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# Trial of NewGait System to Alter Running Mechanics in a High School Athlete: A Case Report

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## Background and Purpose

Running is a complex skill requiring synchronization from various neural centers, joints, and muscles. Progress has been made in understanding the biomechanics of running<sup>1</sup>. By understanding the biomechanics of running, both therapists and runners are better able to observe the effect of forces placed on the joints and muscles involved, however translating these observations to changes in biomechanics within such a complex system is a major challenge for runners and therapists. Research centers and major clinical centers have the opportunity to work with 3D videos, augmented feedback, biofeedback, and robotics<sup>2,3,4,13</sup>. These systems are often too expensive or too timely for smaller centers. Therefore, the purpose of the current case study is to introduce the cost-effective NewGait™ system and describe how it was successfully used to provide long term improvement in functional ankle joint mechanics, running and jumping mechanics for a female competitive athlete.

## Case Description: Patient History and Systems Review

The patient in this study was an eighteen-year-old female with a history of physical therapy intervention for treatment of low back pain, hip pain, and bilateral ankle and foot pain since the age of ten-years-old. The patient had been involved in gymnastics, diving, and pole vaulting, with performance and injuries strongly influenced by ankle range of motion and strength<sup>5,6,12,16</sup>.

Past medical history included recurring left sacral and lumbar mechanical dysfunction (left posterior innominate with associated L5-S1 FRS R), recurring severe motion restrictions both ankles and feet with hard end feel documented since age twelve<sup>15</sup>, and severe functional strength restrictions ankle dorsiflexors and plantar flexors since age ten. Chief complaints included limited sports participation due to pain in the patient's feet, ankles, hips, and low back. Observational findings included minimal trunk rotation or reciprocal arm swing during gait, recurring failure of hip extensor and hip flexor activation, habitual pattern of maintaining ankles in neutral position during walking, running, leaping, and jumping except during midstance phase of gait. The patient's preferred motor pattern had been to use a pattern of reverse action of latissimus dorsi and quadratus lumborum to compensate for lack of ankle function<sup>15</sup> and hypertrophied, shortened long toe flexors and extensors. Other examination findings include the following:

1. Deep muscle tension and spasm bilateral medial calves
2. Severe restrictions in anterior/posterior glide at talocrural joint
3. Poor talar rock and side tilt medially or laterally at subtalar joint
4. Poor anterior/ posterior glide of talus and calcaneus<sup>18</sup>

## Clinical Impression

Despite severe functional ankle motion and strength restrictions, the patient was motivated to excel in sports requiring single leg push off, such as gymnastics, diving, and pole vaulting. She had developed alternative movement patterns to allow for upward momentum in sport to compensate for lack of functional plantar flexion<sup>1</sup>. These substitution patterns, although effective, may have created and perpetuated strain patterns in the patient's pelvic, lumbar, and ankle regions<sup>5,6</sup>. Without these compensatory mechanics, she would not have been able to enjoy or compete in sports. Positive results of past interventions had not been maintained and potential for continued problems and further pain and injury persisted. She hoped to utilize a pole vaulting college scholarship.


## Novel Approach: Initiated Use of NewGait for eight visits



Therapists were introduced to the [NewGait™ system](#) by developers at the APTA-Michigan Fall Conference 2019 (See P3). A trial of this system was started for the current patient following the exhaustion of other treatment modalities. Both therapists and the patient were hoping that the direct proprioceptive feedback provided by the NewGait™ system would influence the neuro-motor system and promote sustainable change in run and jump mechanics, and that the NewGait™ system would provide supplemental external feedback to the patient. Sessions included review of past data continual re-evaluations from the patient, consistent feedback from the patient, as well as two-dimensional videos. This may have resulted in a shift in learning from the cognitive level to the neuro-motor response level.



Configurations for all sessions included the use of a shoulder harness, waist belt, and limb straps on thighs and calves. Elastic assistance bands (AB) were used on hip flexors, extensors, and abductors. Shoelaces were used for attachment of dorsiflexion assistance bands. Heel straps were made from bike tubes to provide anchor for plantar flexion assistance bands (See P1). Multiple assistance band combinations, locations, and directions were used during each session. The most successful placements of AB were documented during each session, as outlined below.



