A Primer on the Handstand: Basic Technique and Common Issues

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ABSTRACT

Background: The handstand is a skill that has become common to a variety of competitive, performance, and recreational activities. As the quality and safety of handstand instruction and practice varies considerably, improper technique or progression can increase the risk of injury. **Purpose:** The purpose of this work is to provide a brief overview of the handstand, and to highlight common postural and functional issues that arise when learning the handstand. **Methods:** This commentary first introduces basic handstand biomechanics, followed by a description of proper and effective use of different regions of the body. Range of motion, strength, and knowledge deficits are then highlighted in correspondence to the potential resulting compromised handstand posture. **Clinical Relevance:** An improved understanding of proper and improper handstand technique, as well as knowledge of common deficiencies, can assist clinicians in understanding areas of the body that may be loaded excessively, identifying root causes, and treating handstand-related injuries.

Key Words: circus, gymnastics, inverted stance, overhead shoulder

INTRODUCTION

The handstand is a skill that is most well-associated with gymnastics where it is momentarily held or is a position within a dynamic skill. Handstands have also increasingly become practiced by many for recreation, enjoyment, and fitness, whether it be for circus, yoga, CrossFit, or calisthenics. From a technical perspective, there are notable differences in the purpose, look, and function of the handstand in these activities, though the stereotypical handstand is one where the arm-supported and inverted posture is held quasi-statically with a straight and roughly vertical body. This version of the handstand, similar to that performed in gymnastics and handbalancing in circus, will be the focus of this article.

The process of learning a handstand requires a progressive approach to developing sufficient strength, flexibility, sensory integration, coordination, and confidence, among other capacities. Individuals often come to learning a handstand with deficiencies in one or more of these categories, and the appropriate prescription of drills is necessary for progression. Performing drills that are beyond an appropriate working level, or attempting a freestanding handstand without a sufficient foundation, will often result in moderate or severe breakdown in technique. Inappropriate drill prescription and progression is often a result of deficient understanding of fundamental handbalancing concepts, physical training, cueing and language, etc. In such cases, there are aesthetic and functional consequences, such as increased stresses placed on various parts of the body as well as an increased risk of injury.

This article aims to first provide a very brief introduction to handstand technique, and second to communicate how common issues and deficiencies affect handstand quality, posture, and the potential for injury. The focus will be on identifying functional deficiencies or limitations based on the performance or posture of the handstand. Details of the handstand can be discussed at length, though this article will focus primarily on upper body, upper limb, and gross functional issues from an admittedly high-level perspective to provide foundational knowledge to individuals that may see and treat handstand-related injuries.

THE HANDSTAND: AN OVERVIEW

Basic Biomechanics

A fundamental understanding of biomechanics and quiet stance is essential to understanding the handstand and the compensations that may result from physical or knowledge deficits. The goal of a basic 2-arm handstand can be seen as maintaining quiet balance while in a near-straight and near-vertical, arm-supported posture. A biomechanical requirement that must be fulfilled at all times for balanced stance is that the vertical projection of the center of mass (COM) of the body lies within the base of support,[1] that being the hands when in a handstand. The idealized single inverted pendulum model is useful to understand details of balance.[2] Inverted quiet stance can be characterized primarily by an anterior-posterior sway (where anterior is the direction the fingers point in the handstand).[3,4] The average COM lies just anterior to the axis of rotation, often resulting in a slight forward tilt of the body. Controlling balance is primarily done by generating a torque about the axis of rotation, that being the wrists in the handstand.

Fundamental and necessary characteristics of balancing a handstand include structure throughout the body and controlling balance. Structure can be defined as having a strong and rather rigid connection between the wrists and the toes (the most superior point of the handstand) that can remain stable even in the presence of small disturbances throughout the body. Such structure effectively reduces the body to a single degree-of-freedom inverted pendulum, and in doing so, isolates and simplifies control to torque about the wrists. Sufficient structure is often achieved through alignment with near 180° shoulder flexion, scapulothoracic stability primarily through scapular elevation, and mid-section and lower limb engagement while maintaining a straight spine.

The control of balance in a handstand can be viewed as a spectrum with gross control on one end and calm control on the other.[5,6] Gross control can be defined as mostly involuntary and large movements at the shoulders, elbows, spine, hips, and knees that occur in a rather delayed and anxious manner where there is little confidence that such actions will maintain balance. Calm control can be defined as the use of isolated torque about the wrists that produce strong, confident, and almost proactive adjustments to finely manipulate the body as a whole. Learning to balance a freestanding handstand comes with improving balance proficiency by moving from the body's default approach of gross control to one of calm control.

