BAREFOOT RUNNING WITH ELONGATED OR SHORTENED ACHILLES TENDON AFTER RUPTURE

Daniel Jandacka[1], Jaroslav Uchytil[1], David Zahradník[1], Roman Farana[1], Julia Freedman Silvernail[2]and Joseph Hamill[1,3]

Human Motion Diagnostic Center, University of Ostrava, Czech Republic[1]
Kinesiology and Nutrition Sciences. University of Nevada Las Vegas, USA[2]
Kinesiology, University of Massachusetts, Amherst, USA[3]

The aim of this study was to compare the internal abduction moment in the knee joint during barefoot (BF) running by athletes who have experienced Achilles tendon (AT) rupture compared to a control group. The study featured 14 recreational runners without other acutemusculo-skeletal injuries. Three groups were created: with a shortened AT (n = 3), with an elongated AT (n = 6), and a control group (n = 5). Kinematic and ground reaction force data were synchronized and then used to calculate the internal abduction moment in the knee. The normalized maximum values of internal abduction moment in the knee joint of the affected limb for the experimental groups exceeded those for the healthy subjects(ES > 0.81). These data suggest that biomechanical risk factors for knee osteoarthritis in limbs with a history of AT rupture may be increased during BF running.

KEY WORDS: Achilles tendon, rupture, barefoot running, biomechanics, injury prevention

INTRODUCTION: The incidence of Achilles tendon (AT) rupture has increased in recent years(Houshian et al., 1998). AT rupture primarily affects athletes over the age of 30 (Vosseller et al., 2013). Despite all medical efforts, it has not been possible to restore the original functional properties of the plantar flexors and proprioception in affected athletes (Bressel et al., 2004). It is mainly AT length that is affected in this group (Rosso et al. 2013). Despite a shortening or elongation of the AT, athletes do manage to return to an active lifestyle. However, previous musculo-skeletal injury is associated with a higher incidence of injury among runners (Saragiotto et al., 2014).
Proprioceptive exercises are recommended for athletes recovering from AT rupture (Bressel et al., 2004). A very popular form of proprioceptive exercise is barefoot running (Lieberman et al., 2010). This current phenomenon is recommended by some authors as a means of treating athletes' chronic injuries or as a form of preventive exercise (Hryvniak et al., 2014). Sinclair (2014) stated that barefoot running may reduce the incidence of knee joint injury in healthy subjects. Nevertheless, in individuals with a history of AT rupture the plantar flexors maysuffer from a functional deficit even two years or more after surgery (Jandacka et al., 2013)andit is not clear whether these runners may be at risk of a secondary injury during barefoot running. The plantar flexors operate primarily in the sagittal planeand a deficit in performance in the sagittal plane may logically be substituted by increased loading on the lower limb joints in the frontal plane. An increased internal abduction moment during dynamic activity has been associated with increased joint contact forces on the medial plateau (Kutzner et al. 2013). Moreover, prospective gait research has suggested a causal relationship between internal abduction moment and the development of symptoms of osteoarthritis (Lynn et al., 2007).
The aim of this pilot study was to compare the internal abduction moment in the knee joint during barefoot running by athletes with an elongated or shortened Achilles tendon (AT) as a result of previous rupture and by a control group. On the basis of previous research into running biomechanics byJandacka et al. (2013),we expect higher internal abduction moment in the knee joint in the group with elongated AT.

METHODS: This pilot study featured 14 recreational runners without recentacute musculo-skeletal injuries. Nine of the athletes had a history of AT rupture at least two years before the data collection for this study. Using data from AT length measurement, we divided this group of nine into two subgroups – with shortened AT and with elongated AT. The control group consisted of five recreational runners who stated no history of serious musculo-skeletal injuries (Table 1).The experimental groups consisted of volunteers whose affected AT was more than 4 mm (twice the standard deviation of the control group) longer or shorter than the contralateral AT (Table 1).

Table 1
Descriptive statistics of participants

	Elongated AT	Shortened AT	Control
	n = 6	n = 3	n = 5
Age (years)	30.8 (6.1)	39.3 (12.6)	30.6 (3.8)
Mass (kg)	73.6 (10.6)	69.7 (16.7)	72.5 (12.4)
Height (m)	1.77 (0.09)	1.71 (0.13)	1.75 (0.05)
Right Plantar Flexion IC (˚)	24 (8)	21 (7)	24 (10)
Difference in AT length (mm)	24 (5)	-10 (2)	2 (2)

Note: Difference inAT length means the difference between left and right AT, IC means initial contact.

A combination of ultrasonography and a system of infrared cameras (Qualisys Oqus, Göteborg, Sweden) was used to measure AT length (Rees et al. 2008).AT length was defined as the distance between thegastrocnemius musculotendinous junction and the calcaneal osteotendinous junction (Silbernagel et al. 2012).

