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

A prospective study on full-body kinematic related risk factors in the development of exertional medial tibial pain (EMTP)

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INTRODUCTION

Approximately 50% of all sports injuries are secondary to overuse.[1] One of the most common overuse injuries is exertional medial tibial pain(EMTP),[2] especially in female athletes.[3-4] EMTP is characterised by exertional pain along the posteromedial border of the middle and distal thirds of the tibia [5] and can include various diagnostic entities. [6, 7] As generally described in literature, EMTP results from repetitive microtraumata which cause local tissue damage,[1] and commonly this mechanism occurs during regular physical activity. The development of prevention and rehabilitation strategies for lower extremity (LE) injuries including EMTP therefore is of great concern for researchers and health care professionals.

Current literature has pointed out influences of both distal and proximal factors in the development of EMTP,[3, 8-10] suggesting that potential contributors can be found from the ground up and/or from the pelvis down.

In contrast to the well identified distal contribution of an excessive or prolonged pronation pattern in EMTP,[3-4, 8] no consensus on the specific contribution of proximal kinematic factors in LE overuse injuries can be found in current literature.[11,12] This inconsistency can be interpreted as an indication that it may be important to evaluate functional output measures like the ability to maintain dynamic joint stability (DJS) during functional activities, besides evaluating point output measures like peak kinematic parameters.[11, 12] DJS may operationally be defined as the ability of the joint to maintain position or intended trajectory.[13-14] The maintenance of DJS along the entire kinetic chain seems to be important in the prevention of injuries. [15]

For the purposes of this study, a functional test was chosen to evaluate this ability to maintain DJS. The role of both distal and proximal DJS factors in EMTP remains unclear since no comprehensive and prospective research has been done on these parameters.[3, 13, 14] Therefore, the purpose of this prospective cohort investigation was to determine parameters associated to DJS of ankle, knee, hip, and lumbo-pelvic joints in both frontal and transverse plane during a Single Leg Drop Jump (SLDJ). We hypothesized that female athletes with less ability to control the LE movement, which results in reduced DJS of the evaluated joints, are at risk of developing EMTP.

METHODS

Participants

Subjects were 86 female students, who were freshmen in 2010-2011(n=46) and 2011-2012(n=40) in Physical Education at Ghent University, Ghent University College and Ghent Artevelde University College, Belgium. Mean age of these students was 19.38±0.85 years. At the beginning of the academic year, full-body kinematics during SLDJ of the students were assessed. Freshmen in 2010-2011 were followed throughout two academic years and freshmen in 2011-2012 were followed throughout one academic year, with consistent monitoring of their intra- and extramural sports activities. This individual amount of sport participation was then used as time at risk for every subject.

After the injury follow-up period, 79 of the 86 subjects were taken into account for statistical analysis. Seven students developed other LE injuries and therefore were excluded from the study.

The injured leg of the subjects who developed EMTP was used in the statistical analysis. If an injured subject developed bilateral symptoms, the 'most painful' leg based on visual analogue score was taken into account. Those 22 injured legs were matched with legs of the control group. The percentage of observed dominant legs in the control group was matched with the percentage of observed dominant legs in the injured group so that leg dominance would not play a role in the statistical outcome. Therefore, 1 leg per participant of the control group was eliminated at random until the number of non-dominant/dominant legs of the injured group was also present in the control group.

Testing procedure

Before the actual SLDJ testing procedure, weight, height and leg dominance were determined. Subsequently, 3D-kinematic data were collected using 6 Oqus cameras and Qualisys Track Manager software (Qualisys AB, Sweden). The ground reaction force data were recorded by a 1m force plate (AMTI©, USA) that was mounted flush in the middle of the wooden running track on which the SLDJ was performed. Ground reaction force and kinematic data were collected synchronously at 1000 and 200Hz, respectively.[16]

Marker placement during this protocol, was based on the Liverpool John Moores University lower limb trunk(LLT) model.[17] After the standing calibration trial, a functional warm-up procedure protocol of 5 minutes of cycling on a cycle ergometer and 20 submaximal single leg jumps were performed.

Thereafter, the investigator demonstrated the actual SLDJ and the subjects performed 2 practice trials per side so they would feel comfortable to complete the task. Subjects started standing on top of a box of 30.5cm height, on both feet in a natural position. The SLDJ was executed 3 times per side.

