

Serve Up Brain Gains

How Pickleball Enhances

- Vestibular Function
- Balance
- Cognitive Resilience

Presented by

naples brain center
unlocking potential

Darcy D. Dane, DC, DACNB

Sponsored by

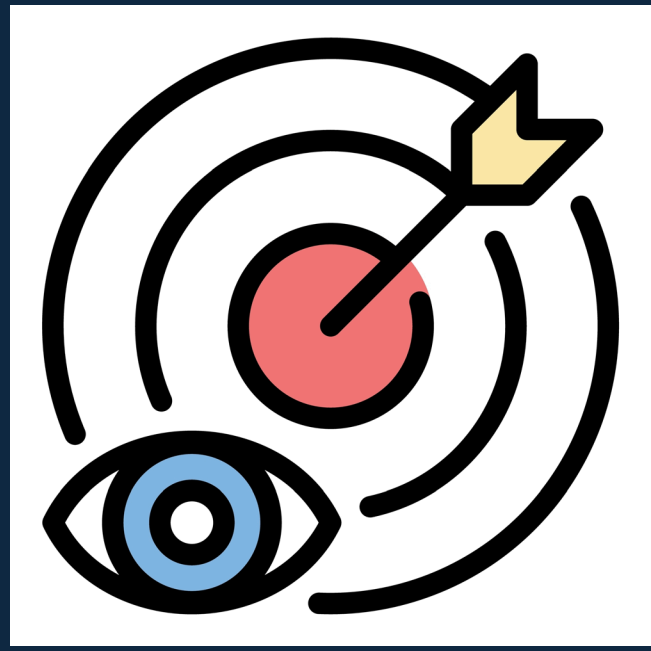




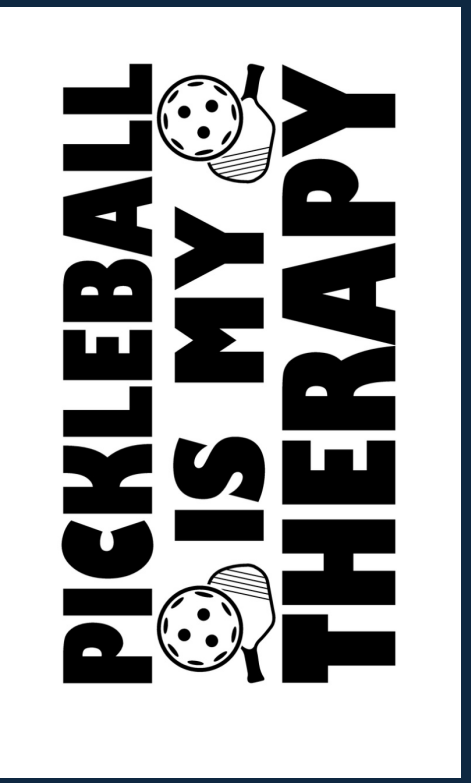
The Problem We're Actually Treating



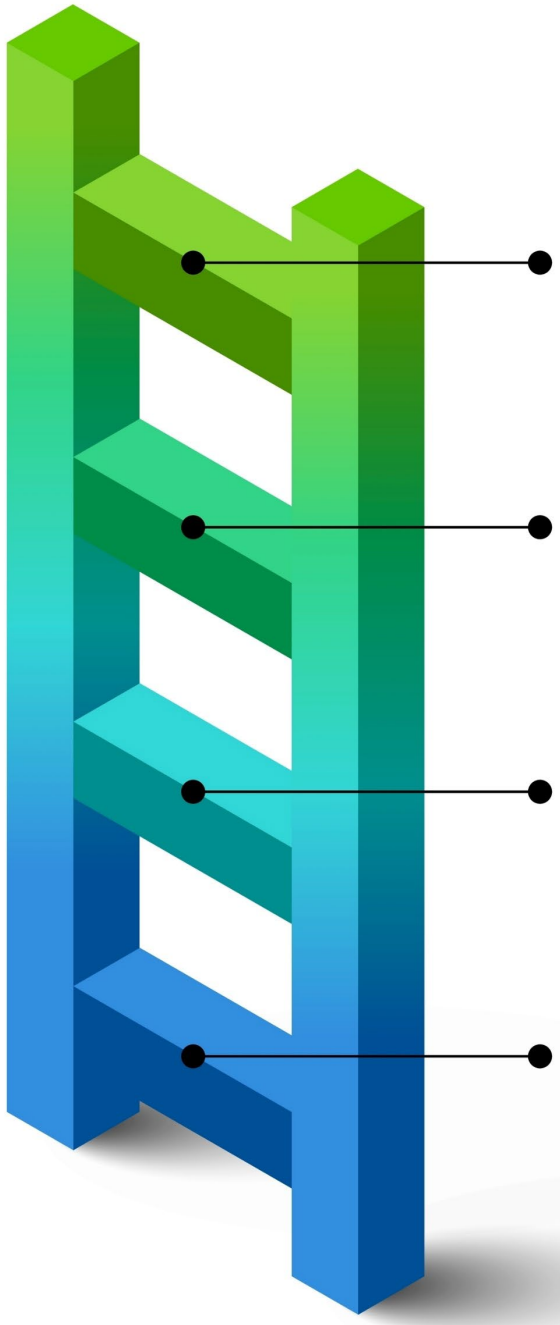
- Clinic drills often fail at transfer
- Falls, dizziness, and slowed thinking rarely travel alone
- Patients need a task they will repeat without us
- Open-skill activity trains what a closed-skill circuit can't



