PART II

The Physics Engine of Inversion

Force, leverage, pressure and balance.

$$\tau = F \times d$$

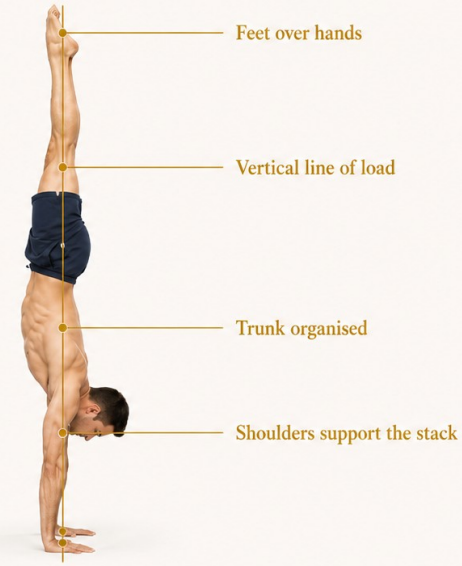
$$\sum M = 0$$



Chapter 9

Gravity, line of load and the inverted body

FIGURE 9 | Line of Load in the Handstand



In an organised handstand, the line of load passes from the floor through the hands and upward through the stacked body.

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

Gravity supplies the external demand; the athlete supplies organisation against that demand. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

The practical coaching question is: where is the line of load, and what must the athlete do to keep that line controllable? A technically attractive position can still be a poor decision if it creates excessive wrist moment, shoulder collapse, lumbar extension, fear or rapid fatigue.

The professional standard is to move from observation to mechanism. Instead of saying "the line is bad", the coach identifies whether the error came from hand pressure, wrist angle, shoulder elevation, rib-pelvis control, kick-up velocity, surface friction or insufficient recovery between attempts.

Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Load line	The bodyweight vector acts downward through the body centre of mass.	Teach the athlete to feel the line over the middle of the hand, not to chase a rigid picture.
Stack	Better stacking reduces unnecessary joint moments.	Correct the shoulder-rib-pelvis relationship before adding time.
Sway	Small deviations create corrective torque demands.	Coach early corrections rather than late saves.

KEY IDEA

The handstand begins when gravity becomes a line to organise, not a force to fear.

EVIDENCE NOTE

Direct handstand literature repeatedly uses centre of mass, centre of pressure, joint moments and balance control variables to describe the skill rather than only visual aesthetics.

CREDIBILITY & CAUTION

Do not call an arched handstand weak automatically. It may be a mobility compensation, a style choice, a fatigue response, or a balance strategy.

FIELD CHECK

Film from the side. Draw a vertical line through the mid-hand. Note where the shoulder, ribs, pelvis and feet fall relative to that line.

Chapter 10

Centre of mass and base of support in a handstand

FIGURE 10 | Centre of Mass over Base of Support



A handstand is balanced when the body's centre of mass is controlled over the base of support created by the hands.

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

The centre of mass must remain controllable over the hand-created base of support. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
COM too far forward	Athlete tips over toward the fingers.	Use fingertip pressure drills and reduce kick-up speed.
COM too far back	Athlete falls toward the wall/heels of the hand.	Use heel-pull drills and shoulder-opening cues.
Base too narrow	Rotational errors increase.	Use consistent hand width and stable finger spread.

KEY IDEA

Balance is the relationship between the body centre of mass and the hand base, not merely how long the athlete survives upside down.

EVIDENCE NOTE

Wyatt et al. investigated dynamic interactions between CoP and CoM during handstand balance, supporting a control-based reading of the skill.

CREDIBILITY & CAUTION

A large base does not fix poor control. Wider hands may increase confidence but can also change shoulder angle and line mechanics.

FIELD CHECK

Mark the hand outline with tape. Repeat 5 kick-ups. If the hand base changes every attempt, do not judge balance consistency yet.

Chapter 11

Centre of pressure: the hand as a balance platform

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

The handstand is steered by pressure, especially through the fingers and palm heel. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Finger-side CoP	Used to prevent overbalance.	Teach sustained fingertip pressure, not clawing panic.
Palm-heel CoP	Appears when the athlete underbalances.	Cue a gentle shoulder shift forward or reduce heel pressure.
Side-to-side CoP	Indicates rotational or single-hand asymmetry.	Check hand angle, elbow lockout and shoulder height.