While the relationship between structure through the body and balance control is somewhat evident, it should be acknowledged these qualities have a bit of a symbiotic relationship. If sufficient structure cannot be found throughout the body, balance control will likely revert to gross control, especially in novice individuals. Only with finding sufficient structure through the body is calm control possible, though strong and confident

calm control through the hands and fingers will also encourage one to maintain a solid and unified structure through the body.

Set-up and Positioning

While the legs and hips are made for weight-bearing support, the arms and shoulders must be used in a manner for which they are not designed. The shoulder, often described as a joint with considerable range of motion that lacks stability,[7] must be able to bear half of one's bodyweight while creating sufficient stability at the scapulothoracic and glenohumeral joints. Scapulothoracic strength and stability is often a primary deficiency and a weak link for many learning a handstand, and this negatively impacts overall body structure and balance control. The general position of the scapula should be elevated with accompanying protraction, along with the natural upward rotation that comes with humeral elevation.[8] The intention is to create a stable foundation at the shoulders that in turn creates the necessary strong connection between the hands and fingers and the rest of the body, thus enabling calm control. Most novice individuals must attempt to elevate their scapulae near maximally, as this use and level of activation is not common to activities of daily living. More experienced or stronger individuals can find sufficient scapular elevation and stability with sub-maximal effort. The shoulders should be at or near 180° of flexion; using 180° of flexion will result in a slightly forward-tilted handstand (**Figure 1A**), while flexion just shy of 180°, accompanied by slight thoracic flexion and 'hollowing' of the chest, can align the body vertically with slightly forward-tilting arms (**Figure 1B**). This second position may be considered more technically correct in some schools of thought, though either variant will allow for achieving a high ability level.

The hands should be placed approximately shoulder-width apart with the index or middle finger pointed forward and the fingers spread comfortably, but not excessively, wide. Various finger postures can be used, though common postures include flat fingers, engaged fingers with slightly flexed proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints, and tented fingers that use metacarpophalangeal (MCP) extension, PIP flexion, and DIP extension. The selection of finger posture is often based on comfort, though it is critical that the fingers can contribute functionally to balancing. More specifically, the hands and fingers must become a rigid unit that produce downward-directed force to generate wrist flexion torque to counter the torque generated by the body's COM that lies slightly forward of the wrist axis of rotation. The location of the applied downward force in the hands or fingers to generate this wrist torque can vary, though focusing the force application through the fingertips results in the longest lever arm (and functional base of support) between the axis of rotation and the point of force application.

The position of the balance point, or the anterior-posterior location of the average center of pressure (COP), under the hands and fingers often depends on the ability of the individual. The magnitude of the COM anterior-posterior displacement is bounded anteriorly by the force the hands and fingers can apply into the ground to counter forward-leaning tilt and posteriorly by the axis of rotation at the wrists. Additional anterior or posterior displacement of the COM beyond these bounds requires quick and gross movements of the body and limbs to salvage balance and remain inverted. Less skilled individuals may have a COP that is more forward on the palm due to feeling increased control through substantial hand and finger use, which can offer a fair margin of error both in body control and balance control in spite of its inefficiency in energy expenditure. More advanced individuals will have better body control and greater precision in managing sway, and the balance point can lie further rearward on the palm closer to the axis of rotation.

The head position should be such that the neck is in slight extension to glance at a focal point on the ground centered between the hands when elevating the eyes (ie, peering upwards). The position of the focal point can generally lie somewhere between the fingertips and even a few inches behind the palms. Exceptions can be made in some cases, but this is appropriate guidance for most novices. Using a fixed focal point on the ground located beneath the head very clearly allows one to use a visual reference to understand how the body is moving when inverted due to the sway in a handstand being roughly parallel to the ground.[9,10] The use of a neutral head position with a distant focal point provides different and less rich visual information to assist with balance, in addition to accompanying vestibular disruptions that occur with a more inverted head position.[11] More advanced individuals should become proficient at balancing a handstand when their head is in any orientation and with the eyes closed, thus negating the necessity of visual information.

As the primary focus of this article is the shoulders and arms, brief attention will be given to the remainder of the body. Sufficient shoulder flexion aids considerably in alignment of the midsection and legs. Finding sufficient structure through the midsection and legs in the novice individual can often be achieved through focusing on a posterior pelvic tilt and using moderate leg adduction, full knee extension, plantarflexed ankles, and pointed toes. The structure found in the mid- and lower-body through these cues then aids in creating whole-body structure. Additional and refined cues are often used as one progresses with improved control and ability.