Before data collection, the participants performed barefoot running for a duration of five minutes. Subsequently each participant performed five valid attempts at barefoot running over force plates at a designated speed of 3.2 m/s (±5%).The running speed was verified using EGMEDICAL OPZZ15 wireless photocells (EGMedical s.r.o., Brno, Czech Republic). Lower limb kinematics were recorded using a system of infrared cameras (Qualisys Oqus, Göteborg, Sweden). The measurement of reaction forces on a base was performed using two force plates (Kistler, 9286 AA a 9281CA, Kistler Instrumente AG, Winterthur, Switzerland),which were built into a 17 meters-long runway at floor level. Kinematic (frequency 240 Hz) andforce (frequency 1200 Hz) data were mutually synchronized. Internal moments in the knees were determined using inverse dynamics and expressed in the local thigh coordinate system. Moment data were normalized with respect to body mass. The minimum value during the stance phase of running represented the peak internal abduction moment. The angle of the talocrural joint in the sagittal plane at the moment of initial contact expresses the relative position of the foot and the lower leg. Descriptive statistics were calculated for dependent and control variables. The difference in the dependent variables between the experimental and control group was evaluated using effect size. Effect sizes (ES) were calculated and interpreted as <0.2 trivial; 0.21-0.50 small; 0.51-0.80 medium and >0.81 large (Cohen 1992).

RESULTS:

Table 2
Peak Internal Abduction Moment (Nm/kg) during the stance phase of barefoot running in each group (mean ± standard deviation)

	Elongated AT	Shortened AT	Control	Effect Size	Effect Size
	n = 6	n = 3	n = 5	Elongated/ Control	Shortened/Control
Affected (Left) Knee (Nm/kg)	-0.88 (0.32)	-0.80 (0.04)	-0.54 (0.19)	1.8	1.4
Unaffected (Right) Knee (Nm/kg)	-0.62 (0.25)	-0.52 (0.05)	-0.58 (0.12)	0.3	0.5

The normalized maximum values of internal abduction moment in the knee joint of the affected (left) limb for the experimental groups exceeded those for the healthy subjects with large effect size. A small effect size on the normalized maximum values of internal abduction moment was recorded in the unaffected limbs (Table 2, Figure 1).

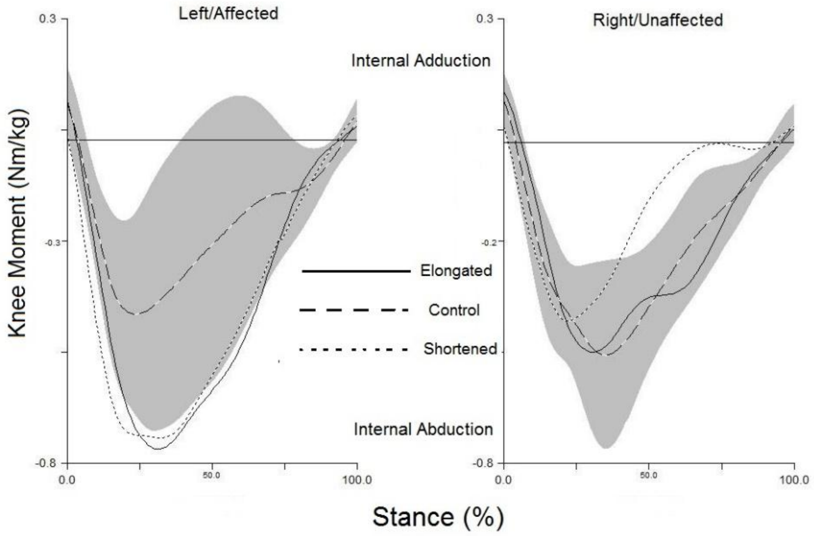

Figure 1: Comparison of internal moments in the knee joint during the stance phase of barefoot running between experimental groups and the control group (mean ± standard deviation of the control group in grey).

DISCUSSION: The study confirmed the expectation of a higher internal abduction moment in the knee joint during barefoot running in the group with elongated AT compared with the control group. Nevertheless, a higher internal abduction moment in the knee joint was also found in the group with shortened AT. It appears that a functional deficit in the AT may cause higher values of biomechanical risk factors for knee osteoarthritis (Lynn et al., 2007). Lynn et al. (2007) stated that increased internal abduction moment in the knee joint during locomotion leads to a progression of the symptoms of knee osteoarthritis.
The internal abduction moment in the knee of the unaffected limb was higher with small effect in the group with elongated ATbut it was lower with small effect in the group with shortened AT. At the end of the stance phase,the abduction moment appears to be considerably lower in the group with shortened AT (Figure 1). However, these changes range between 0.04 - 0.06 Nm/kg and are not clinically relevant.
Lieberman et al. (2010) recommended barefoot running as a proprioceptive exercise; however, this may represent a risk in terms of the development of symptoms of osteoarthritis both in people with shortened AT and in those with elongated AT. In this study, we did not have the opportunity to study a group of subjects who had undergone AT surgery with no subsequent elongation or shortening of the AT. We, therefore, do not know whether the increase in internal abduction moment is associated with a change in AT length or whether running biomechanics are influenced by other changes in properties connected with AT rupture.

CONCLUSION: Barefoot running as a proprioceptive exercise for recreational athletes with a history of AT rupture may bring increased biomechanical risk factors for knee osteoarthritis in the affected lower limb. Both shortened and elongated Achilles tendons may lead to increased internal abduction moment in the knee during running.

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