Return to Run After Stroke: A Case Series

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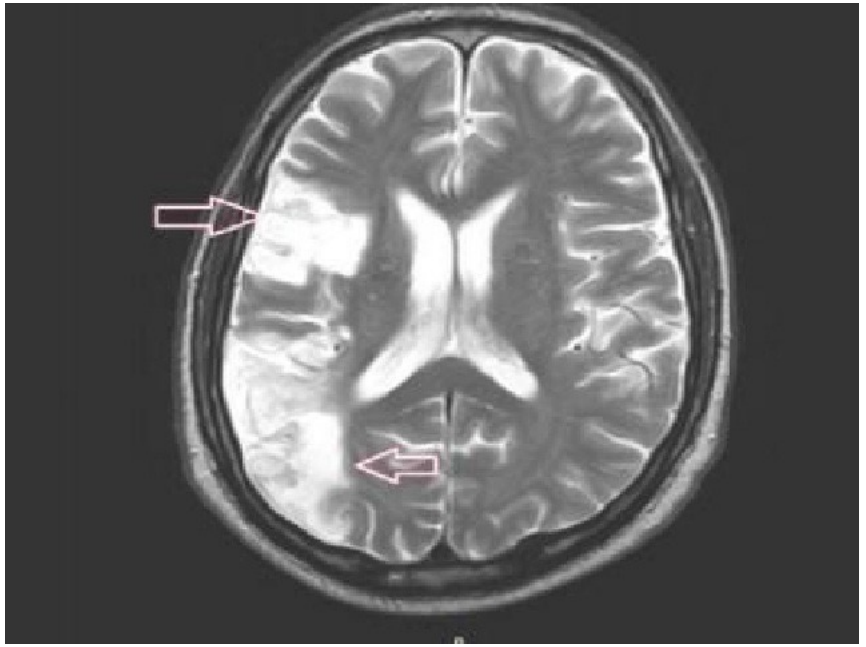
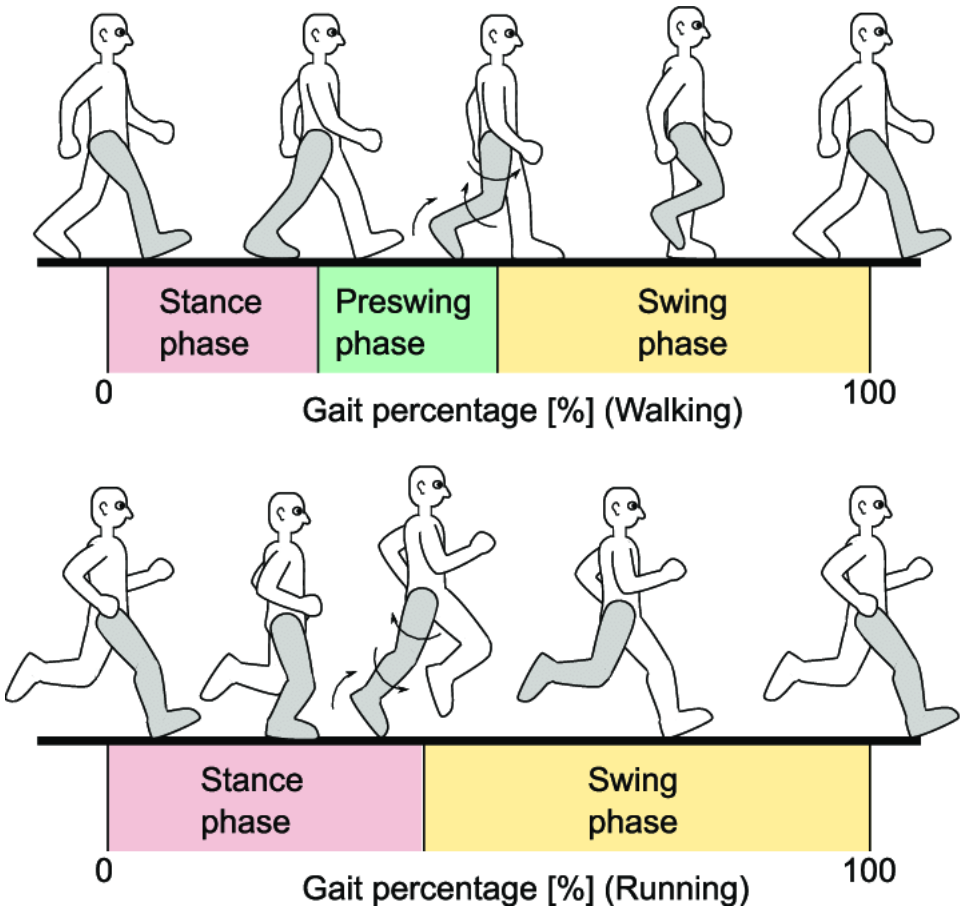
Establishing a Need