KEY IDEA

The hand is a pressure map; balance improves when the athlete learns to steer that map.

EVIDENCE NOTE

Blenkinsop, Pain and Hiley compared standing and handstand balance and described a wrist-based strategy for handstand control, analogous in role to ankle strategy in standing.

CREDIBILITY & CAUTION

Fingers are steering tools, not brakes for violent saves. Excess gripping can increase forearm fatigue and worsen later attempts.

FIELD CHECK

Ask the athlete to lift the heels from a wall line using only finger pressure. If the movement is jerky, reduce hold time and train pressure sensitivity.

Chapter 12

Force transmission from floor to wrist to shoulder

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

Ground reaction force enters through the hands and must be transmitted through the wrists, elbows, shoulders and trunk. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Hand contact	Receives vertical GRF and pressure shifts.	Use full-hand contact and consistent finger spread.
Wrist	Accepts extension and moment demand.	Progress wrist loading gradually.
Shoulder	Acts as the main vertical support platform.	Push tall; avoid sinking into passive end range.
Trunk	Prevents energy leak from ribs and pelvis.	Use hollow-line control without breath locking.

KEY IDEA

Every handstand rep is a force-transmission event from the floor into the body.

EVIDENCE NOTE

Force-plate handstand and press-to-handstand studies provide a basis for interpreting vertical load, CoP movement, joint moments and timing.

CREDIBILITY & CAUTION

If the shoulder collapses, do not keep adding wrist drills. The load chain must be read joint by joint.

FIELD CHECK

Watch a wall hold for three collapse points: heel of palm overload, elbow softness and shoulder sinking. Fix the first visible leak.

Chapter 13

Moment arms at the wrist, elbow, shoulder and spine

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

A moment arm is the distance between the line of force and the joint axis; in handstands small distances matter. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Wrist moment	Affected by CoP position relative to wrist axis.	Teach pressure shifts and manage extension range.
Shoulder moment	Affected by shoulder angle and COM line.	Improve overhead stack and scapular elevation.
Spinal moment	Affected by rib flare, pelvis and leg line.	Coach rib-pelvis control and avoid uncontrolled banana shape.

KEY IDEA

A handstand fault becomes important when it increases the moment demand beyond the athlete's control or tolerance.

EVIDENCE NOTE

Prassas developed a biomechanical model of press handstand torque requirements, and later studies such as Mizutori et al. extended joint-moment analysis in skilled gymnasts.

CREDIBILITY & CAUTION

Moment-arm language is useful only when it changes a decision; do not overwhelm beginners with equations during early confidence practice.

FIELD CHECK

When a joint hurts, identify whether the load line has shifted farther from that joint before blaming weakness alone.

Chapter 14

Why the wrist behaves like an inverted ankle

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

During handstand balance, the wrist and fingers often perform the correction role that the ankle and toes perform in standing. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Standing	Foot and ankle regulate sway over a broad base.	Understand the analogy.
Handstand	Fingers and wrist regulate sway over a smaller hand base.	Train pressure precision.
Walking handstand	Hands repeatedly replace the base under a moving COM.	Train weight shifts before distance.

KEY IDEA

The wrist is the inverted ankle of the handstand, but it has less familiar tolerance and a smaller correction window.

EVIDENCE NOTE

Balance-control studies comparing standing and handstand support the concept of different joint strategies depending on orientation and support base.

CREDIBILITY & CAUTION

The analogy should not be overextended: the wrist has different anatomy, tissue tolerance and injury patterns than the ankle.

FIELD CHECK

Use a 0-10 pressure scale: 0 = no finger pressure, 10 = maximal gripping. Most control drills should live around 3-6, not 10.

Chapter 15

Shoulder elevation as a vertical support strategy

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

The shoulder complex is the main pillar between the floor and the body column. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Passive sink	Shoulders move toward ears without active support.	Teach active elevation and protraction.
Over-shrug with rib flare	Athlete gains height but loses trunk line.	Pair push tall with rib control.
Stable pillar	Scapulae upwardly rotate/protract and the trunk stays organised.	Progress hold time or balance challenge.

KEY IDEA

Push tall is not a slogan; it is the active organisation of the shoulder platform under bodyweight.