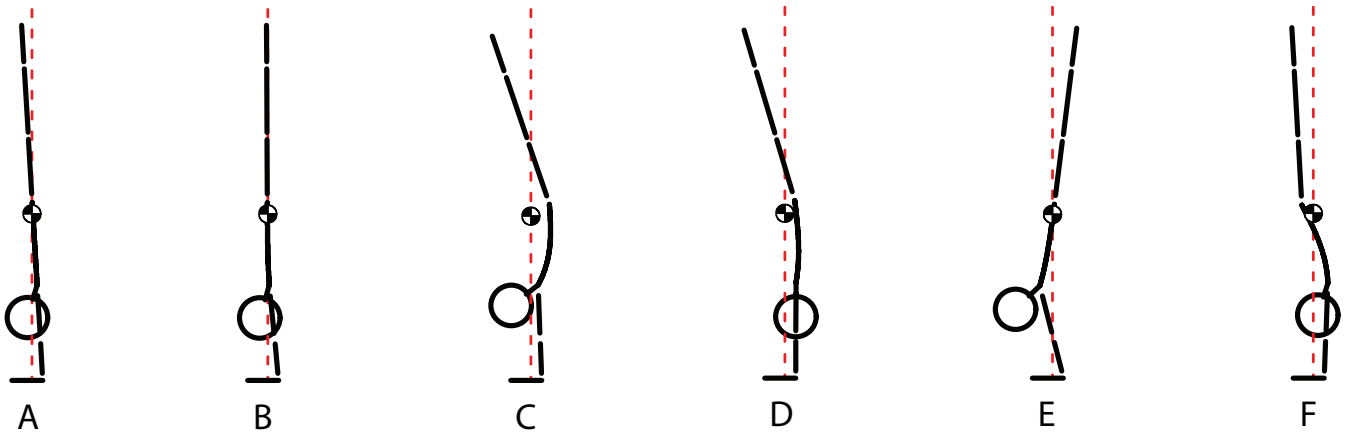
COMMON ISSUES

The position that one places themselves in the handstand and the quality of their balance can be used to identify deficiencies, where these limitations could be related to flexibility, strength, or an understanding of technique and process. Such deficiencies will often be functionally detrimental in some capacity, perhaps completely limiting the attainment of more advanced skills, and in some cases, deficiencies can increase musculoskeletal demands and the risk of injury. Deficiencies described herein include those that are commonly seen in individuals learning a handstand based on their posture and function when attempting to perform a wall-supported, spotted, or freestanding handstand. Additional diagnostic assessment may be necessary to be certain of the actual deficiency and improper postures may simply be suggestive of underlying issues. Multiple deficiencies may occur simultaneously and all must be overcome to enable an efficient handstand. As well, when training a handstand, individuals will inevitably suffer from technical breakdown and use their bodies in ways that require capacities in excess of that which is minimally necessary to execute an ideal handstand. Individuals should therefore have appropriate excess functional capacity in flexibility and strength to reduce the risk of injury during learning. Admittedly, the terms deficiency or insufficient are not defined by quantitative measures, though this section attempts to convey root causes and their associated effects on the handstand in a qualitative manner.

Limited Shoulder Flexion or Thoracic Extension

Limited active shoulder flexion range of motion or limited thoracic extension, or both, can have significant and detrimental consequences to handstand alignment and

Figure 1. Common variants of the handstand, both technically correct (A-B) and incorrect (C-F). Center of mass is shown at approximately the center of the body, the vertical projection of which, the balance point, intersects the mid-palm.



A, Straight, yet tilted handstand that utilizes 180° of shoulder flexion and a straight body from wrists to toes. B, Vertically-aligned handstand that utilizes slightly less than 180° of shoulder flexion and slight thoracic flexion or hollowing. C and D, Handstand postures typically resulting from either limited strength in shoulder flexion or scapular elevation (or both), or from limited range of motion in shoulder flexion or thoracic extension (or both). These limitations result in spine extension and the legs placed over the head to remain on balance, though the posture in D uses a neutral or flexed neck to force the shoulders open. E, Handstand posture common to individuals that have high levels of strength where a forward lean of the shoulders exploits shoulder flexion strength. F, Handstand posture often resulting from limited strength in shoulder flexion or scapular elevation (or both) where the shoulders relax slightly into near end-range of shoulder flexion and hip flexion allows remaining on balance.

