LABORATORY VALUES INTERPRETATION RESOURCE

Updated 2022

Joint Task Force of the
APTA Academy of Acute Care Physical Therapy
and the
APTA Academy of Pediatric Physical Therapy

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EVOLUTION OF THE 2022 EDITION OF THE LABORATORY VALUES INTERPRETATION RESOURCE BY THE APTA ACADEMY OF ACUTE CARE PHYSICAL THERAPY IN COLLABORATION WITH THE APTA ACADEMY OF PEDIATRIC PHYSICAL THERAPY

As research related to the field of acute care physical therapy continues to evolve, the APTA Academy of Acute Care Physical Therapy convened a task force in 2020 to review and update the Laboratory Values Interpretation Resource. Additionally, the APTA Academy of Acute Care Physical Therapy collaborated with the APTA Academy of Pediatric Physical Therapy to address the need for clinical considerations across the lifespan. This updated resource includes expanded laboratory (lab) value information and updated references and recommendations. The document was adapted to improve usability in the busy acute care setting based on ongoing practitioners' feedback. The Joint Task Force consisted of physical therapists (PTs) in various acute care and pediatric settings across the country.

The Joint Task Force reviewed the body of evidence for updates within the past five years and discussed clinical relevance using expert opinion. For consistency, reference ranges were primarily derived from one reputable laboratory values textbook unless seminal research was related to the test. Each lab test in this 2022 version briefly explains the lab panel, reference ranges, possible critical values (lab results outside the reference range), clinical factors (diseases or conditions) that could cause the trends, clinical presentation, and potential clinical implications.

The point of care bedside reference document that was introduced in 2017 was also updated. The APTA Academy of Acute Care Physical Therapy, with the involvement of stakeholders, will continue to perform periodic reviews of this reference document no later than every five years per best practice principles.

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Point of Care document available separately

1. Understanding Laboratory (Lab) Values

a. Reference Ranges and Clinical Recommendations

The reference ranges and clinical recommendations in this resource are based on the current, best-available evidence. Considering the absence of a universal reference range for any of the more than 5,000 lab tests, accredited laboratories must establish and validate their reference values at least annually. Thus, any given result should be interpreted based on the reference value of the laboratory in which the test was performed. Reference ranges must be validated whenever a new reagent kit or diagnostic instrument is introduced. Furthermore, differences in patient populations (demographics and attributes) might result in variability of reference ranges. Abnormal values are those results outside a specific range obtained from a cohort of healthy individuals.[1]

This resource was created to support the physical therapist (PT) and physical therapist assistant (PTA) with clinical decision-making, related to lab values, in the acute care setting. This information is intended to be used to promote best practice through critical thinking and clinical reasoning within the clinician's scope of practice (refer to APTA Acute Care Core Competencies for PTs and PTAs: https://www.aptaacutecare.org/page/corecompetencies)

PTs and PTAs have the professional responsibility to provide evidence-based care, adhere to high standards, and collaborate with the interprofessional team to achieve optimal patient outcomes. PTs and PTAs treat patients with potentially critical and rapidly changing medical conditions, which require close monitoring and modification of physical therapy interventions based on multiple factors, including lab values, vital signs, and symptoms. Although the recommendations made in this document utilize the best available evidence, the clinician should make the final judgment regarding the appropriateness of physical therapy interventions. The goal of clinical standardization is not to produce rigid interventions but to establish evidence-based and consensus-founded guidelines.

b. Trends and Clinical Context

Current electronic health records allow for efficient retrieval of laboratory results, reference ranges, and critical values. When reviewing the medical record, PTs and PTAs should not rely exclusively on a single lab finding; instead, they must consider various other factors, including the patient's baseline values, rate of change in the value, lab value trends, and further diagnostic workup. An isolated abnormal value may be difficult to interpret; however, a series of values taken at different time points may reveal additional insights into trends.[2]

PTs and PTAs must be aware of the patient's lab value trends for several tests including leukocytes, electrolytes, and hemoglobin to better understand the clinical context and implications of an abnormal value. Individuals with chronic medical conditions, such as anemia, might be asymptomatic during exercise, while a patient with a precipitous drop in hemoglobin and hematocrit may require urgent medical attention. In some cases, the pattern of change in the value, such as with cardiac troponin testing, may assist the PT and PTA with making informed decisions about the timing of their intervention.

