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# The Importance of Assessing Muscle Health – Practical Tools for Clinicians

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**Human body composition is an emerging field of science that looks beyond body mass index to explore the different distributions of muscle and adipose tissue on health outcomes. Declines in skeletal muscle mass and function (e.g., *sarcopenia*) independently contribute to adverse health outcomes and often reflect poor muscle health. Therefore, it is imperative for clinicians to better understand the different methodologies to measure muscle mass, as well as muscle function. Familiarity with the array of existing and emerging clinical tools and measures is a critical step to help clinicians identify and address poor muscle health. This article briefly reviews practical and emerging body composition methodologies (bioelectrical impedance analysis, dual energy x-ray absorptiometry, ultrasound, computed tomography) and offers clinicians tools to measure, quantify, and address muscle health concerns in their patients.**

## INTRODUCTION

Skeletal muscle (SM), the primary component of lean soft tissue or lean mass (LM), serves as the major protein reserve in the human body. Although decreases in SM mass and function are part of the natural aging process, an ever-increasing body of research supports that decreases in muscle health (e.g., sarcopenia) independently contribute to adverse clinical outcomes. Addressing the presence of sarcopenia in acute and chronically ill patient populations is crucial as this condition negatively impacts individual health (e.g., self-care, treatment response, quality of life) and increases the financial burden on healthcare systems.[1] While excess adiposity is often a focal point of care for many clinicians, and body mass index (BMI) is the common clinical metric used to evaluate obesity, sarcopenia is highly prevalent across the BMI spectrum.[2] Therefore, it is imperative for clinicians to better understand the different methodologies to measure muscle mass and muscle function (referred to as muscle health). Familiarity with the available tools and measures can help clinicians to identify this highly prevalent, clinically significant condition.

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## Why Body Composition Matters

Human body composition analysis is an emerging field of science that looks beyond BMI to explore the different distributions of SM and adipose tissue on health outcomes. Compromises in muscle health are the hallmark feature of sarcopenia; a clinical condition characterized by low muscle strength and low muscle mass.[1] The more recent inclusion of muscle function into patient assessments is intended to facilitate better application and integration into clinical practice. Sarcopenia is occult, often difficult to detect on physical examination (PE) and may not automatically trigger nutritional interventions. Other physiological indications that coexist and may contribute to the onset of sarcopenia may include chronic illness, inflammation, poor oral intake, a sedentary lifestyle, and declining functional status. Weight loss is not considered a reliable indicator to identify or screen for sarcopenia[3] and currently, there is no consensus on how best to measure muscle health.

Clinicians are encouraged to use direct measures of muscle mass, as well as devices or tools to assess muscle function. It should be emphasized that further evaluation regarding the validity of assessment techniques for body composition applicable to a wide array of patient populations are recommended. This brief review intentionally focuses on the most common and emerging tools relevant to clinical practice. For a more in-depth appreciation on the development, use, strengths, and limitations of these and other body composition assessment tools, please refer to reference 4. Table 1 depicts several tools most applicable in the clinical setting.

## Measurement Techniques to Assess Body Composition

### Bioelectrical Impedance Analysis

Bioelectrical Impedance Analysis (BIA) uses low-intensity, electric conduction with single, multiple, or a spectrum (BIS) of frequencies to determine estimates of total body water (TBW). By using predictive equations, TBW is used to calculate estimated fat free mass (FFM) and fat mass (FM).[5] For clarity, FFM encompasses LM and bone, while FM refers to the actual lipid content in adipose tissue.[6] To use BIA or BIS, electrodes are placed on the hand, wrist, foot, and/or ankle and a low intensity electric current(s) is applied creating measures of reactance and impedance (Figure 1). Body tissues such as FM with low amounts of water and electrolytes will produce a high impedance, compared to LM which will have low impedance reflecting the high water and electrolyte content.[5]

Conventionally, BIA or BIS is a clinical favorite in multiple settings due to its low cost, portability, and noninvasive nature. However, BIA and BIS results are only considered valid and reliable when repeated measures are obtained over time and when steady state conditions have been met, especially those related to hydration and fluid status. For example, in patients with heart failure, a BIA measurement could produce falsely low estimates of body fat due to the increase in TBW. In contrast, an individual with decreased TBW such as dehydration, will produce falsely high measures of body fat as there is less conductivity measured. If clinicians or researchers decide to utilize BIA or BIS as a measurement tool, it is crucial to obtain baseline and follow up measures, and to consider the appropriate type of device, the intended target population for the device, and conditions of measurement (e.g., fasting requirements, fluid status, medications).[5] Handheld and scale-type devices are readily available over the counter and easily incorporated into clinical practice. However, because manufacturers do not share their FFM and FM predictive equations, the same device must be used for follow-up measures to support valid comparisons.

