GAIT PARAMETERS YOU CAN MEASURE IN THE CLINIC

CADENCE: steps/minute

Have patient walk 30 seconds and count each step, then multiply times 2. You can also just do this for 60 seconds.
(Average speed for an adult is 105 to 120 steps/min and is age related)

Cadence can also be assessed in a 10 meter walk – time in seconds and count the number of steps, then calculate: 60/time(sec) x # of steps =cadence

60/_____time(sec) x _____ steps = _____ **Cadence** (steps/min)

VELOCITY: Meters/minute or feet/minute

Method 1: Have patient walk for 30 or 60 seconds and measure how many meters they walked (multiple by 2 if going for 30 seconds). This may be hard to do if they do not walk fairly slowly.

If in hospital with one foot floor tiles you can count tiles for number of feet/min, then divide by 3.281 for meters/min (1 meter = 3.281 feet.)

Method 2: This method works well if you don't have much space to test in your clinic. Mark off 10 meters on the floor in your clinic with tape, time in seconds how long it takes your patient to walk this far, having them start a few feet before the line and keep going a few feet after the line. Divide the number of seconds by 60 sec/min, to give you minutes. Then divide 10 meters by the number of minutes to give you meters/minute.

Example: pt walked 10 meters in 7 seconds
7sec/60sec/min = 0.117 minutes
10 meters/0.117 minutes = 85.5 meters/minute
(Average normal speed in adults is 80 meters/minute, but age dependent)

60/_____ time(sec) x _____ distance (10 meters) = _____**Velocity** (meter/min)

STRIDE LENGTH: Divide the velocity (meters/min) by cadence (steps/min), this gives you the number of meters for each step (this is the average, and not accurate if uneven step length between left and right), now multiple this by 2, and this will give you your average stride length.

Example: 70 meters/min (velocity) / 80 steps/min (cadence) = 0.875 meters/step
0.875 meters/step x 2 steps/stride = 1.75 meters average stride length

Velocity ____ (meters/min)/Cadence____(steps/min) x 2 = ____ **Stride Length** (m/min)

Steps in RAS Gait Training

1. **Assessment – find the patients current cadence by counting heel strikes for 60 seconds, or 30 sec x 2 to get steps/min. Velocity and stride length can also be assessed at this time.**

2. **Entrainment – match RAS frequency to gait cadence and train at this cadence for the 1st part of session with emphasis on heel strike on the beat. Verbal cues may be used to encourage increase in step length, improved weight bearing, and improve posture etc. as appropriate.**

3. **Frequency Modulation – Increase the RAS frequency by 5 – 10% without compromising good gait mechanics. Train at this speed again working on decreasing gait deviations and heel striking on the beat.**

4. **Adaptive Gait Patterns – advanced gait techniques can be trained such as stop and go to work on initiation with PD patients, or turns maintaining RAS frequency.**

5. **Fading – RAS should be faded, with the patients encouraged to maintain RAS frequency. Have patient work on mental imagery of the music during ambulation.**

6. **Reassessment – reassess cadence to assess carry over and to reevaluate gait pattern.**

Equipment for Clinic Use

Walkman with dual headphone adaptor and extra head set
(adaptor available at Radio Shack for about $5)

Portable metronome –available at music stores for $25-30

Cassette or CD Player with high speed dubbing to make tapes

Set of master tapes or CDs to record from at sequential speeds ranging from 50 to 115 steps/min

Rhythmic Auditory Stimulation (RAS) for Gait Training

1. Pregait activities in the parallel bars with rhythmic cueing:

    a) weight shift side to side
    b) weight shift forward and backward with lower extremities in step position
    c) weight shift forward and backward with swing through practice on affected side
    d) weight shift practice for stance on affected side

2. Ambulation training with RAS (metronome, synthesizer, live musical cueing) during a treatment session.

    Protocol:

    1) have patient ambulate for 30 seconds (multiply by 2) or 60 seconds to get starting cadence (steps/minute).
    2) match ambulation speed with rhythmic cueing, emphasize heel strike on the beat. Train at this cadence for the 1st part of the session working on increased step length, increased weight bearing on the affected side, arm swing and other gait deviation corrections as appropriate. Verbal cues may be used to emphasize the beat and correct gait deviations.
    3) increase cadence speed by 5-10% without compromising good gait mechanics. Train at this speed again working on decreasing gait deviations. Verbal cues may be used to emphasize the beat and to correct gait deviations.
    4) fading: turn off music and continue gait training to assess carry over; have patient work on mental imagery of the music during ambulation.
    5) set up home program with RAS if they are an out patient.