Learning Objectives



- Explain the neuromotor and vestibular mechanisms by which pickleball improves dynamic balance, hand-eye coordination, and cognitive processing in clinical populations
- Apply evidence-based pickleball-derived exercises and progressions to enhance vestibular function, postural stability, and cognitive resilience
- Design safe, individualized pickleball integration programs (including modifications) to promote neuroplasticity, reduce fall risk, and support long-term brain health



How I'll Grade the Evidence Today

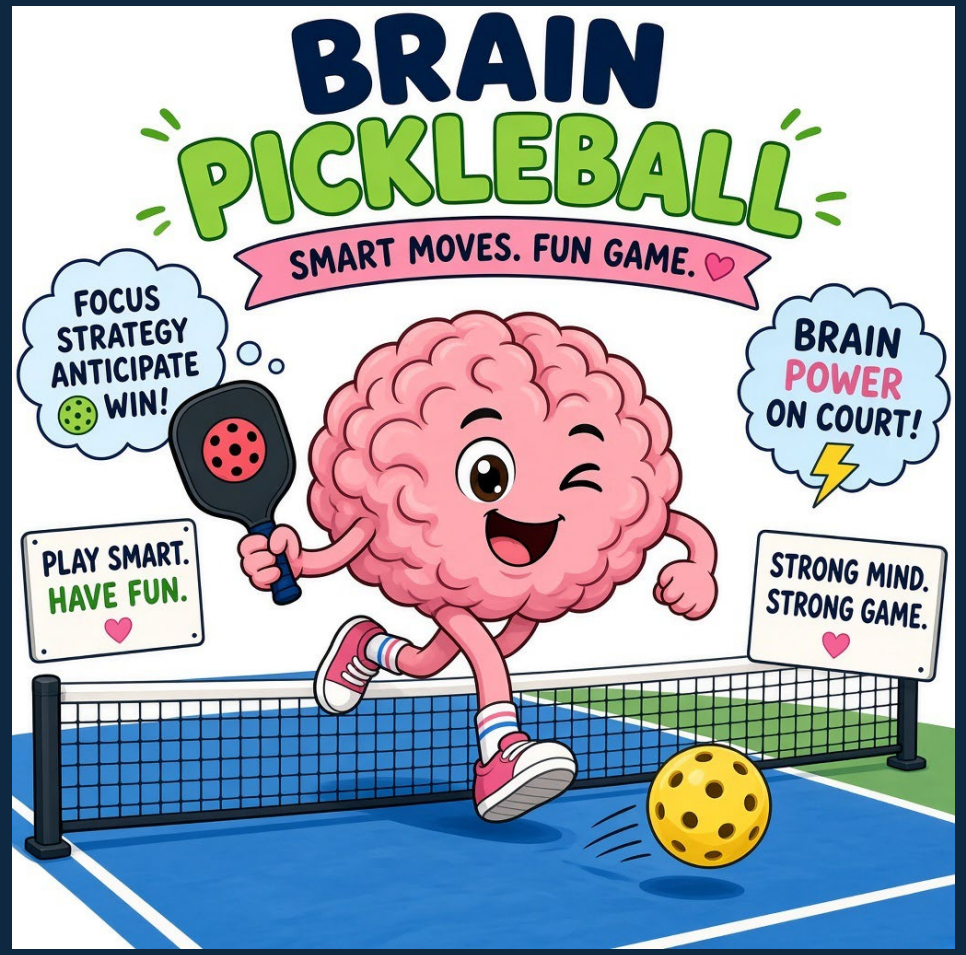
Tier 1: Cochrane reviews and clinical practice guidelines

Tier 2: Cohort and cross-sectional studies (associations)

Tier 3: Pilot or feasibility studies, theses, conference reports

Tier 4: Mechanism and clinical reasoning

Foundations and Neuroscience



- The sport
- Neurophysiology
- Vestibular and balance
- Cognitive resilience
- Evidence review

Pickleball by the Numbers

- About 13.6 million U.S. players in 2023, up 52% in one year; press reports in 2025 put the estimate near 20 million
- Players 55+ were the largest age bracket in 2021 (about 1 in 5 participants)
- Smaller court, slower ball, and faster learning curve than tennis
- Singles and doubles both reach moderate intensity in older adults
- Growth has brought a matching rise in injuries