PTs must also be aware of the clinical context in which the value was taken. For instance, clinicians must be cognizant of the time the lab specimen was drawn, contributions of acute and chronic medical diagnoses, potential drug and pharmacologic implications, as well as the patient's recent nutrition and hydration status. Collaboration with the interprofessional team, as well as awareness of facility guidelines, is imperative as lab values can change quickly due to medical intervention including IV fluids, electrolyte replacement, or blood transfusion.

c. Possible Critical Values

Pagana et al. define possible "critical values" as values outside the normal range to the degree that may constitute an immediate health risk to the patient and/or require action from the medical provider.[3] Knowledge of possible critical values may assist PTs and PTAs with clinical decision-making.

The Joint Commission requires individual healthcare organizations to define the circumstances under which a test result is considered "critical," as well as when and how it will be reported. It is advisable for the PT to

collaborate with the interprofessional team regarding the potential risk of mobility and exercise when compared to the benefits for patients with concerning trends in their overall health, not limited to lab values and/or vital signs.[4]

The PT should also understand the medical plan to address a patient's critical value and the timing of specific interventions. While a possible critical value may not be an indicator to postpone further treatment, it is advised that the PT or PTA monitor and document precautions during physical therapy intervention, patient response, and any follow-up actions.

d. Age Considerations

This resource is intended to be a practice document across the lifespan. The Joint Task Force is comprised of PTs with expertise ranging from pediatrics to geriatrics. Pagana et al. was consistently utilized throughout this document with additional supporting references, including integrated pediatric-specific resources. Whenever available, specific age ranges were provided. Causes, presentation, and clinical implications are relevant across the lifespan. Evidence specific to the pediatric population is identified and should be considered in addition to the listed information. Reference ranges include age intervals when available. When a specific age range is not provided, "pediatric" is considered to be relevant for ages birth to 18 years of age. The medical community has defined and accepted age-dependent reference intervals due to physiological differences between children, adults, and older adults.[5] For example, lab value reference ranges for common hematological markers (erythrocytes, hemoglobin, hematocrit) account for the dynamic changes that occur with growth and development across the lifespan. Reference ranges for serum creatinine, which typically increases from birth to adulthood, directly correlate to increased muscle mass development among the general population who do not present with underlying disease or comorbidities.[6] Therefore, it is advisable when reviewing the reference ranges presented within this resource that clinical considerations may vary based on the patient's age and medical condition.

e. Cultural Competence

Cultural competence involves the understanding and appreciating the impact of ethnicity, race, religion, age, language, socioeconomic status, sexual orientation, and gender identification while delivering physical therapy services to meet the patient's needs.[7] Although cultural competence primarily refers to the culture and language of racial and ethnic minority groups, the definition has evolved to include individuals with disabilities and the LGBTQIA+ community.[8] Cultural sensitivity begins with recognizing cultural similarities and differences between individuals.

Cultural humility is a lifelong commitment to self-evaluation and self-critique to fix power imbalances and develop partnerships with people and groups who advocate for others.[9] Ongoing identification and awareness of their own biases will allow PTs and PTAs to create safe and inclusive environments for all patients.

Culturally competent PTs and PTAs will continue to hone their skills to promote effective communication, understand barriers to patient access, and create an environment of mutual respect.[10]

f. Race and Ethnicity Considerations

According to the U.S. Census Bureau, beyond 2030, the population is projected to become more racially and ethnically diverse. The population of people who identify as Two or More Races is projected to be the fastest-growing racial or ethnic group over the next several decades, followed by individuals identifying as Asian and Hispanic.[11]

Significant knowledge has been gained in the area of race and ethnic variability in medicine over the past two decades, but continued diligent effort and research are required to remove the existing bias in clinical algorithms and practice. Specific lab values are known to correspond to certain ethnic groups, but these distinctions are not often considered in the establishment of clinical lab reference ranges.[12–14]

Race and ethnicity are often used in clinical algorithms and practice guidelines across specialties including Cardiology, Nephrology, Obstetrics, and others. This practice may contribute to underdiagnosis and delayed treatment of patients identifying with specific racial and ethnic groups.[12,15,16] Given that race and ethnicity are

social constructs, including these variables in clinical tools and decision-making may lead to adverse or unanticipated effects, possibly even reinforcing healthcare disparities that currently exist.[13,17]

In March 2021, the Agency for Healthcare Research and Quality (AHRQ) has requested information on the use of clinical algorithms that may introduce racial/ethnic bias into healthcare delivery and this investigation remains under review.[18]

g. Sex and Gender Considerations

It is important for PTs and PTAs to create a welcoming and inclusive environment. This can be achieved by recognizing healthcare disparities and establishing cultural competence. It is crucial to recognize that sex and gender are not interchangeable terms.

