

CASE SERIES

GAIT RE-TRAINING TO ALLEVIATE THE SYMPTOMS OF ANTERIOR EXERTIONAL LOWER LEG PAIN: A CASE SERIES

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ABSTRACT

Background/Purpose: Exercise induced lower leg pain (EILP) is a commonly diagnosed overuse injury in recreational runners and in the military with an incidence of 27-33% of all lower leg pain presentations. This condition has proven difficult to treat conservatively and patients commonly undergo surgical decompression of the compartment by fasciotomy. This case series investigates the clinical outcome of patients referred with exertional lower leg pain symptoms of the anterior compartment of the lower leg following a gait re-training intervention program.

Case Description: 10 patients with exercise related running pain in the anterior compartment of the lower leg underwent a gait re-training intervention over a six-week period. Coaching cues were utilized to increase hip flexion, increase cadence, to maintaining an upright torso, and to achieve a midfoot strike pattern. At initial consult and six-week follow up, two-dimensional video analysis was used to measure kinematic data. Patients self reported level of function and painfree running were recorded throughout and at one-year post intervention.

Outcomes: Running distance, subjective lower limb function scores and patient's pain improved significantly. The largest mean improvements in function were observed in 'running for 30 minutes or longer' and reported 'sports participation ability' with increases of 57.5% and 50%, respectively. 70% of patients were running painfree at follow-up. Kinematic changes affected at consultation were maintained at follow-up including angle of dorsiflexion, angle of tibia at initial contact, hip flexion angle, and stride length. A mean improvement of the EILP Questionnaire score of 40.3% and 49.2%, at six-week and one-year follow up, respectively.

Discussion: This case series describes a conservative treatment intervention for patients with biomechanical overload syndrome/exertional compartment syndrome of the anterior lower leg. Three of the four coaching cues affected lasting changes in gait kinematics. Significant improvements were shown in painfree running times and function.

Level of Evidence: 4

Keywords: Chronic exertional compartment syndrome, biomechanical overload syndrome, overuse injury, gait analysis, running

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The protocol for this study was approved by the Sports Surgery Clinic Research Ethics Committee, Santry, Dublin 9, Ireland.

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We affirm that we have no financial affiliation (including research funding) or involvement with any commercial organization that has a direct financial interest in any matter included in this manuscript, except as disclosed in an attachment and cited in the manuscript. Any other conflict of interest (ie, personal associations or involvement as a director, officer, or expert witness) is also disclosed in an attachment.

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BACKGROUND / PURPOSE

Exertional lower leg pain is a commonly diagnosed overuse injury in recreational runners and in the military with an incidence of 27-33% of all lower leg pain presentations.¹⁻³ Typically, patients present with incremental pain on exercise, which is described as 'tightness', or 'constricting pain'. Symptoms can increase with up-hill running or by increasing running speed with a fixed cadence. Symptoms tend to worsen to a point whereby continued running is impossible. The pain and symptoms are alleviated by rest and are occasionally accompanied by temporary paraesthesia or foot slapping, however typically the individual is able to briefly recommence running prior to a recurrence of symptoms. Classically the patient is pain free when not exercising.

Zhang et al describe the underlying pathophysiology as transient muscle ischemia,⁴ where due to increased intra-compartmental pressure the arterial blood supply to muscle is reduced, causing ischemic pain similar to acute compartment syndrome (a surgical emergency) but termed chronic exertional compartment syndrome (CECS) due to its progressive sub acute nature. The underlying pathology is suggested as fascial non-compliance or muscle hypertrophy but to date no conclusive proof of tissue necrosis or cell hypoxia has been demonstrated.⁵ CECS has been described in the anterior, peroneal and deep posterior compartments⁶ of the lower leg but the anterior is the most commonly affected.⁷ The diagnosis is typically confirmed with intra-compartmental pressure measurement but a systematic review of diagnostic pressures revealed substantial overlap of criteria and significant confounding variables of measurement technique, throwing doubt on the diagnostic process,⁸ and recent work by Roscoe et al suggests that a major revision of diagnostic criteria may be needed.⁹ Other diagnoses exist including medial tibial stress syndrome, stress fracture, popliteal artery and common peroneal nerve entrapment, all of which may need to be excluded.

