Biomechanical Subcomponents of Gait

A Useful Movement Analysis Framework for Implementing High Intensity Gait Training

**This resource goes beyond the scope of the 2020 Locomotor Clinical Practice Guideline and is intended to provide an evidence-based framework for clinicians when implementing High Intensity Gait Training with patients of varying abilities.*

- The 2020 Locomotor CPG strongly recommends moderate-high aerobic intensity walking training to improve walking speed and distance in individuals >6 months post CVA, TBI, and i-SCI.
- The Biomechanical Subcomponents of Gait are a framework that provides a decision-making guide for clinicians implementing High Intensity Gait Training to evaluate and treat locomotor deficits.
- This framework was developed with consideration of the metabolic cost – or cardiovascular demand – of each of the four key biomechanical subcomponents while walking, and has been successfully applied to neurologic populations in both research and clinical practice.
- These subcomponents help focus a therapist's attention on gait deficits that likely most impact the patient's walking ability and inform treatment interventions.
- Achieving the below criteria in each of these subcomponents characterizes successful stepping during gait training. The specific movement strategies utilized to achieve successful stepping are not a primary consideration. (See here for why.)

The four key subcomponents and criteria include…

1) **Stance Control**: absence of vertical limb or trunk collapse during stance
2) **Limb Advancement**: adequate foot clearance and a positive step length bilaterally
3) **Propulsion**: ability to move center of mass in a specific direction (forward, backward, etc.) during stance, separate from limb advancement
4) **Postural Stability**: maintaining upright in sagittal and frontal planes, keeping center of mass within base of support

- Ideally, patients receive assistance only as needed to achieve the above stepping criteria with no more than 3-5 consecutive errors at a time. While experiencing error is an important part of motor learning, too much error can result in less stepping practice.
- Assisting or challenging these subcomponents can allow the patient to successfully participate in task-specific stepping practice at an appropriate challenge point and cardiovascular intensity.
- The following pages describe common deficits seen in each subcomponent and provide pictures of example interventions. Based on the patient's performance, the therapist can decide whether the patient would benefit from assistance, guidance, trial and error practice, or challenge in each subcomponent. As the patient improves, assistance is withdrawn and challenge is increased.

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Manipulating the Biomechanical Subcomponents of Gait

Subcomponent	Common Movement Problems	Example Strategies to Assist	Example Strategies to Challenge	Other considerations
Stance Control	• Knee buckling • Severe knee hyperext thrust • Sagittal plane hip collapse • Uncontrolled ankle equinovarus	• Harness support • Manual assistance • Swedish knee cage • Bracing, taping • Allow UE support	• Weighted vest • Decrease UE support • Stairs • Stepping activities demanding increased single leg stance time	• Stance time asymmetry is not a primary focus
Limb Advancement	• Inability / difficult to initiate swing • Insufficient toe/foot clearance • Negative step length	• Manual assistance • Banded assistance for ankle / knee / hip flexion • Contralat heel lift • Bracing, ACE wrap	• Stepping toward or over targets • Ankle weight • Banded resistance (posteriorly) • Incline • Stairs	• Limb advancement strategy patient chooses (steppage, circumduction, etc.) is not a primary focus
Propulsion	• Slow walking speed • Negative step length	• Manual assistance • Decreased speed demands • Banded anterior-directed assistance at pelvis • UE support on treadmill	• Increased treadmill speed (without UE support) • Overground timed challenges • Inclines • Banded posterior-directed resistance at pelvis • Pushing or pulling heavy loads	• Challenging propulsion is typically the most efficient way to elevate HR into target zone
Postural Stability	• Inability to remain upright without UE use or other physical assistance	• Manual assistance • Banded stabilizing assistance at pelvis/trunk to external supports • Harness support • UE support	• Decreased UE support • Uneven and compliant surfaces • Reduced sensory feedback • Perturbations • Variable directions • Dual task	• Focusing on balance may decrease HR intensity, so may benefit from alternating between propulsion-demanding tasks and balance challenges within a session

***Reminder: Gait training is performed while targeting 70-85% max HR or 60-80% HR reserve.**

Donelan, JM. “Mechanical and metabolic requirements for active lateral stabilization in human walking.” *Journal of Biomechanics*. 2004; 37: 827-835.
Gottschall, JS. “Energy cost and muscular activity required for propulsion during walking.” *Journal of Applied Physiology*. 2003; 94: 1766-1772.
Gottshcall, JS. “Energy cost and muscular activity required for leg swing during walking.” *Journal of Applied Physiology.* 2005; 99: 23-30.
Grabowski, A. “Independent metabolic costs of supporting body weight and accelerating body mass during walking.” *Journal of Applied Physiology*. 2005; 98(2): 579-583.
Holleran, CL. “Feasibility and potential efficacy of high-intensity stepping training in variable contexts in subacute and chronic stroke.” *Neurorehabilitation and Neural Repair*. 2014; 28(7): 643-51.

A.

A. Stance control assisted as needed with knee block and body weight support. Postural stability assisted with manual assist at pelvis and use of hemiwalker.