**If patient is using an assistive device the patient will need to be trained in sequencing with this device correctly during RAS training. Two point gait works the best for rolling walkers, and canes. Three point gait is usually required for a standard walker and a hemi-walker, this will affect your music selection. It is recommended that patient's are progressed to a 2 point gait as quickly as possible, as this is a much more normal gait pattern. The longer the patient stays with a 3 point pattern, the harder it is to get them out of this

3. Advanced Ambulation Skills training with rhythmic cueing:

    a) Lower extremity (LE) sequencing up and down 4 inch or 6 inch step
    b) Affected upper extremity (UE) – arm swing with use of tambourine or dowel
    c) Advanced lower extremity (LE) coordination patterns
    d) Stop and Go training to work on initiation of gait (useful with Parkinson's patients)
    e) Walking on different surfaces and on curbs, ramps, and stairs
    f) Practice turns and going through doorways

Recommendations for Using RAS in the Clinic

Inpatient Use

Assess cadence and go trough RAS procedure every gait training session using live music with a Music Therapist or using a metronome or cassette tapes or CD

Set up on a home program at D/C

Outpatient Use

Assess cadence each session and follow the RAS procedure for training using a metronome or cassette tapes

Set patient up on a home walking RAS program using cassette tapes or a metronome. I usually start with 3-5 min 2x/day depending on endurance levels. They are given tapes with their current cadence on one side and 5 to 10% faster cadence on the other side

Have them walk a loop in their house, or walk outside if safe or with someone if they have headphones on.

Every patients gets a log sheet to fill out their duration and speed of their daily walks, this increases compliance significantly.

SUGGESTIONS FOR SETTING UP A HOME PROGRAM

Recommendations for all patients:

1) Monitor heart rate and pulse as you progress with the RAS program, make sure they are safe amb the amount of time you are recommending for home daily program.
2) Write up an instruction sheet which instructs patients what speed and how long to walk at each speed, be conservative with time, as most patients are very deconditioned. I typically start with a 3-5 min walk 2x/day. Make sure patient can do the program in your clinic safely for the duration you've set. Have patient log their daily walks on a log sheet for you to monitor each visit. This significantly improves compliance.
3) Check their program every week or two and recheck their normal walking cadence and change out tapes if appropriate. I usually go with their current walking cadence on one side of the tape, and then 5-10% faster on the other side.
4) Progress duration of home walking program weekly as tolerated. I usually increase the duration 1-3 minutes per week as tolerated until they are up to 15-20 minutes of ambulating daily with RAS.
5) Make sure patient is safe to walk independently or walks with a friend or spouse, and that they are safe to assist. Encourage them to walk in a place where they are not in the street or have to cross the street as this is a hazard with a walkman on.
6) You can also set them up walking a loop in their house if poor weather or if there is no safe place to walk outdoors.

Equipment for Home Programs:

- Cassette or CD Walkman – you can get a dual headphone adaptor ($5 at Radio Shack) to use in the clinic or for the patient to use at home with their spouse. (you can get a walkman for around $20 and an extra set of headphones for around $10)
- Portable metronome- great for clinic, and patients can get for home use if they are distracted by the music (example TBI's). They are about $25-30. Listen to the click before you buy it to make sure it is not annoying to you (some digital ones are).
- Cassette player or Boom box for clinic and home use. For the clinic get one with high speed dubbing to make tapes. (you can get one for as low as $70-80)
- Set of master tapes or CD's to record from with speeds ranging from 50 steps/min to 115 steps/min. You can order these through our Website at **http://www.colostate.edu/dept/cbrm/**

SUGGESTIONS FOR GAIT TRAINING WITH RAS FOR VARIOUS DIAGNOSES

STROKE PATIENTS:

1) Instruct patient to work on evenness of step length on each side, emphasize hitting heel on the beat on each side.
2) Heel to toe gait pattern.
3) Weightbear as much as possible through affected leg staying with the beat bilaterally. Have patient work on decreasing gait deviations as appropriate.
4) Work on arm swing and trunk rotation.
5) Work on posture while walking, through trunk and upper body too.
6) Push velocity but not at expense of gait quality, you don't want to reinforce bad habits or increase tone.
7) Slowly progress duration, to increase endurance.