Historically, first line treatments^{10,11} such as myofascial release, orthotic intervention, stretching, massage, and training load modification¹² have been tried in an attempt alleviate CECS. However, none have proved successful in a return to similar levels of activity. This was primarily due to an inability

to modify the intra-compartmental pressures with short term intervention.¹³ To date, the only definitive treatment is surgical decompression of the compartment by fasciotomy, an operative technique used to open the fascia covering the muscle compartment thereby de-tensioning the purported constrictive effect on muscles. However, a high proportion of surgical interventions are unsuccessful.¹⁴ Published outcome data on operative data is good in the short term but studies are limited with regard to duration of follow up, use of outcome measures, and demonstrate wide variation in operative technique.^{14,15}

Recent work on running technique and kinematic and kinetic changes of gait by Davis and Heiderscheit may provide details relating to the underlying mechanism behind the propagation of muscle overload. Reduction in the stride length, ground contact time, vertical oscillation and lower extremity angle all contribute to improved running economy,¹⁶ reduced ground reaction force, and movement efficiency.^{17,18}

During running gait, tibialis anterior (TA) and extensor hallucis longus have a high state of preactivation¹⁹ prior to rear foot initial contact. TA activity decreases rapidly with running induced metabolic fatigue.^{7,20} This led the authors of this case series to believe that, based on clinical observations in a military population, chronic exertional compartment syndrome is a mechanical muscular overload rather than a pathological process. The authors suggest it be considered as a Biomechanical Overload Syndrome.³

Recent researchers have shown it is possible to change muscle loading patterns by altering kinematics.²¹⁻²³ Therefore, the authors designed a gait re-training program to reduce the overload pattern. The aim of this gait re-training was to reduce the eccentric activity in TA, the proposed mechanism of increased compartment pressure in anterior compartment syndrome, by promoting a slight forefoot or midfoot ground contact pattern.^{7,24,25} This was facilitated via the use of visual feedback. Visual feedback has been shown to improve patient compliance and successful adoption of technique with lasting benefit.²⁶ This teaching tool was utilized within the gait re-training to improve the training effect.

This case series is intended to examine the clinical outcome of patients referred with exertional lower

leg pain symptoms of the anterior compartment of the lower leg following a gait re-training intervention program. A patient reported outcome tool and overall running distance competence, along with maintenance of kinematic changes were used to help track these outcomes.

CASE DESCRIPTION: PATIENT HISTORY AND SYSTEMS REVIEW

Ten adult subjects, nine males and one female (mean +/- SD: 30.5 +/- 8.8 years, weight 80.8 +/- 11.4 kg, height 182.6 +/- 6.7 cm, BMI 24.2 +/- 2.4 kg/m), presenting with anterior exertional lower leg pain were recruited for the trial. Subjects were included after giving their informed consent to participate in this study, which received ethical approval (Study 25-AFM-003).

CLINICAL IMPRESSION #1

Subjects were recruited based on a primary complaint of exercise induced lower leg pain localized to the anterior shank. Subjects presented with incremental pain, which worsened to a crescendo such that they were unable to continue running. Symptoms typically alleviated by rest following running cessation.

EXAMINATION

On initial presentation a full clinical history was taken and an examination performed by a sports medicine physician and physiotherapist. Any further investigation required was performed including magnetic resonance imaging (MRI) to exclude stress fracture and medial tibial stress syndrome. The subjects' current running shoes were used during retraining without orthotics, which were removed if prescribed.