- Stroke is affecting younger populations (Yahya et al, 2020)
- High variability in motor recovery
- Running is a component of work, sport and leisure activities (Spencer et al, 2018)
- Community participation
- Health benefits
- Lack of literature guiding clinicians



Run vs. Walk

- Similar but more difficult (ROM, strength, balance, control) (Spencer et al, 2020; Thordarson, 1997; Dugan et al, 2005)
- Double float (Thordarson, 1997; Dugan et al, 2005)
- Increased stride length and cadence
- Accomplished by greater limb propulsion
- Greater demand for load absorption



Miyazaki et al, 2021

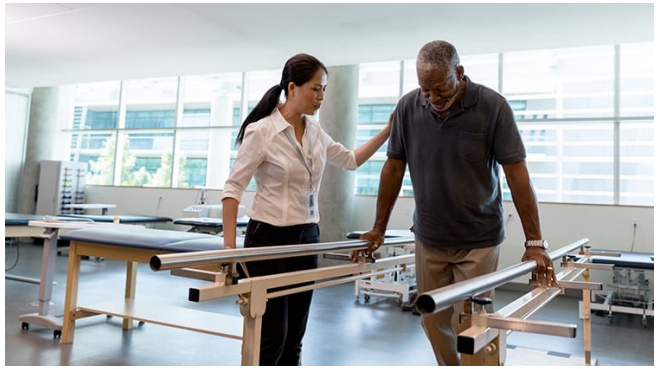
Where to Look for Clinical Guidance

TBI (Williams et al, 2010)

- Conceptual framework
- HiMAT
  - bounding

Walking Interventions

- CPG (Hornby et al, 2020)
- HIIT (Boyne et al, 2023)
- Power exercises (Morgan et al, 2015)



Hypothesis

Program: HIIT Protocol

F = 2 - 3x weekly

I = 30 - 60 seconds of max safe running speed (≈70% HRR)

T = 20 - 30 minutes of cycling high intensity + 3 mins of active recovery

T = treadmill → overground

Program: Exercises

Impairment	Parameters			← Regression	Base Exercise	Progression→		
Limb coordination, power, push-off deficit	3 x 20 30s rest		Triple flexion, upright with hands on wall	Triple extension, upright with hands on wall	Triple flexion and extension with hands on wall	Triple flexion and extension in modified plantigrade	Triple flexion and extension with no UE support and coordinated arm swing	
BIL explosive power	3 x 6 0-60% 1RM 1 min rest		Split squat with wider BOS	Split squat, no jump	Mini split squat jumps	Split squat jumps, full range	Add resistance	
Decreased push off, explosive power	3 x 6 0-60% 1RM 1 min rest	Bil hop	SL calf raise (focus on power push off)	SL hop vertical	SL hop forward	SL hop F/B/L		
Dynamic balance, APA, load absorption, decreased push off force	3 x 20 1 min rest	SL calf raise with L TTWB for balance	SL calf raise	SL Vertical Hop	Bound Forward	Bound Diagonally	Bound Forward, Diagonal and laterally on color command	Bound onto compliant surface or bound over box
Reactive postural control (cue involved side stepping)	2 x 10	Lateral weight shift standing	Lateral stepping	Lateral perturbations	Lateral lean and random PT support release	Lateral lean and random release, EC	Lateral lean and random release, compliant	Lateral lean and random release, complaint, and EC
Coordination, task specific practice	5x 30 second rest	RE to slow walk	Hallway Fast walk obstacle course	Hallway Fast Walk with head turns	Hallway Fast Walk with slow/fast commands	Hallway Fast Walk with slow/fast/pivot commands	PRE to Run obstacle course → slow/fast	

