Gait & Posture 29 (2009) 387–391

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Full length article

Intrinsic gait-related risk factors for Achilles tendinopathy in novice runners: A prospective study

Ans Van Ginckel [a,*], Youri Thijs [a], Narmin Ghani Zadeh Hesar [a], Nele Mahieu [a], Dirk De Clercq [c], Philip Roosen [b], Erik Witvrouw [a]

[a] Department of Rehabilitation Sciences and Physiotherapy, Faculty of Health Sciences and Medicine, Ghent University, De Pintelaan 186 3B3, B-9000 Ghent, Belgium
[b] Department of Rehabilitation Sciences and Physiotherapy, Artevelde University College, Ghent, Belgium
[c] Department of Sports and Movement Sciences, Faculty of Health Sciences and Medicine, Ghent University, Ghent, Belgium

ARTICLE INFO

Article history:
Received 7 April 2008
Received in revised form 9 October 2008
Accepted 10 October 2008

Keywords:
Kinetics
Achilles tendon
Running
Risk factors
Gait

ABSTRACT

The purpose of this prospective cohort study was to identify dynamic gait-related risk factors for Achilles tendinopathy (AT) in a population of novice runners. Prior to a 10-week running program, force distribution patterns underneath the feet of 129 subjects were registered using a footscan® pressure plate while the subjects jogged barefoot at a comfortable self-selected pace. Throughout the program 10 subjects sustained Achilles tendinopathy of which three reported bilateral complaints. Sixty-six subjects were excluded from the statistical analysis. Therefore the statistical analysis was performed on the remaining sample of 63 subjects. Logistic regression analysis revealed a significant decrease in the total posterior–anterior displacement of the Centre Of Force (COF) ($P = 0.015$) and a laterally directed force distribution underneath the forefoot at 'forefoot flat' ($P = 0.016$) as intrinsic gait-related risk factors for Achilles tendinopathy in novice runners. These results suggest that, in contrast to the frequently described functional hyperpronation following a more inverted touchdown, a lateral foot roll-over following heel strike and diminished forward force transfer underneath the foot should be considered in the prevention of Achilles tendinopathy.

1. Introduction

The development of Achilles tendinopathy (AT) is a multifactorial process influenced by both extrinsic (environmental) and intrinsic (person-related) risk factors [1–6]. Although it has been stated that overuse injuries are resulting from training errors, underlying anatomical or biomechanical features would prevent a runner from training as long or intensely as another runner before incurring an overuse injury [7].

The most prominent hypothesis concerning running patterns suggests that rapid and repeated transitions from pronation to supination cause the Achilles tendon to undergo a 'whipping' or 'bow-string' action [2,6,8,18]. In hyperpronation, resulting either in delayed resupination [8,10] or excessive motion in the frontal plane especially in a lateral heel strike [5], the Achilles tendon is even more subjected to whipping [8]. This whipping action creates shear forces across the Achilles tendon exerting particularly high eccentric stresses on the medial side of the tendon [9]. Cross-sectional studies have reported more inversion at touchdown, significant greater maximum pronation velocity, more pronation and a shorter time to maximum pronation in runners afflicted with AT [8,11,12].

It should be noted, however, that prospective studies are still lacking hampering a clear cause–effect relationship especially when the importance of foot roll-over characteristics (e.g., hyperpronation) in the onset of AT is considered.

The purpose of this prospective cohort study was to determine intrinsic dynamic gait-related risk factors for AT in a population of novice runners. It was hypothesized that novice runners developing AT show an altered roll-over pattern of the foot in force distribution measured with a pressure plate.

2. Materials and methods

2.1. Subjects

Healthy, able-bodied novice runners ($N = 129$) participated voluntarily. All were recruited from the participants of three Start To Run programs (STRs) organised in April 2006 and April 2007 if they met the criteria of a novice runner. A novice runner was defined as an individual having no former experience in running or jogging and taking part in a STR for the first time. All subjects were injury-free at the time of enrolment and did not sustain any injury to the lower extremities and back during

* Tel.: +32 9 3325374; fax: +32 9 3223811.
E-mail address: Ans.VanGinckel@UGent.be (A. Van Ginckel).