CLINICAL IMPRESSION #2

Based upon the clinical reasoning of both the sports medicine physician and physiotherapist, and supported by history and MRI examination to exclude stress fracture or periostitis and any muscle pathology, subjects were diagnosed with 'anterior biomechanical overload syndrome' (ABOS) and deemed suitable for the study intervention. Subjects agreed to undergo a six week gait re-training intervention using kinematic measures pre- and post-intervention combined with a self-report outcome measure of

functional ability, and the exercise induced leg pain (EILP) questionnaire,²⁷ to ascertain intervention success. The EILP is a validated and reliable self-report measure of exercise-induced leg pain symptoms.²⁷ It measures the perceived severity of symptoms that impact function and sports ability.

INTERVENTION

On initial assessment subjects were asked to run at a self-selected pace for 2.5 to 3 minutes on a commercial treadmill at 0 degree incline (NordicTrack, Icon Health and Fitness™, Beaumont, California). Treadmill speed was then self-selected by the subject between 9 to 12 kph. When subjects informed the tester they were comfortable running at their preferred pace a video recording was taken. Video recording was taken prior to the onset of symptoms to minimize any pain effect on running biomechanics. 10km/hr for 60 seconds. A 10 second digital recording was taken using 2HD video cameras (Panasonic HDC-SD80, Panasonic Corporation™, Japan) recording at a frame rate of 60fps (resolution 1920 x 1080i) from sagittal and coronal viewpoints obtained against a fixed reference backdrop (MAR Systems™, England). Subjects were instructed to maintain their running position in the center of the treadmill belt during data recording. Both cameras were fixed to wall mounts maintaining a consistent field of view between subjects. Angular and kinematic data from each recording was interpreted using a 2D motion analysis system connected via HDMI cabling to a plasma screen (Contemplas™ TEMPLO V6.0 GmbH, Germany).

Sagittal plane two-dimensional (2D) analysis has previously been assessed for validity and reliability against the 'gold standard' of three-dimensional (3D) analysis in previous studies of treadmill running.^{25,28-30} Moreover a pilot comparative analysis (2D versus 3D) demonstrated comparable reliability in measures across five consecutive foot contacts while treadmill running (Appendix A). Initial foot contact was matched synchronously for both 2D and 3D measurement. Stance phase kinematics, such as foot inclination and tibial angle, were found to be highly agreeable between both methods at identical gait cycle time points. While there was some differences in absolute magnitudes (e.g., max hip flexion [2D versus 3D] of 56.23° and 64.91°, respectively),

these would not be unexpected due to the difference in how 2D and 3D measures are obtained.²⁸

Following initial 2D analysis, gait re-training began immediately in session one in the form of verbalized cues to alter kinematics at the foot, ankle, knee, hip, and torso. Gait re-training sessions were 60 minutes in duration with each subject receiving a maximum of three sessions over a six-week period. Sessions consisted of running drills and walk-run interval training with the aid of video feedback to facilitate kinematic change. The use of video feedback was progressively withdrawn over the three sessions.

Cues were individualized to each subject in order to reduce ankle dorsiflexion at the landing position. Various cues were used to achieve this goal. Typical coaching cues involved landing with a mid-foot strike pattern, slightly increasing hip flexion, promoting an earlier foot lift-off and running with a more upright torso position. Previous clinical experience in delivering coaching cues suggests that slightly increasing hip flexion was sometimes more effective in reducing ankle dorsiflexion angle at foot-strike rather than instructing subjects to land with a mid-foot strike, although to date there is no research to support this. The authors chose to cue an earlier and slightly higher foot lift-off as it was hoped this would have the double effect of increasing step-rate, which has been shown to reduce ankle dorsiflexion at foot-strike as well as promote increased hip flexion.¹⁸ A more upright body position was promoted if necessary as the authors previous experience in delivering coaching cues had suggested this was often complimentary to achieving greater hip flexion with resultant reduction in ankle dorsiflexion at foot strike.