The 45-Second Rules Version

- Court: 20 x 44 feet
- Underhand serve, diagonal
- Two-bounce rule: serve and return must bounce before volleying
- “Kitchen”: 7-foot non-volley zone at the net
- Games to 11, win by 2



The Movement Vocabulary

- Split-step timed to the opponent’s contact
- Lateral shuffle and crossover steps
- Lunge to reach, then recovery step
- Backward retreat on a lob
- Constant head yaw and pitch to track a small, fast ball



Why This Is Not Just Cardio

- Closed-skill: predictable environment (treadmill, bike, swimming)
- Open-skill: changing environment (racquet sports, ball sports)
- Pickleball adds a decision loop to moderate-intensity aerobic work
- Open-skill advantage for executive function: small effects, mixed designs
- Prescribe it for the skill demand, not just the heart rate



Exercise: The Brain's Fertilizer



- Exercise turns on the brain's growth signal: BDNF
- One year of aerobic exercise grew the hippocampus about 2%, while controls lost about 1.4%
- A single workout raises BDNF; regular training amplifies the response
- Challenge + exercise = plasticity with a purpose
- Pickleball = aerobic intervals + skill learning

The Cerebellum: Prediction and Error Correction



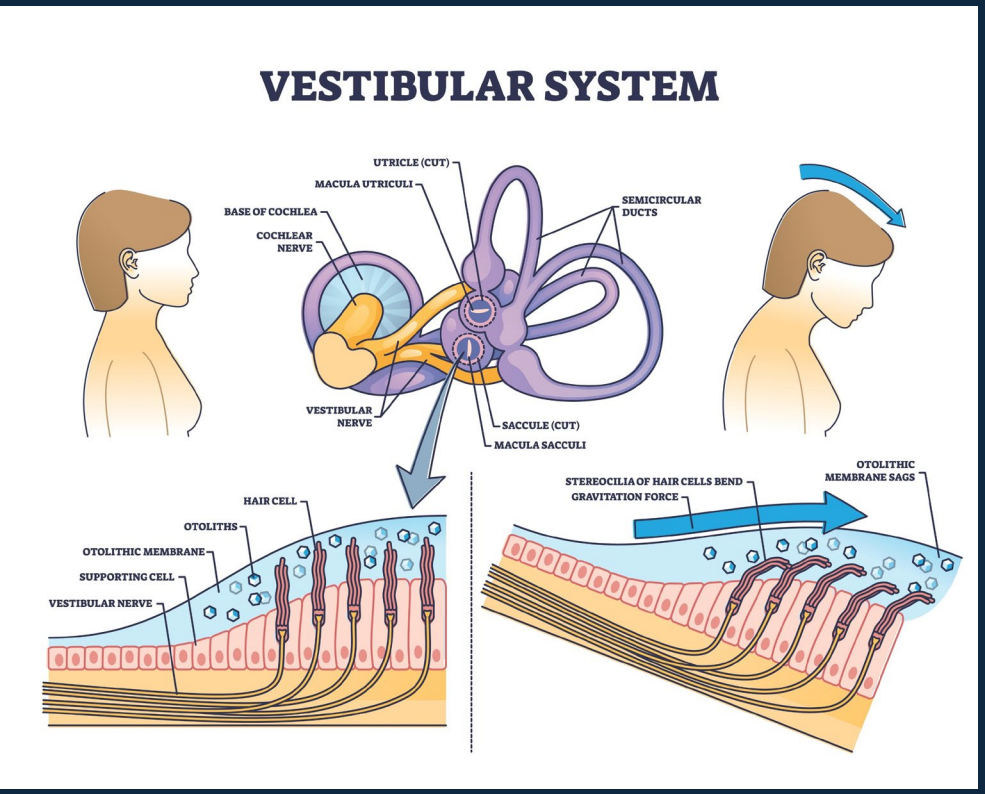
- Cerebellum runs a forward model: where will the ball be, where must I be?
- Every miss is an error signal; repetition updates the model
- VOR gain itself is calibrated by cerebellar adaptation
- Noisy sensory input = late swings, overreaching, freezing
- Reduce the noise first, then reintroduce speed

Multisensory Integration and Re-weighting



- Vision + vestibular + proprioception must agree
- Healthy brains re-weight inputs by reliability
- Glare, uneven surface, fatigue, or injury shift the weighting
- Mismatch shows up as dizziness, veering, a late paddle
- Example: PD patients re-weight poorly

Vestibular Refresher in 90 Seconds



- Semicircular canals: angular acceleration (every head turn)
- Otoliths: linear acceleration and gravity (every lunge)
- VOR keeps the ball steady on the retina when the head moves
- Vestibulospinal pathways contribute to postural tone and stepping
- Aging and injury degrade the signal and how it is weighted