EVIDENCE NOTE

Handstand EMG and gymnastics apparatus studies indicate that muscle activity changes with support conditions and apparatus, reinforcing the need to train support specifically.

CREDIBILITY & CAUTION

More elevation is not always better if it is bought by spinal extension, breath holding or neck tension.

FIELD CHECK

During a wall hold, ask for a small “floor away” push without changing rib position. If ribs flare, the shoulder cue is leaking into the spine.

Chapter 16

Rib cage, pelvis and the line-control column

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

The trunk converts two hands and two legs into one controllable column. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Rib flare	Moves mass and encourages lumbar extension.	Use exhale-to-stack drills.
Posterior tilt excess	Can flatten too much and reduce shoulder access.	Use neutral hollow, not maximal tuck.
Coordinated column	Ribs, pelvis and legs organise around the load line.	Progress to free balance drills.

KEY IDEA

The handstand line is won in the ribs and pelvis as much as in the hands.

EVIDENCE NOTE

Radiographic work in gymnasts has examined sagittal alignment during handstand, supporting the need to treat spinal-pelvic organisation as a measurable component rather than a vague aesthetic.

CREDIBILITY & CAUTION

Do not force a single trunk shape on all bodies. The useful shape is the one that matches the goal and is repeatable without symptoms.

FIELD CHECK

Have the athlete breathe quietly in a chest-to-wall hold. If they lose the line when breathing, their line is being held by stiffness rather than control.

Chapter 17

Hollow, straight and banana shapes explained mechanically

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

Shape changes the location of mass and the correction demand. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Hollow	Ribs controlled, pelvis organised, shoulder angle available.	Useful for many gymnastics and calisthenics lines.
Straight	Minimal visible curve with stacked segments.	Aesthetic target when mobility and control allow.
Banana	Lumbar extension and/or shoulder compensation.	May be a beginner compensation or a style; analyse before correcting.

KEY IDEA

Shape matters because it moves mass and changes the control problem.

EVIDENCE NOTE

The 2025 systematic review of handstand biomechanics summarises a literature that includes joint angles, CoP, torques, velocities and EMG, showing that shape should be interpreted mechanically.

CREDIBILITY & CAUTION

Straight line obsession can create over-cueing. Correct the error only if it reduces control, safety or performance transfer.

FIELD CHECK

Use three photos: best wall line, best free hold, fatigued hold. The difference between them reveals the athlete's real capacity.

Chapter 18

Torque leakage and why small shape errors become large balance errors

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

Torque leakage means force is produced but not transmitted into the desired line or correction. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Bent elbows	Load leaks into elbow angle and shoulder collapse.	Regress and teach lockout with comfort.
Rib flare	Mass shifts and spine extends.	Use hollow-line preparation.
Soft shoulders	Vertical support shortens.	Train scapular elevation endurance.
Loose legs	Long levers become noisy.	Use toe point/leg squeeze only as much

		as needed.

KEY IDEA

Small errors matter when they lengthen moment arms, increase sway or make correction late.

EVIDENCE NOTE

Expertise-level handstand studies suggest that better performers organise coordination more effectively; this supports coaching toward quiet correction rather than heroic saving.

CREDIBILITY & CAUTION

Not every visible error deserves immediate correction. Pick the leak that changes safety or transfer first.

FIELD CHECK

Use the one-correction rule: in each set correct only the first leak that appears before balance is lost.

Chapter 19

Friction, surface, hand size and pressure distribution

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

The floor is part of the handstand system. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Low friction	Hands slide or fingers cannot steer.	Use a safer surface or reduce dynamic work.
High friction	Skin and wrist may be stressed during rotation.	Manage volume and hand care.
Small hand base	Less pressure surface.	Increase precision and avoid rushed walking volume.
Large hand base	More contact but not automatic	Maintain active pressure map.

	control.	

KEY IDEA

A handstand is never body-only; the surface changes the available mechanics.

EVIDENCE NOTE

Apparatus studies show that hand support conditions change muscle activity, supporting surface- and apparatus-specific interpretation of handstand loading.

CREDIBILITY & CAUTION

Chalk, mats, blocks and parallettes change the problem. Do not compare results across surfaces as if they were identical.