Between one and three individualized coaching cues were used until the therapist felt that desired changes were achieved. This allowed for individualization

of coaching cues based on the therapist's observation and feedback from the subject on whether they thought the change was sustainable. Care was taken to cue only minimal kinematic change to avoid early fatigue in subjects. At this stage a 'walk-run' program as a template for embedding these motor patterns was given. This training program was performed three times per week with a minimum of one days rest between sessions (Appendix B). Only two additional independent training sessions were performed on weeks where the subject was reviewed by the sports medicine team. A review of the subjects running gait was typically carried out fortnightly, with kinematic adjustments made as needed. Each subject had three video coaching sessions in total. The EILP questionnaire was also repeated prior to retesting and at one-year post intervention. In addition, a 15-point global rating of change (GROC) was included at one-year follow up to measure subjects perceived change and overall improvement.³³ The scale directed the subject to rate his or her change from 'a very great deal worse' (-7) to 'a very great deal better' (+7).

The running kinematics were quantified from digital video recordings obtained during testing. Running cycle phases of interest and angular data assessed at each event are outlined in Table 1. Kinematic variables were measured for five consecutive strides on both sides, pre- and post- retraining intervention. Stride length was measured from the point of initial contact to the point of toe off. The midstance phase was defined as the last point at which the heel stays in contact with the ground before lifting; given no subjects were forefoot runners.

Initial contact was identified from the rearview coronal imaging, which proved more accurate than sagittal views due to rearfoot supination, which occurs before contact. Thereafter, sagittal imaging was used to measure kinematic data. Foot inclination angle was measured from the sole of the shoe to treadmill. Tib-

Table 1. Kinematic gait cycle variables for both sides at each phase; with pre-, post- and p-values for each.

GAIT PHASE VARIABLE	INITIAL CONTACT						MIDSTANCE		MAX HIP FLEXION		STRIDE	
	Foot Inclin		Tib angle		Back flx		Ankle DF		Hip flx		Stride length	
	R	L	R	L	R	L	R	L	R	L	R	L
PRE	18.32	18.26	11.72	11.98	5.06	5.48	63.18	63.27	35.99	35.1	67.58	69.59
POST	-1.89	-3.43	2.89	2.48	4	3.55	64.92	65.1	45.74	45.17	46.8	50.36
P Value	0	0	0	0	0.102	0.004	0.03	0.052	0.003	0.002	0	0.001

ial angle was measured from malleolus center to mid shaft tibia at tibial tuberosity level, against the vertical. Lumbar flexion angle was measured from the L5 level to the thoraco-lumbar junction, against the vertical in order to represent change in body position.

At midstance, ankle dorsiflexion was measured from mid shaft tibia at tibial tuberosity level through malleolus center against the horizontal at shoe sole level. The point of maximum hip flexion was identified and hip angle measured through mid thigh at femoral condyle level to lumbo-sacral junction, against lumbar flexion angle.

Data analysis and statistics

Statistical analysis was carried out on all data sets for each variable. Paired t-tests showed significant changes in all but two sets of kinematic variables ($p < 0.05$), lumbar flexion ($p = 0.102$) and cadence ($p = 0.354$). A Wilcoxon matched pairs test ($p < 0.05$) was used to analyze the paired datasets. Using the EILP questionnaire, the percentage improvement for each subject was identified and average improvement ascertained. A scatterplot graph (Figure 1) was produced to represent the pre and post intervention differences in time to first onset of pain and time to pain limit/threshold.