Gaze Stability on a Moving Ball



- VOR: head moves, target still, eyes counter-rotate
- Smooth pursuit: eyes follow a moving target
- Saccades: quick jumps between targets
- Vergence: near-far adjustment
- A rally uses all four, but they are not interchangeable in training
- 2021 CPG: strong recommendation AGAINST pursuit or saccades alone as gaze-stability exercise (peripheral hypofunction)

Proprioception, Limits of Stability, and the Kitchen Line



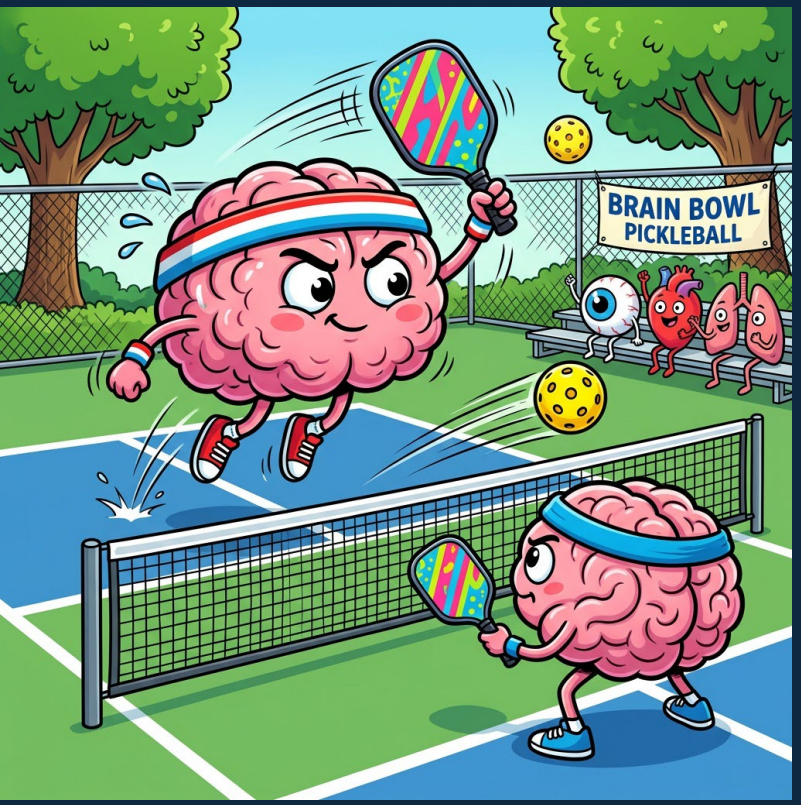
- Ankle, hip, and stepping strategies under time pressure
- Kitchen line demands precise foot placement and inhibition
- Backward and diagonal recovery are the weak links
- Hard court surface is unforgiving
- Repetition of weight shift is the dose

How Recreational Players Actually Fall

- 92 recreational players: 42% reported a fall while playing; 30% fell more than once
- Leading reasons: lunging and moving backward (≈57% and ≈24% in one summary)
- Fallers were older and slower on a pickleball T-test
- Hip abduction strength was NOT associated with fall history
- Hip abduction strength WAS associated with faster change of direction
- Cross-sectional, self-reported falls



Cognitive Resilience: The Hidden Rally



- Working memory: score, server, side, partner
- Inhibition: don’t poach, don’t volley from the kitchen
- Divided attention: ball, partner, two opponents
- Spatial awareness: where is the ball, my partner, the lines, and my next position?
- Shot selection is executive function on a cerebellar swing
- Observational data (N = 86): players beat inactive controls on divided attention, object tracking, and reaction time; aerobic exercisers beat them on inhibition and working memory

Social Engagement and Dementia Risk Factors



- 2024 Lancet Commission: 14 modifiable risk factors, ≈45% of dementia cases
- Social isolation (late life) ≈5%
- Hearing loss ≈7%; untreated vision loss ≈2%
- Population-level association, not proof that pickleball prevents dementia
- Group play is an adherence lever

Open-Skill and Racquet Sport Literature



- Reviews generally favor open-skill for executive function
- Most consistent: inhibitory control and cognitive flexibility
- Effect sizes small; sport classification is messy
- Many studies compare long-term players with novices
- Table tennis is the best-studied racquet analog

Pickleball-Specific Studies: What They Show and Don't

Study	Design	What it supports	Limits
Wray et al. 2021 (Utah State)	6-week feasibility; sedentary rural adults 50+	Improved vertical jump, cognitive performance, pain; good adherence	No control group; feasibility study
Søgaard 2021 (Wichita State thesis)	6-month observational; N = 86	Players > inactive on divided attention, object tracking, reaction time; balance ≈ aerobic group	Observational; thesis; aerobic group better on inhibition and working memory
Hutton et al. (Wichita State symposium)	18-month observational; N = 83	Open-skill exercise may help cognition more than aerobic	Abstract-level report
Myers & Hanks 2024	Cross-sectional; N = 92	Falls common; lunging and backward movement; slower direction change in fallers	Self-reported falls; no causation
Senior pickleball training program	Cohort study	Multifaceted training reduced fear of falling and improved physical performance	Not a fall-rate outcome
Parkinson's: Creighton pickleball; table tennis pilots	Small pilots; conference report	Feasible; signals for balance, mobility	Uncontrolled; tiny samples