0966-6362/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.gaitpost.2008.10.058

the last year preceding the STR. No subject practised any other sport than running training following the STR. The population at baseline consisted of 19 men and 110 women (mean age 39 ± 10, mean height 168.6 ± 7.7, mean body mass 70.4 ± 11.5, mean BMI 24.8 ± 3.5).

Since all subjects participated in the same training program in the same track and field club and with the same coach, risk factors were controlled for training and running surface. The Ethical Committee of the University Hospital approved the study and all subjects gave informed consent.

2.2. Physical Activity Score

According to Mahieu et al. [13], the subjects were asked to fill out the Baecke questionnaire. This reliable and valid questionnaire [14] measures physical activity level by quantifying 'work', 'sports' and 'leisure' activities using a five-point scale (0 = never and 5 = always). By counting up the scores of the three distinct dimensions each subject's total physical activity score was calculated.

2.3. Instrumentation

Prior to the start, dynamic force measurements were performed using a pressure plate (footscan®, 2 m × 0.4 m, 16,384 sensors, 480 Hz, RsScan International) embedded in the middle of a 15-m runway. The pressure plate was hidden by thin rubber mats (rubcor, 5 mm) to prevent targeting of the plate [15]. The subjects were asked to jog barefoot over the runway at a comfortable self-selected pace. No attention was drawn to the localization of the pressure plate in the runway. After two to three practice trials, three valid right and left trials were registered. A trial was considered valid if the following criteria were met: stance phase recorded as a heel strike pattern (from heel contact to toe-off), no visual adjustments in gait pattern (step length or frequency) to aim at the plate.

2.4. Injury registration

During the program injuries were registered on a standardized registration form by the same two investigators (cited as two authors) who were only present on training days. These investigators were blinded to the results of the plantar force measurements since they were not involved in data analysis nor were informed about the overuse injury of interest. The subjects reported injuries freely to these investigators. An overuse injury was defined as a musculoskeletal ailment that causes a restriction of running speed, distance, duration or frequency for at least 1 week [7]. AT was diagnosed as an insidious, gradual onset of mid-portion pain, palpated tenderness along the tendon, (morning) stiffness, tenderness and pain on exertion [1,16,17]. Structures in the differential diagnosis include the sural nerve, posterior ankle structures, medial tendons of the foot and toes and bursae near the calcaneum [17].

2.5. Start To Run program

The STR coaches novice runners to achieve the goal of jogging 5 km (30 min) within a training period of 10 weeks. This initiative is supervised by the Flemish Track and Field Association and is organised in qualified track and field clubs. Participants are trained in a group by a qualified STR coach three times per week. The STR comprises a gradual build-up of interspersed running and walking units during which the participants are encouraged to jog at their own comfortable speed. The program is available in supplementary information.

2.6. Data analysis

For each trial, eight anatomical zones were automatically identified by the software (footscan® software 7.0 Gait 2nd Generation, RsScan International), controlled, and, if necessary, manually corrected by adjusting the pixels per zone [18]. These areas were defined as medial heel (H_M), lateral heel (H_L), metatarsal heads I–V (M_1, M_2, M_3, M_4 and M_5) and the hallux (T_1) [15,18]. Temporal data (i.e., time to peak force, instants on which the zones make contact and instants on which the zones end foot contact), peak force and absolute force–time integrals (mean force × loaded contact time) and relative force–time integrals (absolute force–time integrals × 100/sum of all force–time integrals) were calculated for all regions. Next to total foot contact time, five distinct instants of foot roll-over (First Foot Contact: FFC, First Metatarsal Contact: FMC, ForeFoot Flat: FFF, Heel Off: HO, Last Foot Contact: LFC) and four phases (Initial Contact Phase: ICP, ForeFoot Contact Phase: FFCP, Foot Flat Phase: FFP, ForeFoot Push Off Phase: FFPOP) were defined for each trial according to De Cock et al. [15]. Two medio-lateral force ratios were calculated at these five instants of foot contact (Ratio 1 = $[(H_M + M_1 + M_2) - (H_L + M_4 + M_5)]/$