function. An inability to align the arms with the torso when inverted will often result in compensations where scapular elevation and stability is deficient, the chest flares out, and there is spinal extension that directs the legs over the head (**Figure 1C**). The neck is often, but not always, placed in extension where the individual is likely attempting to use neck extension to assist with shoulder flexion and scapular elevation. While the COM can still be appropriately placed within the base of support and balance is technically possible, the effort required to hold this position increases significantly through the shoulders and anterior chain compared to someone that is uninhibited by shoulder flexion or thoracic extension limitations. The shoulders may lie forward of the balance point as well, in which case the wrists may be placed into greater extension than that necessary with proper alignment. If one also has limited wrist extension beyond what is necessary to hold a proper handstand, the wrists, hands, and fingers could be at risk of increased loading and injury. Alternatively, individuals may use a neutral or flexed neck to attempt to force the shoulders into sufficient flexion to utilize passive stability that comes with near end-range of motion (**Figure 1D**), which often also results in spine extension and the legs falling over the head. Though there is likely some active use of the anterior chain, the lumbar spine is placed into greater extension than desired, especially while the body is under significant stress due to the challenging nature of the skill and the lack of excess capacity in flexibility. Working handstand-related drills with this lumbar extension is not recommended and the limited shoulder or thoracic flexibility should be a primary focus. Finally, individuals that have a high strength-to-bodyweight ratio can more easily find sufficient scapular stability, though active shoulder flexion may be limited, thus placing the shoulders forward of the balance point (**Figure 1E**). While this may be stable, this is not an efficient handstand.

Limited Strength in Shoulder Flexion and Scapular Elevation

A strength deficiency in either shoulder flexion or scapular elevation, or both, can result in poor body alignment as well as functional issues with structure and balance. From the perspective of body alignment, two resulting body positions are fairly common. The first is characterized by unelevated scapulae and insufficient range of motion in shoulder flexion, where this shoulder flexion deficiency may or may not be due to lack of flexibility (**Figure 1C**). This posture often results in extension through most of the spine that directs the legs over the head, very similar to that previously described. These deficiencies will often result in gross balance control, if one can remain inverted, with larger joint movements at the shoulders and hips, rather than isolated control at the wrists. Differentiating limited strength from limited flexibility in shoulder flexion or scapular elevation can be done by assessing shoulder range of motion in unloaded situations and shoulder use and thoracic posture in less intense inverted variations.

The second body position resulting from deficient shoulder flexion and scapular strength is characterized by excessively open shoulders (at or slightly beyond 180° of shoulder flexion) that partially exploit passive stability that comes when nearing end-range of motion (**Figure 1F**). The shoulders are often rearwards (away from the fingers) relative to the balance point, the back resides in extension, and hip flexion is used to keep the COM from traveling too far forward. This particular position, while fairly efficient and not muscularly taxing, limits how far one can progress because shoulder and scapular stability and positioning does not come primarily from strength.

As mentioned, sufficient scapular elevation is something that nearly all individuals must work toward, and most individuals will be working near maximal levels of effort for some time. Individuals with strength limitations will be tempted to rely on passive stability by either sinking (unelevated scapulae, **Figure 1C**) or settling into the shoulders (**Figure 1F**) because a correct and elevated scapular position may feel less stable due to insufficient glenohumeral and scapulothoracic stability. While individuals may feel comfortable in these deficient positions, continuing to train in such positions may result in shoulders, elbow, wrist, or hand pain due to the reliance on passive stability from near end-range of motion at the shoulders and scapulae.

Limited Wrist Flexibility

Most individuals do have sufficient wrist extension to comfortably begin training a handstand, though performing a thorough wrist warm-up and stretch prior to training handstands, improving wrist strength, and maintaining wrist flexibility will aid in preventing wrist injuries. Some individuals do have limited wrist extension and this can negatively affect the handstand position and control due to the use of an excessive and potentially unstable range of motion at the shoulders and thoracic spine (**Figure 1D** and **1F**). These individuals will likely have a reduced range of sway in normal balance, which consequently reduces the margin for error when balancing and therefore requires greater precision in control at the hands and fingers. As well, the entire body must be well-controlled to avoid destabilizing voluntary or involuntary movements that could affect the magnitude of sway. The placement of the balance point may also be affected such that passive stiffness of the wrists—due to being placed near end-range of motion—may place the balance point rearward toward the base of the palms. While this more vertical alignment may be less intense at the hands and fingers for control, this also requires greater precision in balance and body control to avoid using underbalance corrections or having to step down.