OUTCOME

At six week follow up there was a mean improvement of the EILP Questionnaire score of 40.3%. At the one-year follow up, with 9 out of the 10 subjects responding, there was a mean improvement of 49.2% from baseline measures. Eight patients were running

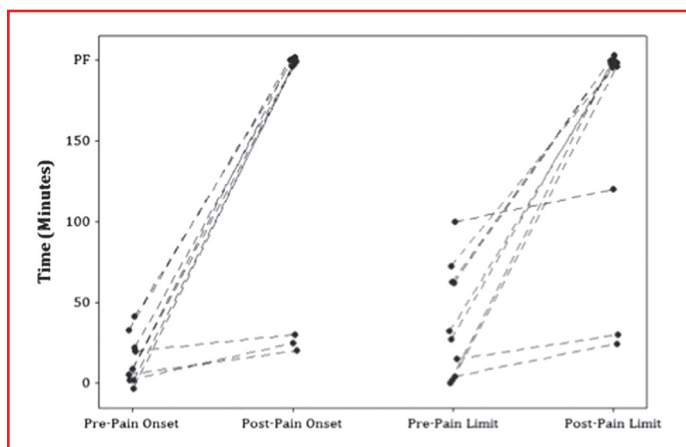


Figure 1. re-training versus post-training time to pain onset (first onset of exertional lower limb pain) and pain limit (time taken to pain limit/threshold), where x-axis 'PF' = 'pain free'

pain free over 30 minutes and the other two patients significantly increased their running distance before symptom onset. Running symptoms reported at one year after intervention reported 7 of the 10 subjects running entirely painfree with one subject symptom free for at least 80 minutes. One subject was not running due to a foot injury and one was subject did not respond. GROC scores at one-year follow up were an average of 4.9 or 'quite a bit better'.

Persistent changes were observed in foot inclination angle, tibial angle, and maximum hip flexion angle (Table 1). Foot inclination angle at initial contact on the right and left foot changed from an average dorsiflexion angle of 18.32 and 18.26, respectively, to plantar flexion angle of 1.89 ($p = 0.001$) and 3.43 ($p = 0.001$), respectively. This represents a technical change from heel strike foot position to slight fore-foot/midfoot strike position.

Similarly, mean tibial angle at initial contact changed on the right and left lower leg from 11.72 and 11.98, respectively, to 2.89 ($p = 0.001$) and 2.48 ($p = 0.001$), respectively. This represents a reduction in tibial angulation to an almost vertical tibia on initial contact.

Maximum hip flexion angle averages on the right and left changed from 35.99 and 35.10, respectively, to 45.74 ($p = 0.003$) and 45.17 ($p = 0.002$), respectively. Small but statistically significant changes were observed in right and left ankle dorsiflexion at midstance changing from 63.18 and 63.27, respectively, to 64.92 ($p = 0.03$) and 65.1 ($p = 0.04$), respectively. A significant reduction in stride length was observed of 67.58cm to 46.8cm ($p = 0.001$) on the right, and 69.59cm to 50.36cm ($p = 0.001$) on the left. There was no significant change in lumbar flexion at initial contact ($p = 0.102$).

Mean differences in EILP questionnaire scores of function are outlined in Table 2. Significant changes ($p \leq 0.05$) in EILP questionnaire scores (Table 2) were seen in all four running activities and perceived ability scores. An average increase in function of 40.3% was observed for EILP scores, pre versus post intervention. Importantly, the largest changes in function were observed for 'Running after 30 minutes or longer' and 'Ability to participate in your desired sport as long as you like', 57.5% ($p = 0.005$) increase and 50% ($p = 0.007$) increase in scores, respectively.

Table 2. Mean improvement in function for the EILP questionnaire pre-gait re-training versus post gait re-training.