## Dual Energy X-Ray Absorptiometry

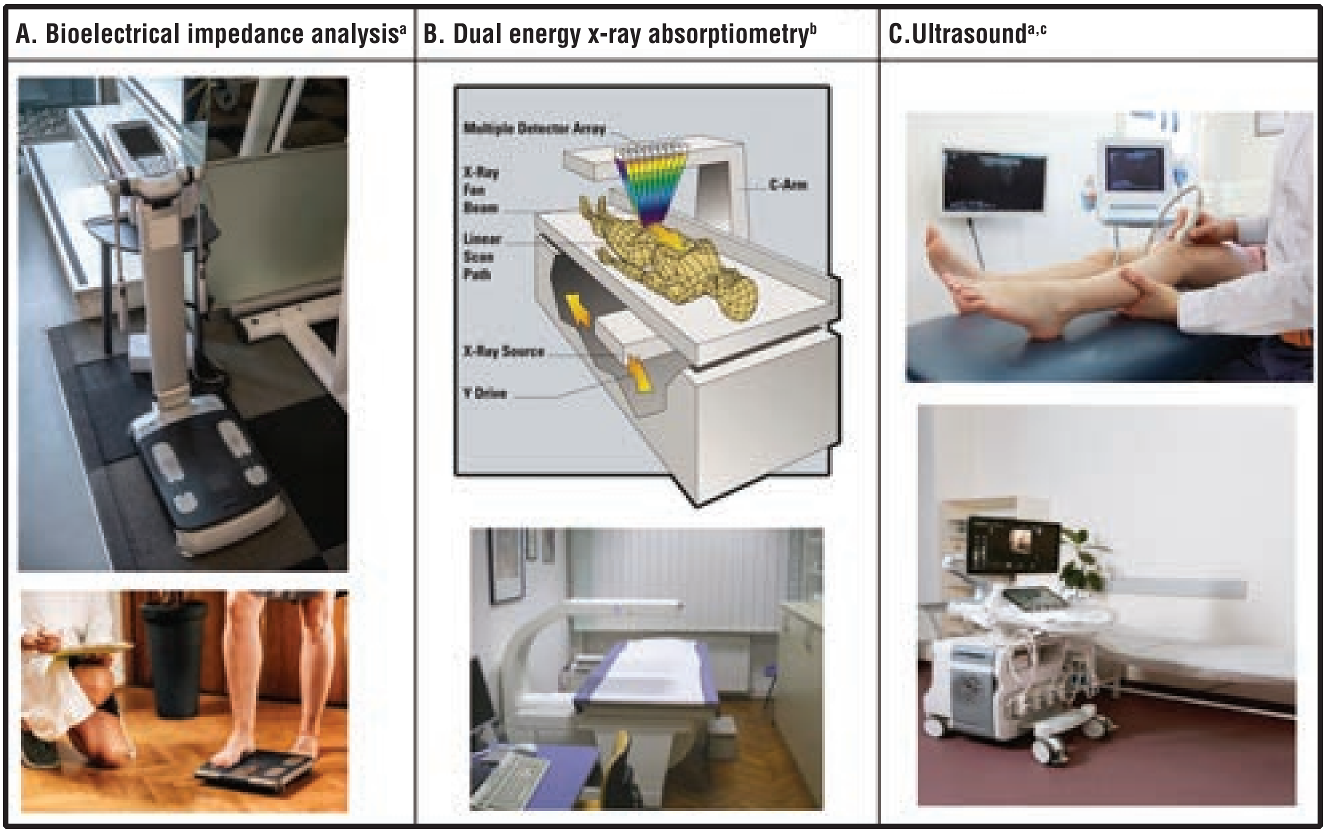
As the name implies, dual energy x-ray absorptiometry (DXA) relies on x-ray technology to procure information about bone density and body composition. It is conventionally used to diagnosis osteoporosis; however, since the 1980s DXA has gained popularity as a body composition assessment tool.[7] DXA technology is based on two, low radiation photon energy x-rays measured with a detector after these two rays pass through the subject (Figure 1). The strength of photon x-ray beams is altered depending on the tissue they pass through, and thus this variation can be captured as body composition measurements. The ratio of the energy from the two beams can differentiate bone, FM, and LM. DXA is useful for measuring specific parts of the body and can provide insights on LM change, especially in appendicular regions.[8]