Program: Exercises

Impairment	Parameters			← Regression	Base Exercise	Progression→		
Coordination, APA, dynamic stability				Alternating toe taps	Toe taps with color command, 2 colors	Toe taps with color command and heel/forefoot initial contact command (2 colors)	Increase color and initial contact sequence difficulty	
Agility and Coordination	3 x 5	Decrease speed	Forward	Lateral	Backward Ladder Drill	Hopscotch Ladder	Crossover shuffle	Crossover shuffle to sprint
DF weakness, clearance, fall risk	2 x 10 or to fatigue			Toe tap	Concentric → isometric hold → slow and controlled eccentric lowering	Increase hold time, add resistance to concentric	add eccentric resistance	
Knee extensor weakness	2 x 10		Mini squat with UE support	Body weight squat with elevated seat	Body weight squats	Narrow stance squats	Add resistance	

Case 1 – Background

- 53 yo M with stroke affecting L MCA 20 months prior
- Collegiate runner
- 3 week stay in IPR → 6 months of outpatient therapy
- Began running 12 months after stroke
- **Goals: break 5 km personal record**

Case 1 - Impairments

- Not many
- PF weakness → decreased power generation
- Balance

Early Running Videos

Interventions

- Task specific: HIIT protocol, endurance protocol
- Power: split squat jumps, triple flexion/extension, bounding
- Coordination: color toe taps

Late Running Videos

Case 1 - Results

Measure	Pre	Post
Run speed (m/s)	3.1	3.28
HiMAT	30	34 (>MDC_{95} TBI)
Mini-BESTest	23	27

- Bounding distance relatively unchanged d/t ceiling effects
- **Beat post-stroke 5 km PR by 45 seconds**

Case 2 - Background

- 50 y.o. M with L MCA stroke 5 years prior
- Physically active military veteran
- 2 weeks IPR → 2 years outpatient
- Wears R AFO for foot drop
- Limited to 1x weekly
- Despised running before injury, driven to run after
- **Goals: run with dog in yard**

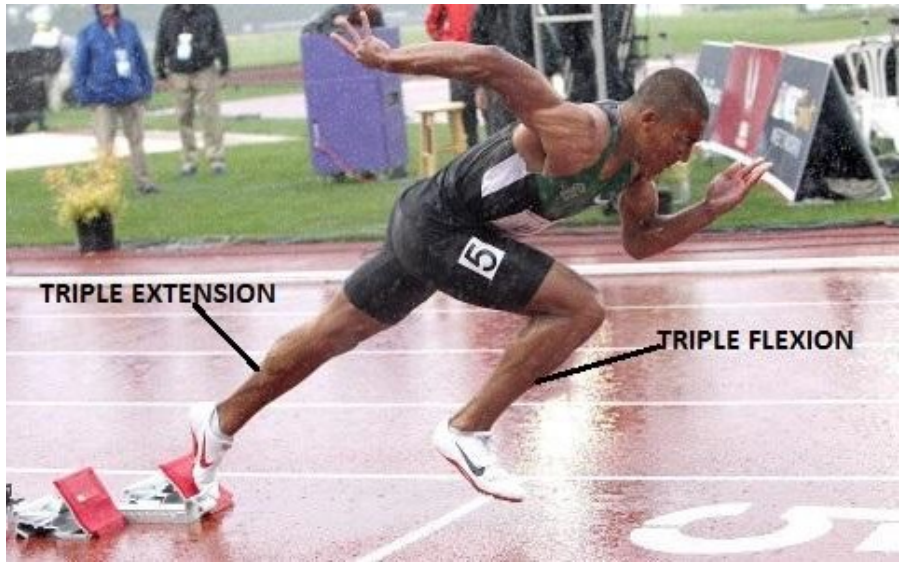
Case 2 - Impairments

- Spasticity
- ROM: DF -20 without AFO
- Strength deficits: hip abd, DF
  - Hip abd → Medial collapse at knee
  - DF → Foot slap, fatigue, toe clearance, reduced load absorption
- Reduced power generation → reduced push off
- Balance