If limited wrist extension occurs with limited shoulder flexion or thoracic extension, working drills that require full bodyweight support near a handstand position may be premature and will likely increase the risk of injury in multiple regions of the body. In such cases, work should be done to increase the usable range of motion to have some functional excess capacity to safely work handstand-related exercises.

Excessively Forward Focal Point

A focal point that is excessively forward (ie, a few inches in front of the fingers or more) or looking at a focal point without using eye elevation can result in unnecessary neck extension and limited shoulder flexion (**Figure 1C** and **Figure 1E**). Limited shoulder flexion has downstream effects as described above. Improving the handstand posture of an individual that has used this technique for some time may not simply be accomplished by changing the focal point, as shoulder flexion and scapular elevation strength may not be sufficiently developed.

Ineffective Hand and Finger Use

A common issue at the hands and fingers is improper or ineffective use to control balance. As mentioned, proper and effective control by the hands can be accomplished by producing a downward-directed force through the fingertips to generate a flexion torque about the wrists. Individuals that lack finger flexion (primarily at the MCP joints) and wrist flexion strength in this manner, or that lack structure through the body, will often attempt to cup or grip the floor by pulling the fingertips back towards the palm. This approach may impose greater force production demands at the fingers due to the misdirected and diagonal force vector through the fingertips, and it generates minimal wrist torque and limits one's ability to control balance in a calm manner. Ineffective use of the fingers may also result in a balance point that is placed too far rearward near the base of the palms as the individual is reluctant to load the fingers properly using a more normal and forward balance point due to the lack of confident control at the hands and fingers. Such a rearward balance point may also limit shoulder flexion and scapular elevation, thus resembling a save strategy when falling into underbalance where the individual attempts to pull their weight forward onto balance. It is important to note that proper and effective use of the hands and fingers for balancing is something all individuals must develop as this posture-specific use of the hands and fingers is not common to any activity of daily life.

Inefficient Balance Point

A balance point that is too far forward will require increased wrist torque, and thus finger flexion and wrist flexion muscle force, to sustain balance. Such a forward balance point often results from insufficient shoulder flexion with either back extension and hip extension or a straight spine and straight hips. A forward balance point could also result from a relatively straight body (180° shoulder flexion, no hip flexion), but an excessive whole-body tilt, though this is less common due to the strength and skill necessary to maintain a straight body position. The necessary increased wrist torque could place extra stress on the fingers, hands, and wrists, and balance will likely not be sustained for long. A balance point that is too far rearward will often result in the same compensations as those described above for improper use of the hands and fingers. Finding an appropriate balance point involves understanding the tradeoff between allowing sufficient anterior whole-body tilt for a manageable margin of sway while also limiting anterior whole-body tilt to minimize excess stress and work in the hands and fingers.

Neutral or Flexed Neck

Individuals with limited shoulder flexion or thoracic extension may try to force these areas open by using a neutral or flexed neck (**Figure 1D**), thus placing their focal point at a distant object. While this may be effective for finding greater shoulder flexion and thoracic extension, these areas will rest in weak passive stability and will likely compromise stability and structure throughout the body.[11] Individuals without insufficient shoulder flexion or with thoracic limitations may also use this head position, and this is often a result of not understanding the value of a fixed reference point that is between the hands and directly beneath the head.

Posterior Chain Inflexibility

As the body is under considerable tension in the handstand due to the nature of the skill, posterior chain tightness can affect one's ability to find even a straight handstand position, let alone other, non-straight positions. Individuals that are tight through the low back and the legs will often have limited shoulder elevation and posterior pelvic tilt, which have downstream consequences and potentially limit handstand-specific exercises that can be performed safely. In such cases, improving lower body flexibility is critical to finding appropriate upper body alignment and structure.

SUMMARY

A critical first step in overcoming structural and functional deficits in the handstand is the identification of range of motion, strength, and knowledge limitations in individuals. The posture in which one places themselves when in a handstand can provide insight to identifying underlying deficiencies. While teaching the handstand and knowing how to address such limitations can be complicated and comes with experience, this article aims to provide an elementary introduction of how the handstand works from a structure-function perspective. The deficiencies and limitations discussed herein include those common to individuals learning a handstand, and while not an exhaustive list, this information can be used to understand how deficiencies in functional capacities negatively impact, and potentially risk, regions of the body.

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