Similar to BIA, DXA can be used on a wide range of body sizes and body types and is non-invasive, yet it remains a greatly underutilized tool in the outpatient setting due to issues surrounding access and availability.[7] The practicality of using DXA for body composition assessment in the acute or inpatient setting greatly limits its use. Unlike BIA, DXA instrumentation is expensive, requires a dedicated room, and requires technician certification. Conventionally, DXA scanning

**Table 1. Clinical Utility of Common Body Composition Devices**

| A. Bioelectrical Impedance Analysis[a] | B. Dual Energy X-Ray Absorptiometry[b] | C. Ultrasound[a,c] |
|---|---|---|
| **Pros:** practical, portable, noninvasive, inexpensive, easily accessible, multiple frequency devices available<br>**Cons:** invalid in patients with hydration concerns, one-time measures provide limited information, cannot compare output across different BIA devices<br>**Clinical Utility:** best used for repeat measures to show changes over time; increasingly used to estimate phase angle, a surrogate measure of lean muscle | **Pros:** valid, reliable, precise<br>**Cons:** requires experienced, trained personnel; access can be challenging; involves low dose radiation; more costly<br>**Clinical Utility:** offers the ability to obtain information on bone health, regional and total body fat and appendicular lean mass for sarcopenia assessment; can precisely estimate one-time measures or changes over time | **Pros:** highly portable, relatively inexpensive, noninvasive, increasingly more accessible<br>**Cons:** requires experienced, trained personnel; relays muscle thickness (mm) or cross-sectional area (mm2), requires several anatomical sites for comprehensive assessment<br>**Clinical Utility:** utility of single muscle limit clinical interpretation (e.g., cannot relay information about sarcopenia or nutritional status) |

**Figure 1. Body Composition Devices**




*a. Images are free of copyright and available from www.shutterstock.com; b. Images are free of copyright and available from www.flickr.com; c. Images are free of copyright and available from www.shutterstock.com and www.pexels.com* captures images of the femoral or lumbar spine, as these are reference standards for determining osteoporosis risk. Obtaining body composition data requires whole-body imaging, which is only performed if requested and would likely pose additional labor and cost burden.[6] Whole-body images relay information on regional and total adiposity, as well as appendicular LM (e.g., LM of the arms and legs combined) and total LM (e.g., trunk, head, appendages). Appendicular LM is adjusted for height and used to diagnose sarcopenia, which ignores muscle function. Like BIA, the reliability of DXA can be compromised in individuals with hydration issues, should be completed when individuals are fasted,[9] and the output may not differentiate adipose tissue types (visceral vs. subcutaneous fat). Since 1999, DXA is used to characterize body composition in the on-going National Health and Nutrition Examination survey, providing population reference values for adults and children.[10] However, DXA imaging for clinical assessment of body composition is still considered 'investigational' and therefore not routinely covered by insurers.

## Ultrasonography

There is growing interest in the utilization of ultrasound (US) as a body composition technique due to its portability, relative affordability, and ease in obtaining repeated measurements. Most work has focused on measuring visceral and subcutaneous adipose tissue (VAT and SAT, respectively), and more recently muscle.[11] US uses high-frequency sound waves from tissues, where the amount of sound reflected depicts changes in acoustic impedance – the product of acoustic velocity and tissue density (Figure 1). As such, US can relay information about adipose tissue, muscle thickness and muscle cross-sectional area of measurement. Total body LM can be estimated via a regression equation using measures of muscle thickness from multiple sites. US can also be used to gauge "fatty infiltrated" muscle (also known as myosteatosis); a condition more common in persons with diabetes symbolizing metabolic and physiologic dysfunction.[12]

The biggest limitation of US lies in the reliability of the operator. Even with the advent of standardized techniques, determining the minimal vs. maximal compression of the transducer onto the skin site by the operator can vary, and alter the thickness and quantifications of SM and SAT.[12] Similar to BIA, BIS, or DXA, hydration, specifically edema, can present challenges to obtaining accurate body composition measures using US. However, with US technique training, edema is no longer an absolute contraindication for using this technique.[13] Differences in US transducers allow for varying ranges of tissue penetration and window width (e.g., linear vs. curvilinear), which may be beneficial for patients with severe obesity or fluid overload.[12] While US has the potential to be utilized within multiple patient populations, issues surrounding inter- and intra-individual measurement variation continue to pose barriers for making this technique more applicable in the clinical setting.