FIELD CHECK

Record surface, hand angle, hand width, wrist wraps, parallettes and chalk use in every serious assessment.

Chapter 20

Work, energy and fatigue in static holds

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

A static hold looks motionless but still consumes energy through constant correction and support. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Support fatigue	Shoulders sink, elbows bend.	Shorten holds; add support endurance.
Correction fatigue	Finger pressure becomes late/violent.	Use smaller sets with more rest.
Trunk fatigue	Ribs flare or pelvis drifts.	End the set before line collapse.

KEY IDEA

Static does not mean free; every second of a handstand has a metabolic and motor-control cost.

EVIDENCE NOTE

Fatigue is a known disruptor of movement control in sport and should be interpreted as a change in both tissue capacity and skill quality.

CREDIBILITY & CAUTION

Long holds that teach collapse are not endurance training; they are compensation rehearsal.

FIELD CHECK

Stop a technical hold at the first repeated line collapse, not at the first fall. Quality fatigue arrives before failure.

Chapter 21

Velocity and impulse in kick-up entry

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

The entry creates the initial balance problem. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Too much impulse	Athlete overshoots and saves with fingers or wall impact.	Reduce kick height; use wall target.
Too little impulse	Athlete cannot stack over hands.	Use progressive kick-up and leg-drive timing.
Inconsistent impulse	Every attempt starts with a different problem.	Standardise hand placement and kick rhythm.

KEY IDEA

A handstand hold begins before the feet leave the floor.

EVIDENCE NOTE

Press-to-handstand and handstand kinematic studies reinforce that timing, joint position and velocity profiles are central to skilled inversion.

CREDIBILITY & CAUTION

Beginners often need less courage and more repeatable entry mechanics.

FIELD CHECK

Count clean entries, not only hold time. A session with 20 calm entries may be more valuable than one lucky 20-second save.

Chapter 22

Walking as repeated controlled loss of balance

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

Handstand walking converts static balance into locomotor balance. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Forward lean	COM moves ahead of the base.	Teach controlled lean, not falling panic.
Hand step	New hand contact replaces the base.	Use shoulder taps and small step drills.
Rhythm	Corrections become cyclical.	Train short lanes before speed.
Fatigue	Step size and shoulder support degrade.	Cap distance by quality.

KEY IDEA

Handstand walking is controlled falling plus base replacement.

EVIDENCE NOTE

Although direct handstand-walk research is limited, the mechanics are consistent with dynamic balance principles and handstand CoM-CoP control evidence.

CREDIBILITY & CAUTION

Do not progress to walking simply because the athlete can hold on the wall. Walking adds single-arm support, fatigue and forward momentum.

FIELD CHECK

Before distance goals, test 10 alternating shoulder taps with quiet rib-pelvis control and no wrist pain.

Chapter 23

Worked calculation I: bodyweight load through the hands

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

Simple calculations make coaching decisions clearer when their limits are stated. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Bodyweight force	mass x 9.81 m/s^2.	80 kg = about 785 N.
Two-hand quiet hold	Each hand may average about half total vertical load.	About 392 N per hand in a symmetrical hold.
Asymmetry	A 55/45 split changes loading meaningfully.	Right 432 N, left 353 N in this example.
Dynamic entry	Acceleration can increase transient forces.	Treat kick-ups and walks as higher demand than quiet holds.

KEY IDEA

A quiet handstand can load each hand with hundreds of newtons before dynamic correction is added.

EVIDENCE NOTE

Force-platform studies in gymnastics make it appropriate to discuss vertical GRF and load distribution, while recognising that simplified field calculations are not full inverse dynamics.

CREDIBILITY & CAUTION

These calculations are estimates for education. They do not measure tendon, cartilage, ligament or nerve stress.

FIELD TOOL

Calculation: Bodyweight force = body mass x 9.81. Estimated per-hand force = bodyweight force / 2, adjusted for visible asymmetry.

Chapter 24

Worked calculation II: wrist moment and centre-of-pressure shift

BEGINNER	COACH	CLINICIAN	ATHLETE	RESEARCHER

A small CoP shift can change the wrist moment even when bodyweight is unchanged. In the MMSx model, a handstand is read first as a physics problem and only second as a shape. The athlete is not simply upside down; the body is a tall inverted column that must keep gravity, pressure and joint torque organised over a small hand base.