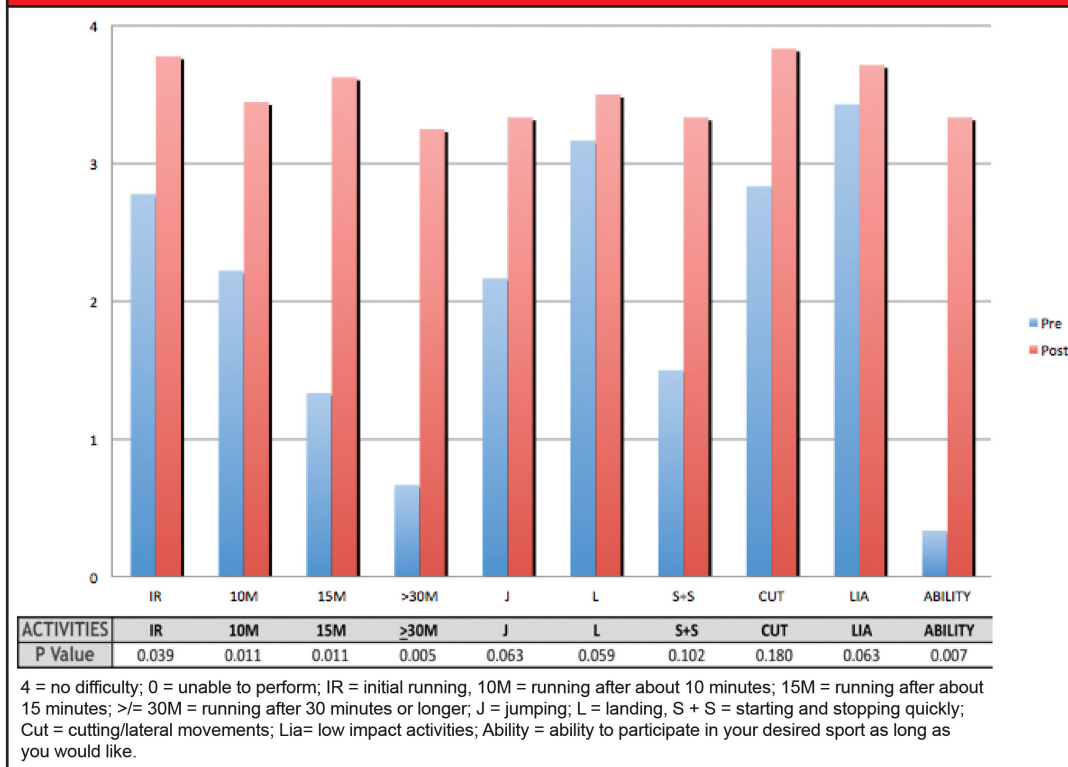


Figure 1 illustrates the change in subjective report of time taken (minutes) to pain onset and pain limit during each subjects run. All but three subjects achieved pain-free (PF) status for exertional lower leg pain, with all subjects showing improvements.

DISCUSSION

The authors hypothesized that by altering key elements of running kinematics in patients with exertional anterior lower leg pain, with no demonstrable stress response in bone, that the symptoms would be alleviated by a more vertical tibial strike angle, reduced stride length, increased running cadence and a more vertical torso angle. In this cohort, all subjects showed an improvement in their pain free running tolerance and 70% of subjects were running entirely symptom free post-treatment. Subjects also reported improvements in their outcome scores and demonstrated lasting kinematic changes in running gait following running re-education training. The only interventions used were coaching cues and intermittent visual feedback over a six-week period.

Subjects demonstrated statistically significant improvements in exercise induced leg pain score (EILP), and

changes in foot inclination angle, mean tibial angle, hip flexion, ankle dorsiflexion and stride length following running re-education training. The results were maintained at follow-up six weeks later. The EILP inventory is highly specific to running function and athletic performance comparing favorably to other lower leg function tools previously used in the monitoring of exercise induced CECS^{15, 22}.

To date there has been limited evidence of the effectiveness of conservative management of chronic exertional anterior compartment syndrome. Diebal et al used forefoot running to reduce the symptoms in a case series of 10 patients with associated reduction in intracompartmental pressures.² However, despite significant improvements in their running performance, none were symptom free and pain remained the limiting factor. Results from the cohort in the current study demonstrate all but three subjects running entirely pain-free. Coaching cues utilized in the current study were individualized in an attempt to alter the kinematic variables selected. Coaching aims were to reduce ankle dorsiflexion at the landing position using a combination of coaching cues including increased hip flexion, early foot lift-off, and a more upright torso.