Falls and Injury Evidence



- Cochrane 2019: exercise cuts fall rate by 23%; balance and functional exercise 24%; multiple types (balance + resistance) 34%
- Pickleball falls ≈63% of ED injuries in national data cited by Myers
- Upper-extremity ED injuries 2015-2024: wrist most common site; fractures the majority diagnosis
- Eye injuries: ≈1,262 ED visits in 2024; ages 50+ over-represented
- No evidence yet that playing pickleball reduces falls

Hour 1 Scorecard



- STRONG (not pickleball-specific): balance and functional exercise reduce falls; vestibular rehab works for unilateral hypofunction
- PLAUSIBLE: open-skill, dual-task, social activity supports executive function and adherence
- THIN: pickleball-specific trials; Parkinson's data; fall reduction from playing
- RISK: lunging and backward falls, wrist fractures, eye injuries
- Use the sport as the practice environment, and dose it

HOUR 2: Clinical Applications and Implementation



- Screen
- Decide
- Drill
- Adapt
- Prescribe

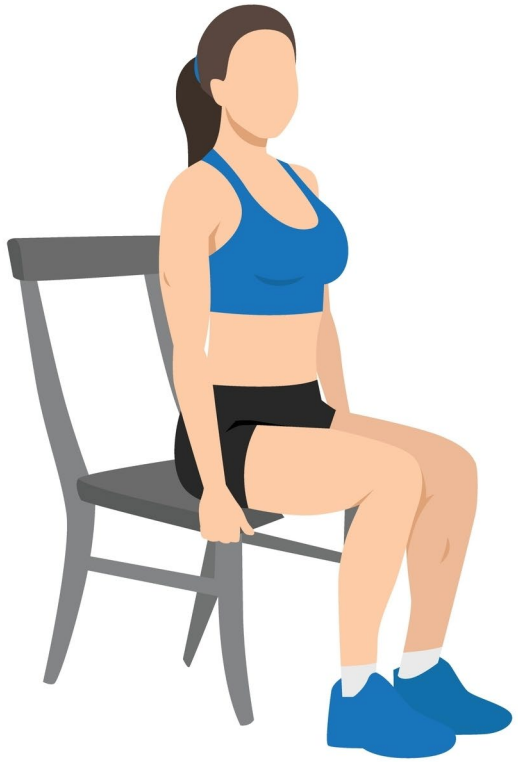
Screen Before You Prescribe



- Red flags: unstable cardiac status, uncontrolled syncope or marked orthostasis
- Acute vestibular crisis: treat the acute problem first
- New or unexplained neurologic signs, or suspected movement disorder: refer to MD, co-manage
- Functional filter: protected backward step, head turns while walking, dual-task cost
- Musculoskeletal screen: neck, shoulder, elbow, Achilles, low back
- The question: court, community, clinic, or not yet?

The Screening Toolkit

Domain	Tools you likely already own	What it tells you
Balance and mobility	Timed Up and Go (add a dual-task version); Mini-BESTest; Four Square Step Test; pickleball T-test (Myers) for sport-specific direction change; reactive backward step	Fall risk, reactive stepping, sensory orientation, direction-change speed
Vestibular	Head impulse (if trained); dynamic visual acuity; symptom provocation with head turns; Dizziness Handicap Inventory	Gaze stability, symptom load, baseline for tracking
Oculomotor	Smooth pursuit; saccades; near point of convergence	Whether a small, fast ball is trackable
Cognition	Gait speed with and without a cognitive task; simple reaction time	Dual-task cost
Musculoskeletal and cervical	Cervical ROM and provocation; shoulder, elbow; hip abductor strength; ankle dorsiflexion; Achilles	What will stop the plan



Running the Timed Up and Go (TUG)

- Setup: chair with arms, a line 3 m (10 ft) away, usual shoes and walking aid
- Say: “On ‘go,’ stand, walk to the line at your normal, safe pace, turn, come back, and sit”
- Time from “go” until their back touches the chair
- 12 seconds or more: increased fall risk (CDC STEADI)
- Repeat while counting backward by threes (or carrying a cup)
- More than about 10% slower with the task = positive dual-task cost