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Mechanical decision table

Variable	Mechanical meaning	Coaching decision
Force	Per-hand vertical force in the example = 392 N.	Estimate from bodyweight and symmetry.
Moment arm	CoP 4 cm in front of wrist axis = 0.04 m.	Measure or estimate from video/pressure mat.
Moment	392 x 0.04 = 15.7 N m.	A simplified external moment demand.
Coaching use	Reduce excessive CoP excursion or	Use pressure drills and volume

	build tolerance gradually.	control.

KEY IDEA

In handstand mechanics, distance matters as much as load.

EVIDENCE NOTE

CoP-based handstand research supports the coaching value of pressure-position thinking, especially for wrist strategy and balance correction.

CREDIBILITY & CAUTION

The model ignores three-dimensional joint axes, shear, tissue properties and acceleration; use it as a coaching lens, not a diagnostic device.

FIELD TOOL

Track three variables together: wrist symptoms, hold duration and visible CoP strategy. Pain with increasing finger-side pressure suggests dose or tolerance review.

PART II FIELD AUDIT SHEET

Use this before progressing to Part III anatomy and muscle analysis

Physics audit

Item	Pass standard	Action if not passed
Hand base repeatability	Same hand width/angle in 4 of 5 attempts	Standardise base and reduce entry speed
COM line	Shoulder/ribs/pelvis remain controllable over mid-hand	Use wall-facing line drill and heel-pulls
Pressure strategy	Athlete can shift between finger and palm pressure calmly	Use low-volume CoP drills
Wrist moment tolerance	No increasing wrist symptoms during or 24 hours after load	Reduce volume or wrist extension demand
Kick-up impulse	Entry is repeatable without wall crash or panic save	Train low kicks and marked target
Walking readiness	Shoulder taps are quiet and pain-free	Delay walking volume

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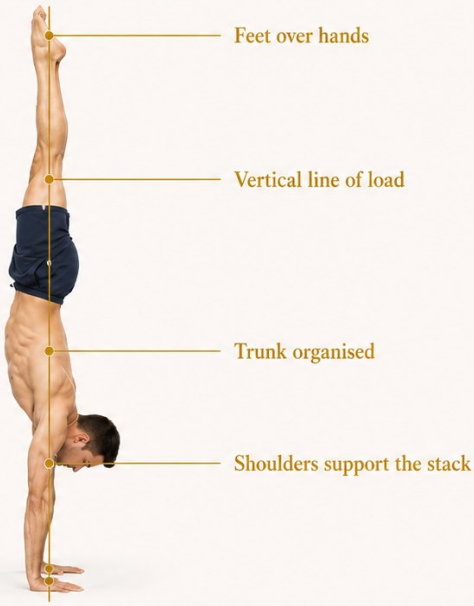
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HS-FIG-009 | Line Of Load In The Handstand

FIGURE 9 | Line of Load in the Handstand



In an organised handstand, the line of load passes from the floor through the hands and upward through the stacked body.

HS-FIG-010 | Centre Of Mass Over Base Of Support

FIGURE 10 | Centre of Mass over Base of Support



A handstand is balanced when the body's centre of mass is controlled over the base of support created by the hands.

HS-FIG-011 | Centre Of Pressure And Finger Pressure Control

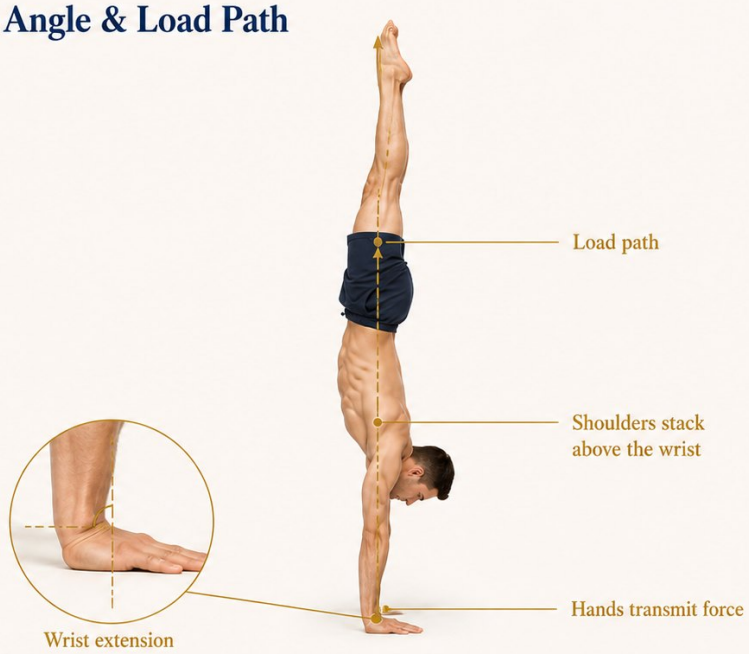
FIGURE 11 | Centre of Pressure & Finger-Pressure Control