This is the first study in which joint angle kinematics are recorded throughout the gait cycle as a measure of gait re-training for exercise induced leg pain. Previous research in this area, make reference only to affected kinematic change in stride length, cadence, and ground contact time.^{2,15}

Mid-Foot Strike position

The focus for the cohort group was on adopting a mid-foot strike in order to reduce TA activity as this has been shown to be highest in late swing through to the foot flat position.¹⁹ All subjects were able to achieve this within six weeks. It has been shown that TA activity increased primarily in late swing for the purpose of altering the landing posture of the limb in preparation for subsequent joint moments and energy absorption.^{21,31}

Excessive tibialis anterior (TA) eccentric activity has been proposed as a major contributor to the mechanism of increased compartment pressure in anterior compartment syndrome.^{7,31,32} Eccentric muscle activity is strenuous and results in more rapid muscle fatigue and by products of breakdown, and possible edema. It may be possible to reduce the eccentric activity in TA by promoting earlier ground contact of the forefoot³² or adopting a midfoot strike. This also results in a more vertical tibia at foot contact, reducing the preload of the anterior compartment

Step rate

An increase in step rate has been shown to reduce tibialis anterior activity. Emphasis was placed on an earlier and higher foot lift-off to achieve this increase while maintaining the same running speed. It had been observed that simply instructing subjects to increase step-rate often resulted in a fast shuffle-like gait pattern. As this was considered undesirable, the former cue was used. This was reflected by a significant reduction in stride length of 20cm ($p = 0.001$) measured post gait re-training. Step rate is inversely proportional to step length and a 10% increase in step frequency has been shown to significantly decrease foot inclination angle.²²

Hip Flexion

All subjects maintained increased hip flexion in this study after intervention. Hip flexion angle has not been addressed in the literature in relation to foot

strike but the authors hypothesized a higher knee position in late swing allows the subject more time to align the tibia and foot to achieve the desired vertical tibia and midfoot strike pattern. While vertical ground reaction force may increase as a result of a more direct downward foot drive, evidence is lacking to make a direct connection between impact forces and many running injuries,³² and in this population no evidence of stress fracture was present.

Torso Position

A more upright torso position was sometimes advocated as a complementary cue to achieve greater hip flexion. However, this was only encouraged if increasing hip flexion was a necessary cue. In this case series, the authors' were unable to effect lasting kinematic change in lumbar flexion during the six week intervention but this did not appear to limit an average increase in hip flexion at late swing of 10°. The method of measurement using 2D kinematics may be too inaccurate to record small differences in lumbar flexion angulation. It may be that lumbar flexion angle was not a good measure of torso positioning and mid-thoracic angulation using electro-goniometers would have been a better method for recording this variable.

As the rate of perceived exertion is initially higher with a step rate increase of 10%²² the authors' used a graduated walk/run program while the new running technique was being learned to limit fatigue. Although not recorded it was found that subjects reported initially increased rating of perceived exertion (RPE), which reduced after four weeks of training. Many studies report that running economy (RE) in experienced runners is best at self-selected step rate.^{32,33} However inexperienced runners have been shown to have better RE at step rates 9% higher than preferred.³⁴ It seems likely that adoption of a new technique and step-rate causes initial increase in RPE and reduction in RE. Improvements in both these values may be possible with training adaption but further research is needed to confirm this observation.

The ability to make both short and long term kinematic changes in running technique is often challenged. In practice, the authors identified changes occurring very rapidly but few studies have looked at the retention of changes made. It has been shown that after only two weeks of retraining, retention is possible²⁶ and

maintained up to six months later.³⁵ Further work is required to demonstrate optimal training techniques and time frames but it is apparent that once kinematic changes are learned, subjects are able to retain these changes in the absence of continued feedback.