Further analysis of kinematic data was done using Visual3D software (C-motion Inc, Germantown). Raw marker positioning was low-pass filtered at 15Hz with a second order, bidirectional Butterworth filter with padded endpoint extrapolation. All joint angles were calculated in reference to the proximal segments, except for the pelvis [18] and thorax segments which were both referenced to the lab coordinate system. An X-Y-Z Euler rotation sequence(ERS) was used.[19] The SLDJ was divided into 2 phases: touchdown(TD) until maximal knee flexion(MKF) and then MKF until take-off(TO), representing landing and push-off phase, respectively. Kinematic variables of interest were DJS parameters of foot, knee, hip, pelvis and thorax segment during TD-MKF and during MKF-TO. More specific, range of motion(ROM) values were measured as the difference between maximum and minimum peak values in the frontal and transverse plane, during the SLDJ. An increased value of this ROM was described as an impaired ability to maintain DJS in this study.[20]

RESULTS AND DISCUSSION

During the follow-up period, 22(26%) of the 86 subjects developed EMTP. Nine of them developed bilateral complaints. A total of 57(66%) subjects did not sustain any overuse injury of the LE and was used as a control group. During the study follow-up, four students dropped out of the education program, none of whom presented with EMTP.

Statistical analysis (Cox Regression Analysis) revealed several significant predictors for the development of EMTP. Especially DJS in the transverse plane (rotations around the Z-axis) seemed to be important, where ROM of both hip and thorax were found to be significant predictors for the development of EMTP. These parameters were found to be significant contributors during the two phases of the SLDJ.

In Table1 the strength of the predictive values of the significant contributors to the development of EMTP, is presented.

Table1: Contributors for EMTP by Cox regression analysis

	B	SE	*P*-Value	Hazard Ratio	95% Confidence Interval
Thorax ROM TD-MKF Z	0,140	0.063	0.026	1.150	1.017-1.301
Thorax ROM MKF-TO Z	0,089	0.044	0.045	1.093	1.002-1.192
Hip ROM TD-MKF Z	0,126	0.049	0.010	1.134	1.031-1.249
Hip ROM MKF-TO Z	0,091	0.039	0.019	1.095	1.015-1.181

EMTP= Exertional Medial Tibial Pain, ROM= Range Of Motion, TD= Touchdown, MKF= Maximal Knee Flexion, TO= Take Off, Z=Z-component, B= Regression coefficient, SE= Standard error

The CRA revealed that the hazard of developing EMTP at any time, increases with 15% if thorax ROM in the transverse plane increases with 1 degree(°) during landing phase. The hazard of developing EMTP at any time, increases with 9% if transverse thorax ROM increases with 1° during push-off phase. Similarly, the hazard of developing EMTP at any time, increases with 13% if transverse hip ROM increases with 1° during landing phase. If transverse hip ROM increases with 1° during push-off phase, the hazard of developing EMTP at any time increases with 10%.

This study is the first to prospectively identify the role of DJS parameters in the development of one of the most important overuse injuries, EMTP. More than 1/4 subjects in this female population developed EMTP. This incidence (26%) is in accordance with a previous study.[3]

The results of this study demonstrated that increased transverse movement of the hip and the thorax during a functional single leg task, are significant risk factors for the development of EMTP in female athletes.

In order to interpret the results of this study, it may be interesting to describe a possible relationship between decreased ability to maintain transverse DJS of the hip and the thorax and increased LL strains, since these strains are described to induce EMTP.[3, 21-22]

Subjects with EMTP demonstrated increased transverse movements of hip and thorax during their performance of the SLDJ. These altered proximal-to-distal movement patterns may cause more eccentric activity of LL musculature in the attempt to control the motion and may therefore lead to excessive traction to the LL musculature.[3] However, muscle origins do not frequently correspond to the site of symptoms in EMTP,[23] so tractions to the tibia may not always be the direct result of traction of the LL musculature. When each touchdown generates this traction on midtibial musculoskeletal structures, the musculoskeletal system may become overloaded and overuse injury of the lower leg such as EMTP may occur.

In addition, muscle fatigue(MF) has been described as being an important contributor to EMTP as well.[24] The results in this study only revealed proximal decreased DJS parameters, whereas in literature distal parameters are described to play an important role in EMTP.[3-4] As more demanding tasks like jumping increase the need for appropriate proximal joint musculature function,[25] less demanding tasks like marching and jogging may be more dependent on distal joint musculature function. This important statement may indicate the need for specific screening tools based on level of activity in order to develop comprehensive preventive and diagnostic screening tools.

CONCLUSIONS

The decreased ability to maintain transverse DJS of the hip and the thorax during SLDJ, was found to be a significant risk factor for the development of EMTP in female athletes. We suggest that the decreased ability to control the LE movement during SLDJ, resulted in increased risk for developing EMTP. Proximal stability seems to be an important factor to take into account for both prevention and rehabilitation purposes.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge Fabienne Van De Steene and Roel De Ridder for their clinical point of view and assistance in analysis of the data, and Dr. Vanden Boscche en Dr. Steyaert for their assistance in data collection of the injuries.

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