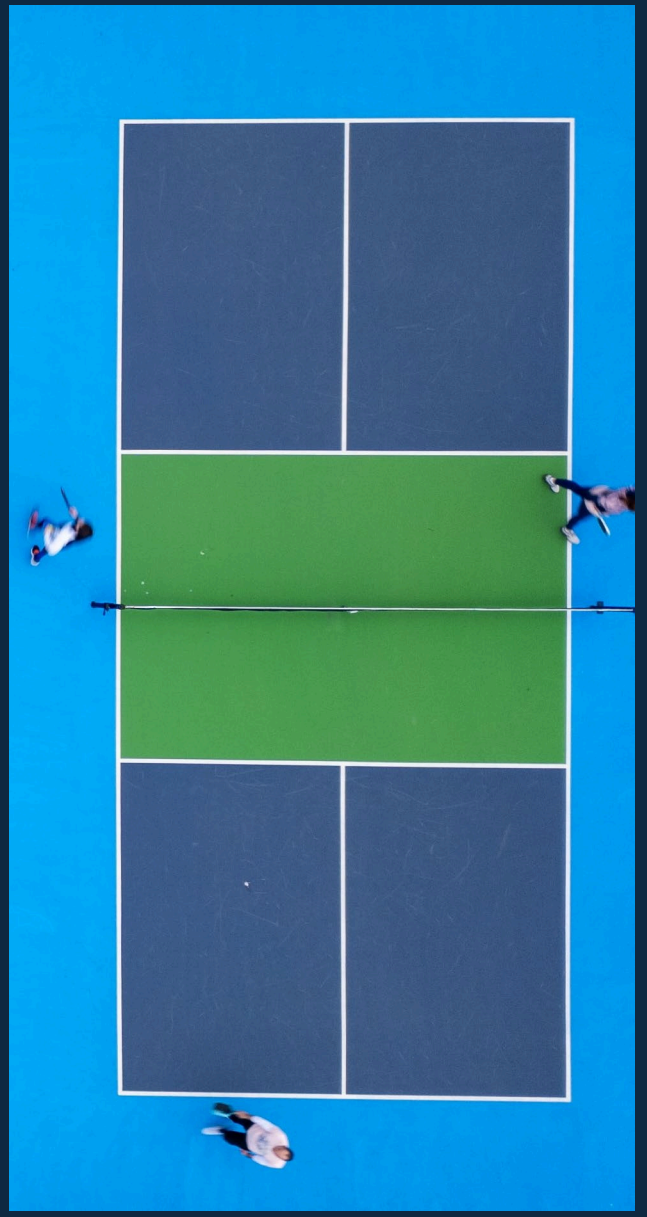
Running the Backward Step Test (Lean-and-Release)



- This tests reactive stepping: can the brain trigger a fast, big step when balance is lost?
- Setup: clear floor behind them, gait belt, a second person if there is any fall risk
- Patient: feet shoulder-width, arms at sides: “Lean back against my hands beyond your limits. When I let go, do whatever you need to, including taking a step, to avoid a fall.”
- You: stand behind, a hand on each shoulder blade, feel their weight, then release suddenly
- Score: 2 = one large step, recovers alone. 1 = more than one step. 0 = no step, or would fall
- Anything below 2 = clinic first
- PD pull test (MDS-UPDRS 3.12): up to 2 steps normal; 3 or more abnormal

Running the Mini-BESTest

- 14 items, each scored 0–2, maximum 28
- Four domains: anticipatory (items 1–3, /6), reactive stepping (4–6, /6), sensory orientation (7–9, /6), dynamic gait (10–14, /10)
- Setup: flat-heeled shoes or shoes off; firm chair without arms; 4-inch medium-density foam; incline ramp; stopwatch; 9-inch box; 3 m taped line
- Needs assistive device = score one level lower. Needs physical help = 0. One-leg stance and lateral step: use the worse side
- Read the script word for word
- Use the sub-scores to choose the drill; re-test at 4 weeks



Decide, Then Progress: One Variable at a Time

- Not yet: red flags from the screen (cardiac, syncope, acute vertigo, new neuro signs)
- Clinic first (any one): TUG 12 s or more · lean-and-release below 2, or not tested · Mini-BESTest item 11 or 12 scored 0 · symptoms rise more than about 2 points with head turns
- Community with conditions: passes the above plus one flag: dual-task TUG more than 10% slower · one-leg stance under 20 s · age 65+ · vestibular or concussion history · Parkinson's with physician aware
- Court-ready: passes everything, no flags
- Progression: one change at a time: still target → step → unpredictable target → second task → soft ball → partner → open play

DEMO 1: Gaze Stabilization with a Paddle

- VOR x1: hold the paddle logo still at arm's length; turn the head left-right while keeping the logo clear
- VOR x2: move the paddle and head in opposite directions
- Seated → standing → stepping
- CPG dosing (peripheral hypofunction): acute/subacute ≥3x/day, ≥12 min total; chronic 3-5x/day, ≥20 min for 4-6 weeks
- Pursuit tracking is a different drill (Demo 5)

DEMO 2: Head Turns While Stepping

- Tape two wall targets at 10 and 2 o’clock
- Call left or right; patient steps, turns head, taps the target
- Yaw first; then pitch (low and high targets, controlled squat and recover)
- Progress speed, then color or number calls, then foam
- Symptom convention: about 2-point rise that settles = training