This case series has a number of limitations. No biomedical markers were placed on patients to act as reference points and this has been shown to introduce possible error in the reporting of kinematic angles.³⁶ Error was minimized by comparing five steps on each leg and taking the mean value and using fixed angle cameras and backdrops, however it is recognized either using reference markers or 3D analysis, despite being available to the authors, would have been more accurate but too time consuming and costly for the clinical population.

The effect of being tested/observed influences the performance of motor tasks so the authors cannot be sure that running technique observed in lab conditions mimics technique performed outside in varying conditions. Treadmill running is capable of being used to obtain a representation of the typical human running action²⁴ but the problem of being observed may be overcome in future with wearable inertial sensors currently being developed. In this way we hope to improve compliance, feedback and recording of kinematic change and also in longer-term compliance. Further studies are required to identify whether kinematic variables are maintained and the extent of follow up required and whether other exertional lower leg conditions can be successfully treated using the biomechanical overload principles on a larger scale.

CONCLUSIONS

This case series provides further evidence that anterior exertional lower leg pain symptoms can be alleviated by kinematic changes in running gait. Follow-up assessment with 2D kinematics at the six-week stage confirmed that 100% of patients had retained their new running form with significant reduction of symptoms as measured using the EILP Questionnaire.

The changes in gait kinematics and resultant improvement in self-reported scores of function and pain free running distance supports the authors' contention that this clinical condition represents a biomechanical overload without irreversible pathological pressure change. As such the authors' recommend

the use of gait re-training as the primary treatment of choice. This case series demonstrated the effective use of visual and verbalized coaching cues to alter running technique and reduce the symptoms of anterior biomechanical overload syndrome. The use of such cues improved the ability of the subjects to adopt a modified gait pattern. These changes in gait were adopted and retained over a six-week period.

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APPENDIX A

APPENDIX 1A Comparison measures (in degrees) between two-dimensional (2D) and three-dimensional (3D) kinematic analysis of gait cycle variables for both sides at each phase pre intervention and post intervention; Initial contact: foot inclination (Foot Incln), tibial angle (Tib angle), Back flexion angle (Back flx); Midstance: ankle dorsi-flexion angle (Ankle DF); Maximum hip flexion: hip flexion angle (Hip flx)

GAIT PHASE	INITIAL CONTACT						MIDSTANCE		MAX HIP FLEXION	
VARIABLE	Foot Incln (°)		Tib angle (°)		Back flx (°)		Ankle DF (°)		Hip flx (°)	
POST RRED	R	L	R	L	R	L	R	L	R	L
2D	-7.2	-7.04	-3.3	0.5	5.2	5.18	25.58	27.52	53.4	59.06
3D	-9.52	-8.74	0.14	1.96	5.28	5.42	17.48	18.9	62.68	67.14
2D	Mean	-7.12		-1.4		5.19		26.55		56.23
3D	Mean	-9.13		1.05		5.35		18.19		64.91

APPENDIX B

RUNNING RE-EDUCATION

NAME _____

WALK/RUN PROGRAM

DATE _____

GOAL: 30 minutes continuous running in 4-6 weeks

Your therapist will help advise you at what level to start.

Level	WALK TIME (mins)	RUN TIME (mins)	TOTAL TIME (mins)	TOTAL RUN TIME	Runs at this level
1	1	1	20	10	1-2
2	1	2	21	14	1-2
3	1	3	20	15	1-2
4	1	3	24	18	1-2
5	1	4	25	20	1-2
6	1	5	24	20	1-2
7	1	5	30	25	1-2
8	1	6	28	24	1-2
9	1	8	27	24	1-2
10	1	10	33	30	1-2
11	1	11	36	33	1-2
12	1	14	30	28	1-2
	-	30	30	30	1-2

Note: Walking pace should be sufficient to ease any symptoms. If discomfort rises to 4 out of 10 on a pain scale, go back to previous level Perform on alternate days. Eg Monday, Wednesday, Friday Progress to next level if pain does not rise above 3 out of 10 within 24 hours