In a handstand, balance is steered by subtle shifts in pressure through the fingers and palm while the whole body remains stacked over the hands.

HS-FIG-012 | Wrist Angle And Load Path

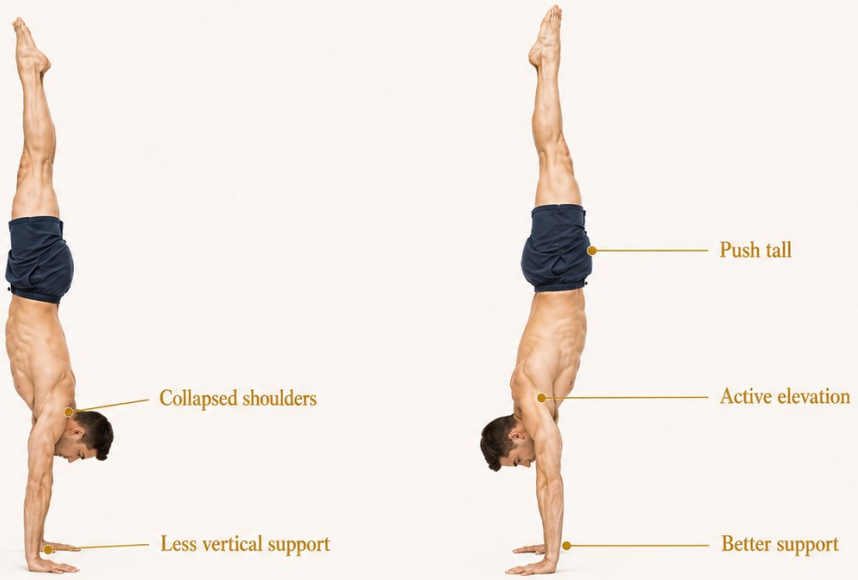
FIGURE 12 | Wrist Angle & Load Path



The handstand places the wrist in substantial extension, and the load path travels from the floor through the hands into the stacked upper limb and trunk.

HS-FIG-013 | Shoulder Elevation As Vertical Support

FIGURE 13 | Shoulder Elevation as Vertical Support



Vertical support improves when the athlete actively elevates through the shoulders rather than sinking into a collapsed overhead position.

HS-FIG-014 | Hollow Line Versus Rib Flare

FIGURE 14 | Hollow Line versus Rib Flare



Good trunk organisation keeps the ribs controlled and the line efficient; rib flare leaks extension and makes the handstand harder to control.

HS-FIG-015 | Kick Up Entry Mechanics

FIGURE 15 | Kick-Up Entry Mechanics



A good kick-up is a controlled transition from the floor to overhead balance rather than a rushed jump into inversion.

HS-FIG-016 | Walking As Controlled Forward Fall

FIGURE 16 | Walking as Controlled Forward Fall



Handstand walking begins by leaning the body forward in a controlled way and placing the first hand step to prevent a fall.

HS-FIG-017 | Handstand Moment Arms At Wrist Shoulder And Trunk

FIGURE 17 | Handstand Moment Arms at Wrist, Shoulder & Trunk



Small changes in alignment alter the moment arms at the wrist, shoulder and trunk and therefore change the torque demand of the handstand.

HS-FIG-018 | Pressure Shift For Front Fall And Back Fall Correction

FIGURE 18 | Pressure Shift for Front-Fall & Back-Fall Correction



Different pressure shifts are used to correct front-fall and back-fall tendencies during a handstand.