	Configuration	Session Plan	Results
1		<p><b>Goal:</b> facilitate hip extension with hip abduction and to drive plantar flexion, facilitating dorsiflexion</p> <p><b>Exercises:</b></p> <ul style="list-style-type: none"> <li>• Warm up                             <ul style="list-style-type: none"> <li>○ quick pelvic rotation</li> <li>○ Walk 30 feet x2</li> <li>○ quick pelvic rotation</li> <li>○ Walk 30 feet x2.</li> </ul> </li> <li>• Walk on treadmill 5 minutes</li> <li>• Descend and ascend 16 standard steps x2. Stairs</li> </ul> <p><b>Notes:</b> Stairs required greater need for prolonged muscle activation as well as a need to lean forward on ascent and to use eccentric muscle control on descent.</p>	<ul style="list-style-type: none"> <li>• Extreme fatigue despite current competitive fitness level</li> <li>• Patient reported no perception of change</li> <li>• No change observed on video</li> </ul>
2	<ul style="list-style-type: none"> <li>• Added two green hip abduction AB to Session 1 configuration</li> </ul>	<p><b>Goals:</b> To increase eccentric activation of hip abductors and develop ankle dorsi/plantar flexion pattern</p> <p><b>Exercises:</b></p> <ul style="list-style-type: none"> <li>• Warm up</li> <li>• Dorsi/plantar flexion ankle drills on mini-trampoline</li> </ul>	<ul style="list-style-type: none"> <li>• Demonstrated active dorsi/ plantar flexion</li> <li>• Demonstrated ability to perform mini jumps with and without NewGait™</li> <li>• Patient reported she could “feel her ankles pushing off”</li> </ul>
3	<ul style="list-style-type: none"> <li>• Decreased assistance for hip abduction from 2 green AB to 1 green and 1 red AB</li> <li>• Hip AB were secured diagonally to increase multiple muscle recruitment</li> <li>• Increased assistance for ankle dorsiflexion AB from yellow to red.</li> <li>• Decreased assistance for plantar flexion AB from green to red.</li> </ul>	<p><b>Goals:</b> “force” hip abduction throughout the gait cycle, replacing need for hip hiking and drive dorsi/plantar flexion</p> <p><b>Exercises:</b></p> <ul style="list-style-type: none"> <li>• Warm up</li> <li>• Descend and ascend 16 standard steps x2</li> <li>• Mini trampoline drills</li> </ul> <p><b>Notes:</b> Patient stated that during the previous week she was able to push off balls of her feet with conscious effort, push off was not automatic. She also felt like her knees were coming up higher when she took a step. New set up for session three dramatically increased difficulty on stairs.</p>	<ul style="list-style-type: none"> <li>• Patient felt more resistance to movement</li> <li>• Demonstrated increased ankle motion with and without NewGait™</li> </ul>