## Computed Tomography

Due to software advances, computed tomography (CT) images conducted for clinical (diagnostic or surveillance) purposes can be utilized to obtain precise information related to adipose tissue and SM. Specifically, VAT, SAT and intramuscular adipose tissue (IMAT) can be individually quantified or comprised to create total adipose tissue (TAT). Additionally, SM mass and SM quality can be ascertained from CT images to diagnose sarcopenia and myosteatosis, respectively. Given the widespread use of CT imaging in patient care, these images serve as a rich archive of body composition data and are increasingly employed in prevalence and outcomes research.[14] Conventionally, CT images inclusive of the third lumbar (L3) region (e.g., abdominal and/or pelvic) are used to examine body composition.

While CTs are distinctly advantageous because of their superior precision relative to other body composition techniques, they remain largely a research tool. The barriers to utilizing CT images are immense, and include but are not limited to extensive training, access to the picture archiving and communications system to retrieve specific CT studies, expertise utilizing the body composition software, and/or personnel time for analyses. Due to concerns regarding radiation and expense, rarely are CTs advocated as prospective body composition technique.[15] There are additional concerns related

**Table 2. Bedside Techniques for Muscle Health Assessment Without Imaging**

| | Assessment Type | Methods | Cutoff Values and Qualitative Observation | Video Resources |
|---|---|---|---|---|
| **Anthropometric Measurements** | **Calf Circumference** | 1. Patient is seated with knees bent at 90° angle, both feet flat on the ground.<br>2. Wrap tape measure around largest width of the calf without compressing skin surface. | Cutoff values indicating reduced muscle mass:<br>Men: <33 cm<br>Women: <32 cm[11] | Measurement Demonstration: https://www.youtube.com/watch?v=IsGTLIZmdec |
| | **Mid-upper Arm Circumference** | 1. Measure from top of shoulder to top of elbow.<br>2. Divide measurement by 2 to find mid-point.<br>3. Measure from shoulder to mid-point, and mark with horizontal line.<br>4. Wrap tape measure around arm at marked line.[1] | Cutoff values indicating reduced muscle mass:<br><br>Men & Women: <22 cm | Measurement Demonstration: https://www.youtube.com/watch?v=myaB4eZDBBc |
| **Physical Examination** | **Temporal** | 1. Stand directly in front of patient, have them turn head left and right. | Look for abnormal scooping and depression. | Assessment for Fat Loss and Muscle Wasting: https://www.youtube.com/watch?v=SeG-dXX_sOU |
| | **Clavicle, Shoulder** | 1. Instruct patient to sit with arms relaxed at the side. (Make sure patient is not hunched forward.) | Look for hollowing and/or shelving of clavicles. Shoulder is squared with protruding acromion process. | |
| | **Quadriceps, Calf** | 1. Have patient sit and elevate leg on low furniture.<br>2. Ask patient to flex foot and relax.<br>3. Gently pinch quadriceps and calf. | Look for depressed contour of inner thigh. Calf without defined muscle "bulb." Poorly defined muscle and fat tissue upon pinch. | |
| **Muscle Performance** | **Timed Up and Go (TUG)[3]** | 1. Patient sits in chair with floor line marked 3 meters (10 feet) away.<br>2. Upon signal, patient stands, walks to line and back at normal pace, and sits down. | Cutoff value indicating decreased physical function:<br>Men and women: ≥20 seconds.[1] | CDC: https://www.youtube.com/watch?v=tNay64Mab78 |
| | **Gait Speed** | 1. Patient walks 4 meters (13 feet) at normal pace.<br>2. Total seconds to walk 4 meters are taken in two timed measurements with faster time scored. | Scoring: Divide 4 by the number of measured seconds to find meters per second.<br>Cutoff values indicating severe sarcopenia: ≤0.8 meters/second.[18] | NIH Toolbox, Motor Measures: https://www.youtube.com/@NIHToolbox/videos |
| | **Standing Balance Test** | 1. Patient stands for two 50 second trials (eyes opened and eyes closed). Repeat same 2 trials standing on foam surface. Last trial is a tandem stance for 50 seconds. | Data from waist accelerometer is calculated into a fully adjusted score. Scores <70 may indicate motor dysfunction. | |
| **Muscle Strength** | **Handgrip Strength** | 1. Patient is seated, both feet flat on ground with arm bent at 90° angle.<br>2. Instruct patient to squeeze dynamometer as hard as they can for 3 seconds. | Scores measure kilograms of force of dominant hand. Cutoff indicating low strength:<br>Men: <27 kg<br>Women: <16 kg[1] | |
| | **Chair Stand Test** | 1. Patient is seated with arms crossed. Instruct patient to fully stand up and sit down 5 times without using arms. | Sarcopenia cutoff value for low strength:<br>Men: >15 seconds for 5 stands.[1]<br>*Cut points for women not available. Suggest using >15 seconds for 5 stands. | American Academy of Orthotists and Prosthetists: https://www.youtube.com/watch?v=_jPI-IuRJ5A |