DEMO 3: Split-Step, Lateral Shuffle, and the Taped Kitchen

- Split-step on cue: small bilateral hop into ready stance
- Lateral shuffle between cones or taped lines
- Step to the kitchen line, stop, reset (inhibition)
- Return to ready stance after every repetition
- Hallway = court

DEMO 4: Lunge, Recover, and Back Up

- Forward lunge to a tossed target, then recovery step to ready
- Backward walking and posterior tap
- Diagonal reaches
- Short sets, full recovery between sets
- Train the get-back, not just the reach

DEMO 5: Oculomotor, Hand-Eye, and the Dual-Task Layer

- Pursuit: roll a ball across a table, then toss
- Saccades: tap between two wall targets
- Near-far: toss from partner, then wall rebound
- Soft toss to the paddle face; foam ball wall rally
- Quiet head until gaze is clean
- Dual-task layer: call colors, count backward, or call the score every fifth hit

Adaptation: Parkinson's Disease



- Suspected PD or mimic: MD referral and co-management
- Evidence is small pilots (table tennis; pickleball conference pilot)
- Train amplitude and external cues first
- Posterior and lateral stepping before live balls
- Quiet court, consistent partner; avoid crowded open play early
- Watch freezing on direction change and dual-task collapse

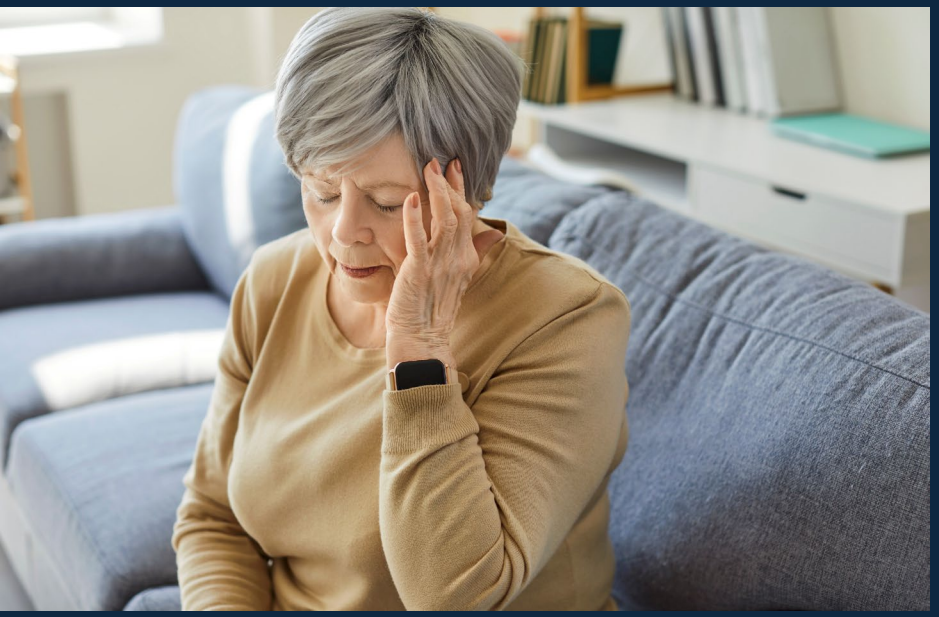
Adaptation: Concussion



- Amsterdam 2022: early light aerobic activity is beneficial
- Sub-symptom threshold aerobic exercise (2-10 days) when exercise testing is available
- Dizziness, neck pain, or headache >10 days: cervicovestibular rehabilitation

- Meta-analysis: sub-threshold exercise lowers symptom scores; tailored multimodal programs help persistent symptoms
- Pickleball is not an early-phase activity: visual motion, strikes, and falls

Adaptation: Vestibular Hypofunction



- Strong evidence for vestibular rehabilitation in unilateral hypofunction (Cochrane 2015; CPG 2022)
- Gaze stabilization is the foundation; pickleball tasks are the transfer layer
- Unilateral loss: head impulses toward the weak side are the ones that fall short; train both directions
- BPPV and central causes: treat or refer first (outside the CPG)
- Include the neck

Seniors, Beginners, and the Deconditioned



- Skill before speed; doubles before singles for most older beginners
- Court shoes (not running shoes); warm-up with posterior steps and trunk rotation
- Eye protection for every session
- Keep sessions short; avoid consecutive heavy days (low-quality data)
- Florida: heat, sun glare, hydration
- Clinic group class as the on-ramp