PARKINSON'S DISEASE PATIENTS:

1) Have patient work on increasing stride length, take bigger steps.
2) Emphasize heel strike and with heel/toe gait pattern, this will help decrease toe walking.
3) Increase cadence if appropriate, emphasis will more likely be on step length.
4) Instruct in improved posture, but not at the expense of their balance, many need balance training also.
5) Can use "stop and go" tape to work on initiation and coordination.
6) Work on arm swing and trunk rotation with gait.
7) Progress duration to work on endurance.
8) Use RAS training to improve ability to walk through doorways, keeping to the beat.
9) Encourage staying to the beat and even going into a marching pattern if needed to improve turns.

MS PATIENTS

1) Keep duration of walking time low, so as to not fatigue, work more on quality of gait depending on patient's specific gait deviations.
2) Work on cadence speed, stride length, even step length.
3) Goal should be to increase the efficiency and quality of their gait, and improve balance as needed.

TBI PATIENTS

1) Depends on patient's specific problems, there is usually the need to work on quality of gait, balance, velocity (including cadence and stride length), and endurance.
2) Increasing speed too much may increase UE or LE tone; take this into account when progressing their program.
3) Many of the same needs as stroke patients.

Effect of Rhythmic Auditory Cuing on Temporal Stride Parameters and EMG Patterns in Normal Gait

**Michael H. Thaut, PhD, Gerald C. McIntosh, MD,
Spiros G. Passas, PhD, and Ruth R. Rice, MS.**

(J Neuro Rehab, Vol. 6, No. 4, 1992)

This study investigated the effect of auditory (musical) rhythm on temporal parameters of the stride cycle and electromyographic (EMG) activity in normal gait.

Methods

16 Normal subjects

EMG of bilateral gastrocnemius muscle

Stride parameters measured

Subjects walked without rhythm for baseline, then walked with matched rhythmic music (same cadence)

Subjects were then asked to walk slightly slower and then slightly faster than normal which was then also matched with musical rhythm to that cadence

Results

In the Rhythm condition at the preferred cadence:

- **** improved stride rhythmicity between the right and left lower extremity.**
- **** Delayed onset of the gastrocnemius EMG**
- **** Shorter duration on the gastrocnemius EMG**
- **** Increased integrated amplitude ratios for the gastrocnemius**

EMG profiles indicate a more focused muscle activity during pushoff of the gastrocnemius with more consistent timing of the muscle activity. This also indicates a more focused motor unit recruitment pattern in the rhythm condition.

Effect of Rhythmic Auditory Cuing on Temporal Stride Parameters and EMG Patterns in Hemiparetic Gait of Stroke Patients

**Michael H. Thaut, PhD, Gerald C. McIntosh, MD,
Spiros G. Prassas, PhD, and Ruth R. Rice, MS**

J Neuro Rehab. Vol 7, No. 1, 1993

This study investigated the effect of auditory (musical) rhythm on temporal parameters of the stride cycle and electromyographic (EMG) activity of the gastrocnemius muscle in hemiparetic gait.

Methods

10 subjects: 5 right and 5 left sided CVAs.

3 trials spaced 2 weeks apart – consisting of a baseline walk at the patients' preferred speed, and a second walk with matched cadence musical rhythm.

Surface EMG on the gastrocnemius muscle bilaterally.

Subjects walked down a 20 foot pressure sensitive walkway.

Results

Weight bearing stance time on the paretic side and stride symmetry improved with rhythmic cuing

Magnitude of gastrocnemius muscle activation during midstance/pushoff increased on the affected side and decreased on the nonaffected side

Variability of integrated amplitude ratios decreased during the midstance/push off phase on the affected side

EMG activity of the gastrocnemius during the swing phase also decreased on the affected side

Decrease in EMG variability and decrease in gastrocnemius muscle activity during the swing phase were positively correlated with improvement in stride symmetry

(These results suggest a strong entrainment effect of auditory rhythmic cues on temporal gait control in stroke patients.)