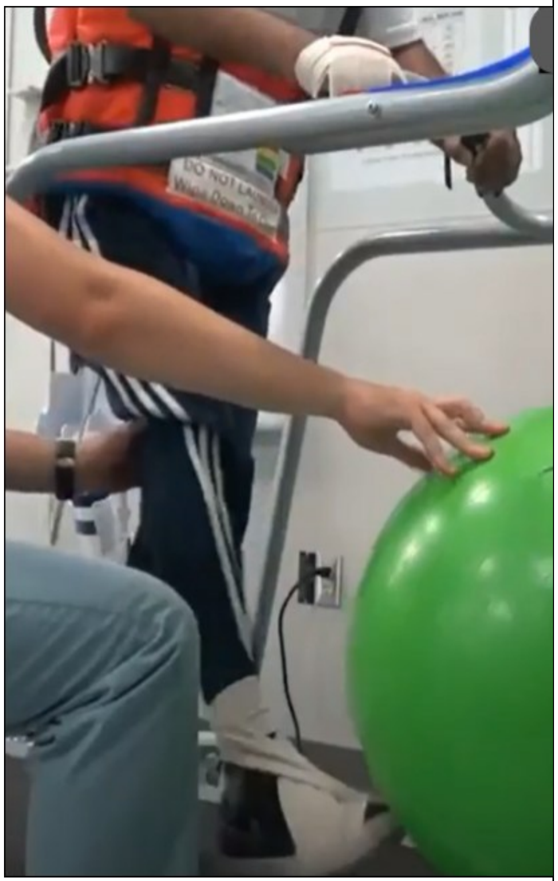
B.

B. Platform walker helps control postural stability and UE weight bearing assists stance control. This allows focus on limb advancement with assist only as needed from therapist. DF ACE wrap also assists.

C.

C. Banded assistance used for limb advancement. Railing used to assist propulsion and postural stability. This set up allows focus on improving stance control in this lower functioning patient. Harness used only for catch (no BWS).

D.

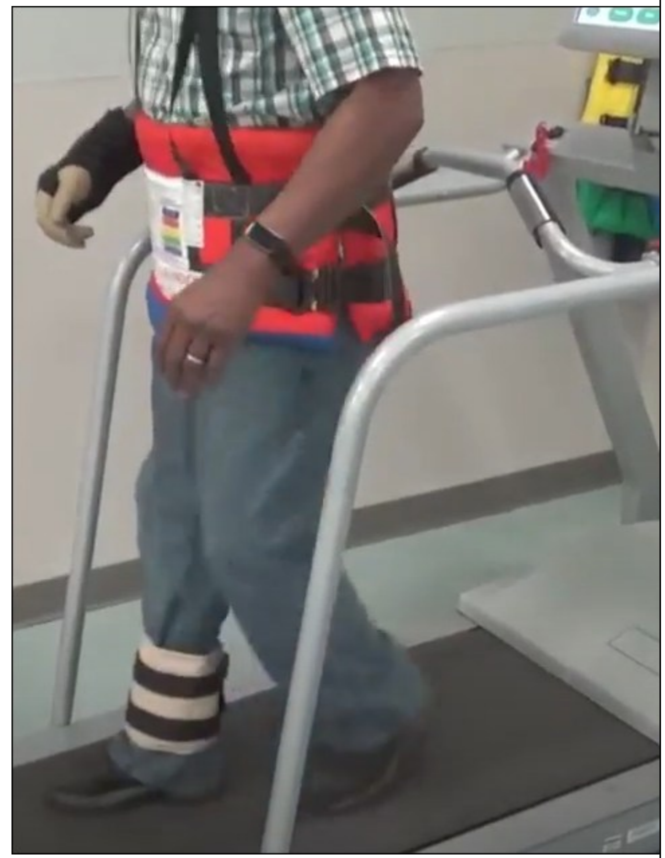


D. A combination of using a ball as an external focus and assist only as needed from the therapist, targeting limb advancement. Handrail use controls for postural stability and propulsion to allow this lower-level patient an opportunity to focus on limb advancement.

E.

E. Limb advancement is challenged by wearing an 8-lbs ankle weight while trying to kick a target – an example of an external focus of attention.

F.



F. An 8-lbs ankle weight challenges limb advancement during backward stepping on a treadmill without UE support, challenging postural stability.

G.	H.	I.
		
G. Postural stability is challenged on a compliant surface, while a knee cage controls severe knee hyperextension (a deficit in stance control). Patient also wears an AFO to assist with limb advancement.	**H.** Having to clear a full step challenges limb advancement during swing phase. Meanwhile stance control and propulsion are challenged during stance phase.	**I.** A resistance cord provides a posteriorly-directed force to challenge propulsion.

J.	K.
	
J. Therapist advances walker speed challenging patient to keep up, targeting propulsion. 10-lbs ankle weight provides a challenge to limb advancement.	**K.** Patient drags a 53-lbs sled while being challenged to keep up with leading therapist engaging him in a dynamic boxing activity, challenging propulsion and postural stability.