to the translation of these data to patient care (e.g., what are the implications of myosteatosis?) and a lack of clinically meaningful cut-points (e.g., high vs. low VAT). As such, advances are required to increase the immediate clinical applicability of body composition measures ascertained from CT imaging.

## Physical Examination, Anthropometric Measurements, and Muscle Function

In instances where BIA, BIS, DXA, or US are not available, the use of anthropometric measurements and comprehensive PE are recommended to assess muscle health.[11] Mid-upper arm and/or calf circumferences are easily obtained in the clinical setting and correlate with compromised muscle health. In addition, clinicians can be trained to evaluate qualitative signs of reduced muscle mass during their PE, taking a 'head to toe' approach focusing on the temples, neck, clavicle, shoulder, scapula, thigh, and calf areas (see Table 2). Nutrition focused PEs are a component of validated nutrition assessment tools, including the Subjective Global Assessment (SGA), and recommended by professional bodies such as the Academy of Nutrition and Dietetics (AND) and the American Society for Parenteral and Enteral Nutrition (ASPEN) to depict muscle wasting. However, PE and anthropometric measurements are more challenging in individuals with obesity and severe fluid abnormalities, as SM may be poorly differentiated.

To complement the anthropometric and PE information gathered, it is imperative to measure muscle function for a comprehensive picture of muscle health. Endorsed by the European Working Group on Sarcopenia in Older People, several tests can be conducted at the bedside or in clinic to assess muscle function (See Table 2).[1] Because of the undue influence of non-nutritive factors (e.g., neurologic impairment), it is not advised to uniformly prioritize muscle function tests over muscle mass assessment.[11] For example, some patients may be too impaired to hold the hand dynamometer or too unbalanced to perform a sit-to-stand test. Muscle function testing can substantiate or support PE, or other clinical findings, regarding muscle health and put into proper context of patient care.



## Practical Applications for Clinicians

Preserving or improving LM and/or muscle function is the overarching goal for any patient, especially the aging. Simply recognizing compromises in LM occur across all BMI strata is vital for clinicians to appreciate. Clinicians are encouraged to look beyond BMI and focus their treatments on simple messaging and early intervention referrals.

Clinicians should take advantage of opportunities to assess eating patterns, honing in on nutrition-impact symptoms (e.g., taste change, gastrointestinal symptoms) or behaviors (e.g., skipping meals, eliminating of food groups) that preclude optimal oral intake. Additionally, incorporating methods to identify patients who report unstable socioeconomic status and/or food insecurity, as these factors increase the likelihood of inadequate dietary intake. Simple interventions, including calorically dense oral supplements or protein supplements (e.g., beverages, bars, powders) may be indicated at or between meals. Animal sources of protein have been shown to upregulate anabolic stimulation compared to plant-based proteins (apart from soy-based isolates) and possess higher levels of digestibility. Expert opinion recommends older adults with comorbid conditions aim to consume at least 65% of daily protein needs from animal sources, such as red meat, eggs, fish, poultry, and dairy. Patients following an exclusively plant-based diet (veganism or vegetarianism) should regularly incorporate soy or pea protein isolates as these plant proteins offer higher amino acid digestibility.[16] Table 3 offers dietary intake probes and potential responses to support improved nutrition messaging.