Rhythmic facilitation of gait training in hemiparetic stroke rehabilitation

M. H. Thaut, G. C. McIntosh, R. R. Rice

Journal of Neurological Sciences 151 (1997) 207-212

This study investigated the use of auditory (musical) rhythm in a gait training program with stroke patients within 3 months post CVA to affect temporal parameters of the stride cycle and gastrocnemius electromyographic (EMG) activity compared with traditional gait training.

Methods

10 experimental and 10 control subjects with hemiparetic strokes completed a 6 week twice daily gait training program

Control group received conventional physical therapy gait program

Experimental had conventional physical therapy, but did gait training with the addition of rhythmic auditory stimulation (RAS). RAS was used as a timekeeper to synchronize step patterns and gradually entrain higher stride frequencies.

All training programs were completed within 3 months of the stroke

Subjects were pre and post tested with surface EMG on the gastrocnemius muscle bilaterally, and stride parameters were assessed using footswitches

Results

Significant difference in the increase in velocity between the experimental group and the control group (164% vs 107%)

Significant difference in the increase in the stride length between the experimental and control group (88% vs 34%)

Significant reduction in EMG variability of the gastrocnemius muscle (69% vs 33%)

The difference in stride symmetry improvement (32% in the RAS group vs 16% in the control group) was not statistically significant

Corene P. Hurt MM, MT-BC, Ruth R. Rice MS, PT
Gerald McIntosh, MD, Michael H. Thaut PhD, RMT

Journal of Music Therapy, XXXV (4), 1998, 228-241

This study investigated the effects of auditory (musical) rhythm on stride parameters in patients with traumatic brain injuries in an entrainment design and also as a training method to improve gait.

Methods

Experiment 1 (Entrainment Design)

8 TBI patients 4-24 month post injury

Patients were asked to walk at their normal speed and gait parameters were measured
Cadence was matched to their normal cadence and they were asked to walk with matched cadence musical rhythm.
Subjects were then asked to walk as fast as they could, and then to walk to a cadence set 5 % faster than this with musical rhythm

Experiment 2 (Training Design)

5 TBI patients 6 – 24 month post injury

Patients were set up on a 5 week daily home gait training program with RAS using cassette tapes

Results

Entrainment Design

Velocity increased by an average of 18% (not statistically significant).
Stride length increased 7% and cadence 8% (not statistically significant)
5 of the 8 patients could entrain to musical rhythm set at 5% over their fast cadence

Training Design

Velocity increased significantly by 51%
Cadence increased significantly by 16 %
Stride length increased significantly by 29%
Stride symmetry improved by 12 % (not statistically significant)

Rhythmic Auditory Stimulation in Gait Training for Parkinson's Disease Patients

M. H. Thaut, G. C. McIntosh, R. R. Rice, R. A. Miller, J. Rathbun, J. M. Brault

Movement Disorders, Vol. 11, No. 2, 1996, pp 193-200

Methods

15 PD patients in the experimental group, 11 in a "self paced" walking group, and 11 in a "no training" group

Experimental subjects were set up on a 3 week home training program with RAS using walkmans and cassette tapes for 30 min/day. They were to walk with musical rhythmic set at their normal cadence for 1/3 of their daily session, a tape set 5% faster for the 2nd 1/3 of the session and a tape set 5% faster than that for the last 1/3 of the session. Normal cadence was assessed weekly and the pt was progressed with new tapes.

The self paced walking group were instructed to walk the same amount of time (30 min/day) , with normal speed 1/3 of session , slightly faster the next 1/3, and slightly faster than that for the last 1/3 of their walking session

No training group continued with their normal daily activities.

All subjects were pre and post tested without RAS and stride parameters and EMG activity was assessed

During the post test the RAS training group was asked to reproduce the speed of the last training tape, this was after their normal walk

Results

RAS trained subjects improved their gait velocity by 25%, stride length by 12%, and step cadence by 10% more than the self paced group who improved their velocity by 7% and no training subjects whose velocity decreased by 7%

Timing of the EMG activity in the RAS group changed significantly in the anterior tibialis and vastus lateralis muscles

RAS group demonstrated rhythmic entrainment as they were able to reproduce the speed of the last training tape within a 2% margin of error with RAS