	Configuration	Session Plan	Results
4	 <p><b>Notes:</b> rationale is to provide more drive, encourage more external rotation and eccentric control of hip muscles, and encourage forward propulsion.</p>	<p><b>Goals:</b> overload system to gain more forward propulsion, and to facilitate more core muscle and eccentric control.</p> <p><b>Exercises:</b></p> <ul style="list-style-type: none"> <li>• Warm up</li> <li>• Monster walk to engage entire body in dynamic stretch and encourage forward lean and eccentric hamstring contraction</li> <li>• Stairs</li> <li>• Running in clinic with forward perturbation from therapist</li> </ul> <p><b>Notes:</b> Patient stated that she noticed she has been walking heel/toe pattern and pushing off balls of feet while walking without thinking about it. Patient stated that she “felt like her body was being controlled like a puppet. She had no choice but to use her hips and ankles. She really enjoyed the feel.”</p>	<ul style="list-style-type: none"> <li>• Increased trunk rotation and beginning of reciprocal arm swing</li> <li>• Patient was extremely tired and felt muscle ache in posterior calves, anterior and posterior thighs</li> <li>• Demonstrated dramatic improvement all skills, with and without NewGait™</li> </ul>
5	<p>Same as Session 4 configuration</p>	<p><b>Goals:</b> encourage more eccentric hip extension and to continue to drive forward propulsion</p> <p><b>Exercises:</b></p> <ul style="list-style-type: none"> <li>• Warm up</li> <li>• Monster walk</li> <li>• Stand to sit drills</li> <li>• Trial of sport specific drills: simulated running to foot plant, repeated push off</li> </ul>	<ul style="list-style-type: none"> <li>• Improved technique all sport specific drills with and without NewGait™</li> </ul>
6	<ul style="list-style-type: none"> <li>• Increased assistance for hip extension from 1 green AB to 2 green AB on left and 3 green AB on right,</li> <li>• Increased assistance for hip abduction on the right from 2 green AB to 3 green AB</li> <li>• Removed assistance for ankle dorsiflexion</li> <li>• Added sacral cinch belt (See P2)</li> </ul> 	<p><b>Goals:</b> alter muscle imbalance, increase pelvic stability and inhibit old pattern of hip hiking to gain push off and propulsion</p> <p><b>Modalities:</b></p> <ul style="list-style-type: none"> <li>• Manual therapy to address pain symptoms.</li> </ul> <p><b>Exercises:</b></p> <ul style="list-style-type: none"> <li>• Warm up</li> <li>• Monster walk</li> <li>• Stand to sit drills</li> <li>• Trial of sport specific drills: simulated running to foot plant, repeated push off</li> </ul> <p><b>Notes:</b> patient observed walking into clinic with forward weight shift, heel/toe</p>	<ul style="list-style-type: none"> <li>• Pain pattern resolved.</li> <li>• Previous drills handled with ease and minimal fatigue</li> <li>• Patient was instructed to continue to wear the sacral cinch belt for all activity.</li> </ul>

		gait pattern with trunk rotation and reciprocal arm swing. She was not consciously aware that gait pattern had altered. Patient reported the beginning of hip and foot pain. Pain was in area of SI joint and on the medial top of both feet	
	<b>Configuration</b>	<b>Session Plan</b>	<b>Results</b>
<b>7</b>	Same as Session 6 configuration	<p><b>Goals:</b> alter sport specific skill mechanics</p> <p><b>Exercises:</b></p> <ul style="list-style-type: none"> <li>• Warm up</li> <li>• Monster walks</li> <li>• Repeated push off</li> <li>• Repeated drive and lifts</li> <li>• Pelvic rotation drills</li> </ul>	<ul style="list-style-type: none"> <li>• Improvement noted in areas addressed.</li> <li>• Persisting over rotation of pelvis to the left</li> <li>• No complaints of pain. Pt. brought video of pole vaulting and shared coaching techniques. Increased speed, forward propulsion, and increased jump height necessitated significant change in vaulting technique.</li> </ul> <p><b>Notes:</b> Video of pole vault reviewed with patient. Major issues included running beyond mark, over stepping with left leg, dropping pole arm back and rotating pelvis to the left</p>
<b>8</b>	Same as Session 6 configuration	<p><b>Goals:</b> improve sport specific skills in pole vaulting</p> <p><b>Exercises:</b></p> <ul style="list-style-type: none"> <li>• Warm up</li> <li>• Monster walks</li> <li>• Pole vault drills with emphasis on altering faulty rotation pattern</li> <li>• Repeat of drills without NewGait</li> </ul>	<ul style="list-style-type: none"> <li>• No complaints of pain.</li> <li>• Minimal imbalance remaining.</li> <li>• Rotation balanced right to left</li> <li>• Suggested use of sacral cinch belt for two more weeks at least during practice</li> <li>• This was determined to be last scheduled appointment secondary to vacations and sport schedule</li> </ul>

**Outcome:**

At the end of treatment the patient reported no back, hip, or ankle pain and minimal intermittent foot pain. Appropriate trunk rotation pattern and reciprocal arm swing were present during gait and running, and a dramatically improved ankle range of motion resulted in a new ability to use functional push off from balls of feet. Pole vault technique required complete modification secondary to increased running speed, forward propulsion, and jumping ability. Changes seen throughout sessions were maintained between treatments, as well as six months following treatment.