In patient populations with sarcopenia or at high risk of sarcopenia, dietary protein intake and physical activity are typically low which negatively affect rates of muscle protein synthesis.[13] Increasing physical activity, specifically progressive resistance exercise training, can preserve or build LM. A 3-month pilot study demonstrates the value of a supervised resistance exercise program

**Table 3. Adequacy of Oral Intake Probes, Implications and Messaging**

| Potential Question | Listen For | Potential Responses |
|---|---|---|
| **How often are you setting aside time to eat a meal each day?** | • Regular mealtimes and patterns of intake.<br>• Do not assume each patient eats formal breakfast, lunch, and dinner.<br>• Focus on meal frequency and consistency. | • Eating regularly scheduled meals is preferred over skipping meals or grazing throughout the day.<br>• This routine makes sure you get enough nutrients and improves how we manage your overall health. |
| **Describe what your plate looks like when you eat, starting with the first meal of the day.** | • Reported protein sources at each meal, along with whole grains, non-starchy vegetables and fruits, and healthy fats.<br>• Do not assume formal eating patterns of 3 meals/day. | • Choosing balanced meals provides energy and supports your nutrition needs.<br>• Try to include different food groups: a starch, like bread or oatmeal, a protein, like meat, eggs or fish, a fruit or vegetable, and a fat, like olive or avocado oil. |
| **What types of protein foods do you eat each day?** | • Proper identification of protein sources and how often these are consumed.<br>• Ideally, there should be at least one protein source at each meal.<br>• A general rule of thumb is 1 gram of protein for every kilogram of body weight (especially for adults >65 years old and/or individuals with history of weight loss). | • Protein sources are like building blocks used to build and preserve muscles.<br>• Animal protein sources: red meat, poultry, fish, eggs, yogurt, cow's milk, cottage cheese.<br>• Plant protein sources: soy or oat milk, nut butters (peanut or almond), lentils, legumes, quinoa. |
| **Optional questions to address potential socioeconomic issues** | | |
| **Who purchases and prepares the food at home?** | • Any struggles with purchasing or preparing meals.<br>• Local resources, such as homemaker services or family support may be needed.<br>• May benefit from congregate meal sites or community programs. | • Let's see if we can get you some additional help. |
| **Do you ever worry about running out of food or having money to buy more?** | • Issues with food insecurity may be contributing to compromises in muscle health.<br>• Local resources may be needed if food insecurity is suspected. Refer to Social Services if available. | • Would you be interested in receiving assistance from organizations to support your needs? |

significantly and positively impacting quality of life, pain, LM and physical functioning in older patients with advanced cancer.[17] Referrals to physical therapy and/or exercise physiologists to assess and individualize functional interventions, as well as engagement with registered dietitians and social workers to reduce nutrition, psychological, and socioeconomic barriers to oral intake are recommended.

## CONCLUSIONS

The landscape of clinical practice is shifting to recognize the importance of muscle health and its impact on outcomes. Clinicians should arm themselves with the knowledge and tools to assess muscle mass and muscle function, utilizing readily available quantitative measures (BIA or DXA), anthropometrics (mid-upper arm or calf circumference), and/or enhanced PE methods. Recommendations regarding consistent, adequate oral intake with high quality protein sources are advocated for any patient with documented or suspected compromises in muscle health. Interdisciplinary collaborations are key to optimizing care and combating the untoward effects of compromised muscle health. ■

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**Answers to this month's crossword puzzle:**

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| 1 M | I | 2 T | O | 3 C | H | 4 O | N | 5 D | R | 6 I | A | 7 L | | 8 S |
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| 9 S | T | E | N | O | T | I | C | | 10 A | N | E | M | 11 I | A |
| C | | R | | T | | F | | | B | | | 12 P | S | T |
| 13 L | I | M | P | | 14 B | I | O | 15 P | S | Y | | H | | I |
| E | | A | | | | C | | Y | | | | O | | O |
| 16 S | 17 O | L | U | 18 B | L | E | | 19 R | 20 E | 21 G | I | M | E | N |
| | V | | | I | | | | 22 U | S | A | | A | | A |
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| E | | I | | U | | E | | A | | E | | M | | I |
| 36 G | E | N | E | S | I | S | | 37 P | A | S | S | A | G | E |