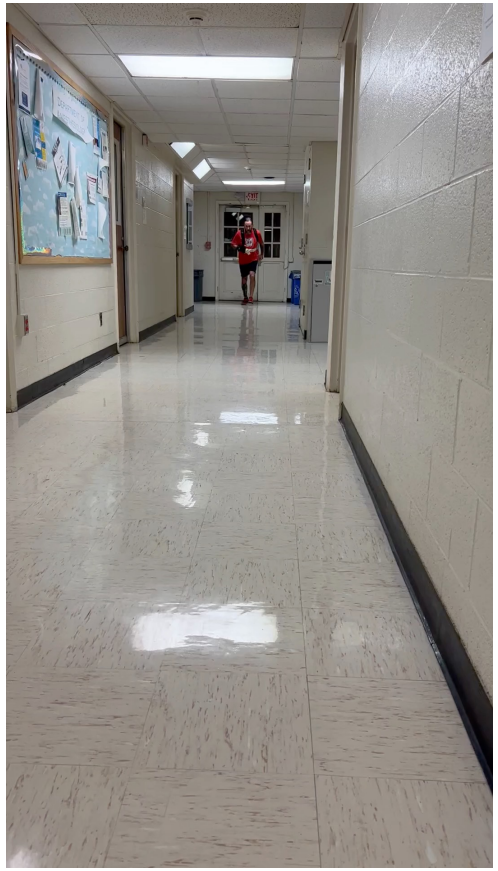
Early Running Videos

Interventions

- Task specific: HIIT protocol
- DF weakness: Isometrics → eccentrics
- Medial collapse: captain morgan's and sidelying hip abd
- Power:
  - Triple flex/ext upright → modified plantigrade
  - Split squat (no jump) → split squat jumps
  - SL calf raise → vertical hop
- Feedback: land quietly



Late Running Videos



Case 2 - Results

Measure	Pre	Post
Run speed (m/s)	unable	2.41
HiMAT	15	20 (>MDC_{95} TBI)
Mini-BESTest	22	21
Bound onto affected (cm)	26	86.67
Bound onto unaffected (cm)	55.8	63.7

- Began running during 2nd session
  - Handrail support → no support by 3rd session
  - Treadmill → Overground by final session
- **Able to run with dogs in backyard**

Case 3 - Background

- 62 y.o. F with R cerebellar stroke 2 years prior
- Completed 41 events at marathon distance or greater
- Hiking and trail running
- 2 weeks IPR, no outpatient services
- Frequent clinical research participant
- 3x falls in last 6 months, all on single track trail
- **Goals: return to run, compete in 50 km races**

Case 3 - Impairments

- R hemiparesis
  - PF weakness → decreased push off
- DF endurance and control deficit → toe clearance → fall risk
- Balance
- Ataxic gait with wide BOS - compensation?

Case 3 – Early Videos

Interventions

- HIIT protocol
  - Fear avoidance behavior → ‘fall back’ in harness strategy
  - Feedback: ‘swing knee through’, ‘lift toes’ for toe clearance → reduced scuff
- Power:
  - Triple ext/flex upright → modified plantigrade
  - Split squat wide BOS → mini split squat jumps
  - Calf raises (no progression)
- Coordination:
  - Fast hallway walking obstacles → head turns, slow/fast/pivot commands
  - Ladder drills – facilitate longer step length

Case 3 – Late Videos

Case 3 - Results

- No running
- FGS: 1.67 m/s → 1.84 m/s
- Run: Double float with a trekking pole
- HiMAT: +1
- **No longer needs HHA on single track trail**
- **Set 5 km PR by 2 minutes**
- **Placed 3rd in trail half marathon in 7 hours (< 1.5 hours from previous year)**

Discussion

- Running is possible after stroke
- Overarching framework is applicable to all ability levels
  - HIIT + Impairment-specific ExRx
- AFO/AD considerations
- Race participation – motivation?

Conclusions: How to Apply…

1. Determine goals
2. HiMAT + gait analysis + joint kinetics → informs running-specific impairments
3. Power exercises: Use exercise chart for progressions and regressions
4. HIIT protocol
5. Reassess
6. Treadmill → Overground (clinical judgment - no handrail use, infrequent scuff, safety?)