**Range of Motion Changes Over Treatment Time**

	Plantar-Flexion	Dorsi-Flexion	Inversion	Eversion
Before	25° *	5° *	0° *	0° *
After	40°	19°	5° *	5° *
Norms	50°	30°	20°	20°

**Table 1:** Changes in ROM over duration of treatment. Severe motion restrictions are illustrated as asterisks (\*) when compared to ROM norms <sup>7</sup>

**Functional Skill Changes Over Treatment Time**

	Single Leg Stance Eyes Closed (secs)		Both Sides Utilized Balance Trainer (BOSU) Eyes Closed (secs)		Double Leg Vertical Jump
	Right	Left	Right	Left	
<b>Before</b>	15 *	15 *	15	15	6" *
<b>After</b>	45	45	60	60	17"
<b>Norms</b>	44	44			15.6"

**Table 2:** Changes in function skills over duration of treatment. Severe functional impairments are illustrated as asterisks (\*) when compared to norms <sup>9, 18</sup>.

**Running Analysis Over Treatment Time**

	Foot Position @ Initial Contact	Hip Angle @ Push Off	Tibia Inclination	Ankle DF Angle
<b>Before</b>	Mid-Foot Striking Pattern	-15 °	Mild Inclination	Decrease (Knee over midfoot)
<b>After</b>	Heel Striking Pattern	+10 °	Appropriate (within 5° of vertical)	Appropriate (Knees over toes)

**Table 3:** Changes in running technique over duration of treatment.<sup>19</sup>

## Discussion

Retraining running technique is a challenge due to the complexity of the task, as well as to the need to integrate neural, joint, and muscular control <sup>11</sup>. Current strategies rely heavily on cognitive awareness and external feedback from a coach or therapist, when running is a complex neuro motor skill, requiring internal feedback <sup>10</sup>. The NewGait™ may have provided enhanced, simultaneous feedback to mechanoreceptors and proprioceptors of the core and limb, initiating change in neuro motor sequencing and development of new motor plans <sup>10,11</sup>. The NewGait™ upper body harness appeared to assist with erect posture and support, while discouraging previous upper body motor control patterns. This may have encouraged the lower body motor plans to dominate walking, running and jumping. The patient had profound, lasting results in ankle and hip motion control, and the patient's running style was dramatically changed. She was able to functionally activate the patient's gastrocnemius for jumping and heel/toe gait pattern during push off. The patient's previously noted, relatively fixed ankle range of motion was significantly increased. The observed changes in ankle joint motion and functional plantar flexion were not expected and difficult to explain.

There were a number of challenges presented to the therapists over the course of this treatment period as outlined below. The therapists were working with a new treatment device with very little instructional information available. The company is currently working to develop instructions and protocols for use of the NewGait™ system as clinicians provide feedback from clinical use. The Clinic Model purchased from NewGait™ was used in the current trial <sup>14</sup> (See Image P3 for most current model). Beneficial alterations to Clinic Model would include the ability to connect AB to the shoulder harness, providing additional feedback to improve trunk extension. For the current patient, a strong "C" curve involving trunk extension is needed in pole vaulting. Additional straps would have help to cue this position for the patient. A shoulder harness keeper (shown in Image P3) is now available for this purpose. Additionally, the current waist belt did not provide enough stability for the amount of load required in this patient. A firmer back to the belt may be helpful. Therapists only had access to medium and large leg straps and yellow, red and green AB available for treatment in this case. The use of smaller leg straps and high resistance blue AB would have made application much more efficient.



Therapists did not record data or take enough photographs. Despite the discussed limitations and novelty of equipment, the patient experienced dramatic and lasting improvements in ankle function, running and jump mechanics. The current case study suggests that the NewGait™ system may be a beneficial clinical tool to alter running and jumping mechanics in athletes. Future research into use with athletes on and off the field is needed to determine the multiple uses of this new device.



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