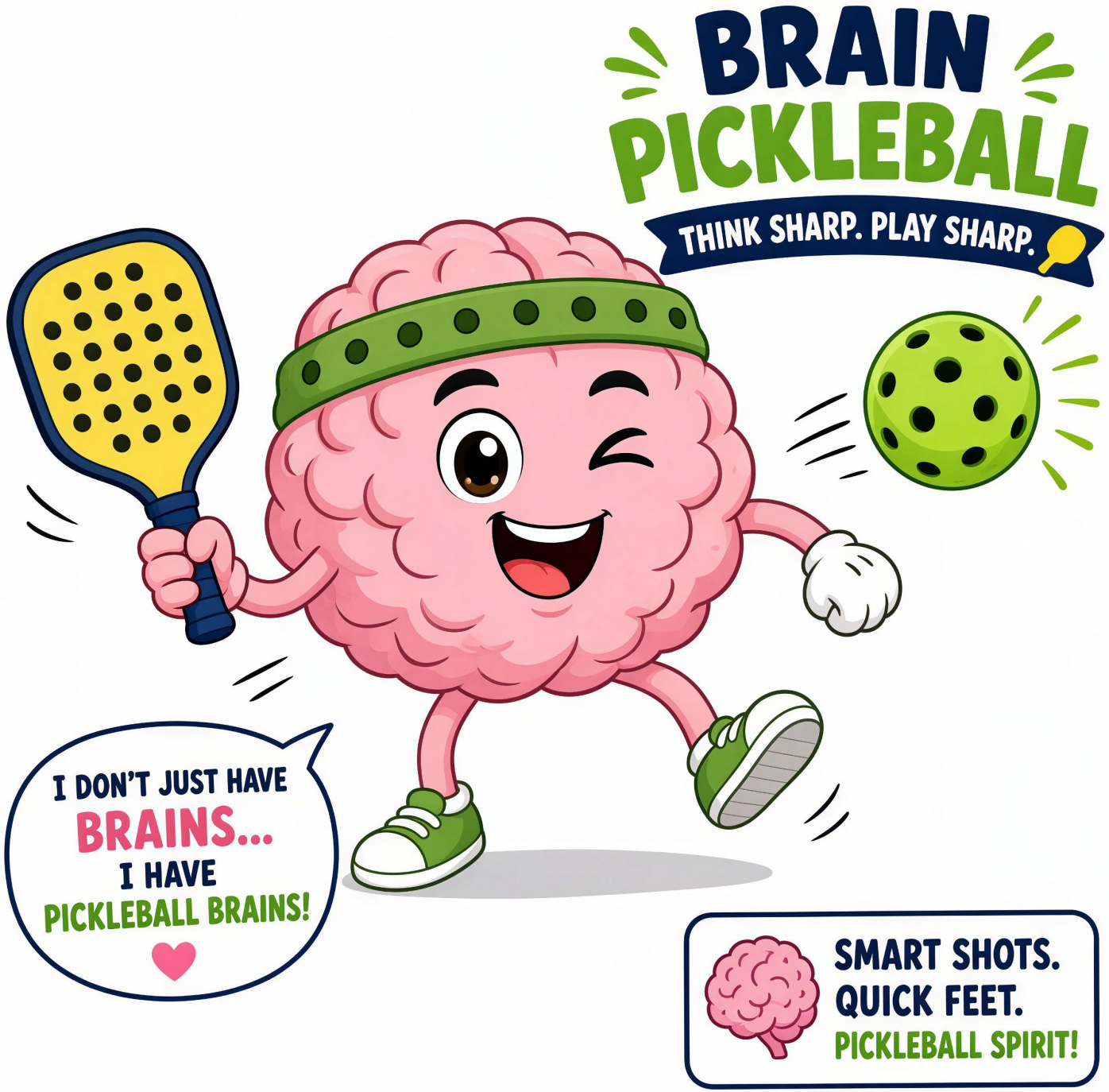
Safety and Progression Rules



- Change one variable at a time
- Variables: surface, target speed, decision load, space, opponents
- Hard stops: near-falls, lingering dizziness, next-day joint pain
- Train the fall mechanisms: lunge and backpedal
- Strength and balance training stay in the plan
- Eye protection and heat precautions every time

Outcomes, Adherence, and the Prescription Template

Setting	Starting framework (clinical suggestion, not trial-derived)
Office	Weekly visits for 4-6 weeks (consistent with CPG visit frequency for chronic unilateral hypofunction); screening re-tests at week 4
Home	Gaze stabilization per CPG if hypofunction is present; plus short wall or partner foam-ball drills 3-4 days/week; log sessions
Community	Doubles only, time-capped, known partner, eye protection; progress after reassessment
Reassess	Dual-task TUG, Four Square Step, symptom or DHI score, adherence log; upgrade environment only if stable



Serve Up Brain Gains: The Recap

- Vestibular function: every head turn to a wide ball is a gaze-stability rep
- Balance: split-step, lunge, recover, and back up: reactive stepping at game speed
- Cognitive resilience: keep score, track the ball, choose the shot, stay social
- Brain gains: aerobic work plus challenge, in a game people keep playing
- Your move: screen → pick the lane → change one thing at a time → protect eyes and wrists