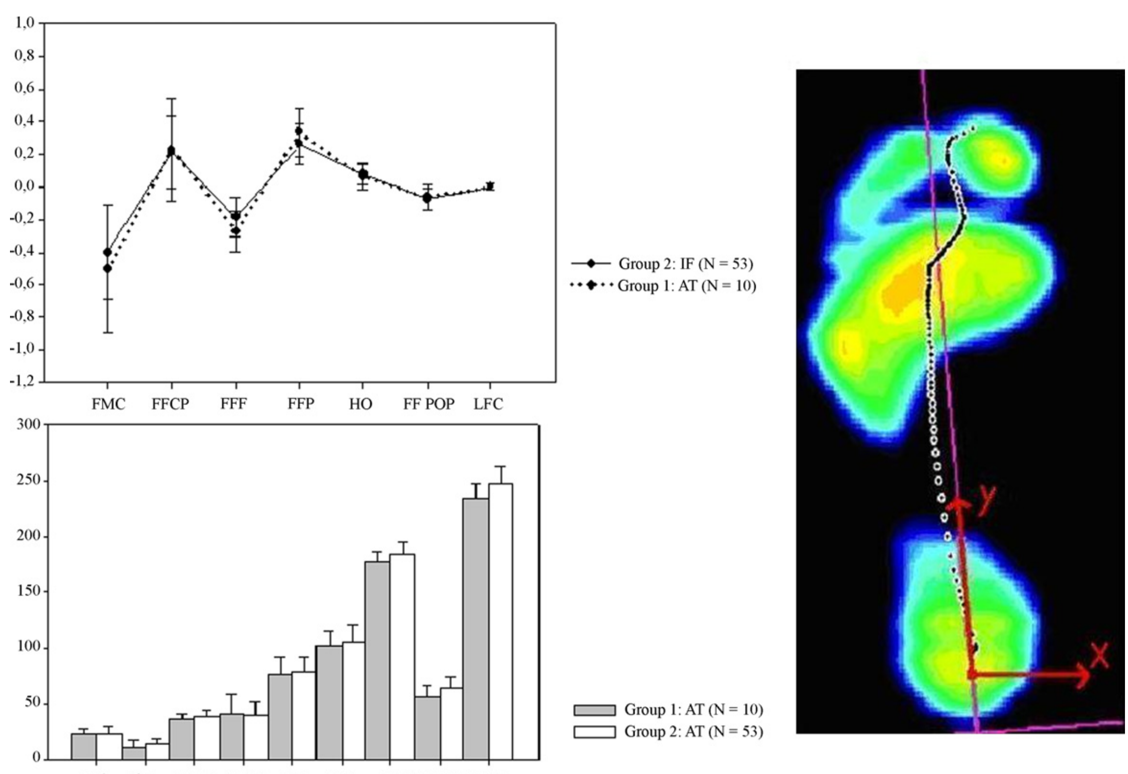

Fig. 1. AT: Achilles tendinopathy and IF: injury-free. Top left: the course of the medio-lateral force distribution (with S.D.) underneath the forefoot at four instants (FMC, FFF, HO, and LFC) and during three phases of foot roll-over (FFCP, FFP, and FFPOP); a positive value reflects a medially directed force distribution, a negative value a laterally directed force distribution. Bottom left: the displacements and positioning of the Y-component of the COF in mm (with S.D.) at the five instants (FFC, FMC, FFF, HO, and LFC) and during the four phases of foot roll-over (ICP, FFCP, FFP, and FFPOP). Right: the course of the COF line along the foot axis during foot roll-over in heel-toe running. The X-component (medio-lateral positioning and displacement) and the Y-component (postero-anterior positioning and displacement) of the COF. The X-component has a positive value when positioned medially to the heel–M_2 axis and has a negative value when positioned laterally to the heel–M_2 axis. Note significantly less displacement of the Y-component during the ForeFoot Push Off Phase and Last Foot Contact resulting significantly decreased total displacement of the Y-component in the AT-group.