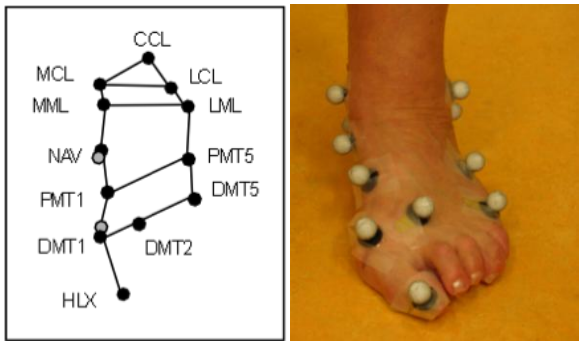

Figure 1: Foot and ankle computer model and foot with markers

For the 25 subjects, the following clinical parameters were assessed: MTP I and subtalar passive motion and alignment sub-scores from the Joint Alignment and Motion (JAM); and synovitis and bone erosions of the MTP I, midfoot and hindfoot, as well as leg tendon involvement by means of Magnetic Resonance Imaging (MRI) [5].

Spearman correlation tests were performed between the three kinematic parameters and also between the various clinical parameters to test for independency of these parameters. The relationships between the kinematic and clinical parameters were evaluated by means of the upper and lower 95% confidence interval (CI) of the correlation coefficient (CC) from Spearman's tests. Relationships with a CC larger than 0.3 or 0.5 were defined as moderate and strong respectively [6].

RESULTS AND DISCUSSION

The cross-sectional cohort of 25 subjects had a mean age of 51 years (range 23-78 years) and mean disease duration of 9 years (range 0.5–23 years). The kinematic parameters were comparable to those of subjects with RA in other studies [2].

The three kinematic parameters were independent of each other. Some clinical parameters were dependent. This might be expected, as some clinical parameters such as joint erosion and joint passive motion are closely related. The results of the Spearman correlation tests between the clinical and kinematic parameters are presented in Table 1.

Maximum first metatarsal-phalange (MTP I) dorsiflexion at pre-swing was related to reduced MTP I passive motion, MTP I synovitis and erosion. MTP I synovitis and erosion may result in pain and reduced mobility, which have both have been related to a reduction in stride length. Smaller stride lengths result in lower walking speeds, less MTP I dorsiflexion and less pressure under MTP I during pre-swing [7,8].

Midfoot pronation and hindfoot eversion range of motion during single-stance were related to subtalar alignment and not to midfoot or hindfoot erosion or synovitis. Turner reported similar findings: changes in hind- and forefoot kinematics were only observed in cases with severe hindfoot impairments [9]. Only a limited amount of hindfoot motion may be required for normal gait, while a more everted hindfoot posture may limit the required eversion motion due to the increase in maximum hindfoot eversion.

Peroneus involvement was moderately related to hindfoot eversion motion but also strongly related to subtalar alignment, hence may have been indirectly related to hindfoot motion.

Pathological changes to the Achilles tendon were related to increased motion of midfoot pronation during single-stance. Only 5 subjects had Achilles tendon involvement and they were the only 5 subjects with staining of the attachment of the plantar fascia on MRI. Both Achilles tendon and plantar fascia have been discussed in relation to pre-tensioning of the foot structures and thus may control midfoot motion during stance [10.11].

Involvement of the tibialis posterior tendon could not be related to changes in midfoot or hindfoot motion; a contradictory finding to study results on the effect of tibialis posterior tendon dysfunction (TPTD) [12]. It should be noted though, that the participating TPTD-subjects all had an everted alignment posture of the hindfoot, which alone was related to significant changes in foot joint motion in this study. Furthermore, Imhauser showed that the tibialis posterior tendon can only be functional if the joints of the midfoot are intact [13]. And these joint are frequently impaired in RA.

CONCLUSIONS

Although RA is a complex disease with multiple impairments to the foot and ankle, relationships between clinical and kinematic parameters were found in our cross-sectional cohort. Not only clinical scores based on MRI were related to joint kinematics, but also easily assessed scores such as MTP I motion and subtalar alignment.

ACKNOWLEDGEMENTS

The Innovation Centre for Rehabilitation Technology, The Netherlands, provided funding for this study, grant IC-7856.

REFERENCES

1. Van der Leeden M, et al., *Arthrit Rheum*. **59**:1596-1602, 2008.
2. Turner DE, et al., *BMC Musculo. Dis*. **7**:102, 2008.
3. Simon, et al., *Gait Posture*, **23**:411-421, 2006.
4. Dubbeldam R, et al., *Gait Posture*. **33**:390-395, 2011.
5. Baan H, et al., *J. Rheumatol*. **38**:1003-1008, 2011.
6. Cohen J, *Statistical power analysis for the behavioural sciences*, Hillsdale: Lawrence Erlbaum Assoc. 1988.
7. Dubbeldam R, et al., *Clin. Biomech*, **25**:796-801, 2010.
8. Rosenbaum D, et al., *Gait Posture* **2**:191-197, 1994.
9. Turner DE, Woodburn J, *Gait Posture* **28**:574-580, 2008.
10. Cheng HYK, et al., *J. Biomech.* **41**:1937-1944, 2008.
11. Cheung JTM, et al., *Clin. Biomech.* **21**:194-203, 2006.
12. Ness ME, et al., *Gait Posture* **27**:331-339, 2008.
13. Imhauser CW, *Clin. Biomech.* **19**:161-169, 2004.

Table 1: Results of the Spearman correlation tests between clinical and kinematic parameters: the lower (low) and upper (upp) values of the confidence interval (CI) of the correlation coefficient. ROM (range of motion)

Spearman correlation test	MTP I max dorsiflexion at pre-swing		Midfoot pronation ROM at single-stance		Hindfoot eversion ROM at single-stance	
	low CI	upp CI	low CI	upp CI	low CI	upp CI
Subtalar motion JAM	-0.65	0.05	-0.57	0.19	-0.55	0.21
MTP I motion JAM	-0.75	-0.13	-0.57	0.18	-0.59	0.15
Subtalar alignment JAM	-0.67	0.02	-0.75	-0.14	-0.78	-0.20
Synovitis MTP I MRI	-0.82	-0.30	-0.41	0.39	-0.67	0.05
Erosion MTP I MRI	-0.86	-0.40	-0.65	0.07	-0.57	0.20
Synovitis Midfoot MRI	-0.69	0.00	-0.57	0.21	-0.40	0.40
Erosion Midfoot MRI	-0.77	-0.17	-0.62	0.13	-0.55	0.23
Synovitis Hindfoot MRI	-0.63	0.11	-0.68	0.03	-0.34	0.46
Erosion Hindfoot MRI	-0.69	0.00	-0.63	0.12	-0.51	0.29
Tibialis posterior tendon inv MRI	-0.42	0.38	-0.32	0.48	-0.45	0.36
Flex hallucis longus tendon inv MRI	-0.50	0.30	-0.31	0.49	-0.34	0.47
Peroneus tendon inv MRI	-0.55	0.23	-0.59	0.17	-0.70	-0.01
Achilles tendon inv MRI	-0.43	0.37	0.02	0.70	-0.28	0.51