According to the National Institutes of Health (NIH), "sex" refers to biological differences between females and males, including chromosomes, sex organs, and endogenous hormonal profiles. "Gender" refers to socially constructed and enacted roles and behaviors which occur in a historical and cultural context and vary across societies over time.[19]

Most lab test results have reference ranges reported as sex-specific (females and males). Patients who identify as nonbinary gender or transgender on gender-affirming hormone therapy do not yet have established reference norms.[20,21] In this situation, dual reporting of reference ranges (female and male) for this individual may occur, and the PT may want to contact the interprofessional team to understand the expected normal ranges for that individual.[20,22]

It is recommended for PTs and PTAs to consider a patient's biological sex and gender terms (refer to Table 1).

Table 1: Glossary of Terms Pertaining to Sex and Gender Roles

Term	Definition
Sex	The classification of a person as male or female (assigned at birth, based on the appearance of external anatomy).[23]
Gender Identity	A person's sense of their gender as a man, woman, both, or neither.[24]
Gender Expression	A person's expression of their gender. It can be expressed through name, pronouns, clothing, hairstyle, behavior, voice, and body characteristics.[23]
Sexual Orientation	A person's enduring sexual, physical, and/or emotional attraction to another person.[23]
Gender-Affirming Care	According to the United States Department of Health and Human Services OASH, "gender-affirming care is a supportive form of healthcare. It consists of an array of services that may include medical, surgical, mental health, and non-medical services for transgender and nonbinary people."[24] Gender-affirming care in transgender and nonbinary youth can be variable and dependent on stages of development, stages of puberty, and timing of articulation of gender dysphoria or gender identity. Per federal health guidance, "early gender-affirming care is crucial to overall health and well-being as it allows the child or adolescent to focus on social transitions and can increase their confidence while navigating the healthcare system."[24]
Gender-Affirming Surgeries	Surgery to create a desired male or female gender characteristics for the face, chest, or genitals.[24]
Gender Dysphoria	The psychological stress that a person feels related to their sense of sex or gender conflicting with that assigned to them at birth.[24]
Gender Nonconforming	Term to describe those whose gender expression is divergent from society's expectations.[24,25]
Gender Diverse or Expansive	Term to describe those whose gender identity is not characterized as either male or female.[24]

Cisgender	Describing a person whose sense of gender is the same as that assigned sex at birth.[24]
Transgender (adjective, not noun)	Describing a person who expresses a gender identity that is not the same as that assigned to them at birth.[24]
Transgender female	A female (woman) who was assigned a male sex at birth.[23]
Transgender male	A male (man) who was assigned a female sex at birth.[23]
Nonbinary (with respect to gender)	A term describing a person whose gender identity lies outside the boundaries of a strict male-female dichotomy.[23]
Transition	The experience of altering one's sex to align gender expression and/or body with gender identity (can include legal steps, name changes, disclosure to others, pronoun change, dressing differently, hormone therapy, and sometimes-but not always-medical procedures such as implants or sex reassignment surgery). This is not necessarily a stepwise progression when the transition is an extremely individualized experience of coming to know oneself and creating changes that make that individual feel more aligned in their mind and body. There is no one way/process/start or finish to transition each person has their own experience of it and the changes that help them align and actualize.[25]

Patients may be in the process of transitioning to their gender through medical (gender-affirming hormone therapy), surgical (gender reassignment surgery, gender reaffirming surgery), or legal (submitting legal documents to reflect their new gender identity). PTs should determine if their patient is in the process of transitioning and undergoing gender-affirming hormone therapy, as this may occur prior to, in conjunction with, or after gender-affirming surgery.[25]

The current recommendation by endocrinologists for transgender patients receiving gender-affirming hormone therapy is to interpret standard lab results (sex-specific reference ranges) based on the affirmed gender, except for high-sensitivity cardiac troponin and prostate-specific antigen (test is dependent on organ size) for which reference range for the sex presumed at birth should be used.[26]

If the transgender patient is not receiving gender-affirming hormone therapy, PTs should use the patient's biological sex as a basis to establish reference values. For example, a transgender female on estrogen replacement therapy should have their lab values compared to normal values of females due to the effects of estrogen on their physiology. In contrast, a transgender male on testosterone should have his lab values compared to males due to testosterone's effect on his physiology. The most important determinant is not whether the medical record gives a gender assignment or whether the patient has undergone gender-affirmation surgery, but whether the patient is receiving gender-affirming hormone therapy that will affect their physiology and lab chemistry parameters. Knowledge of the medical transition status of a transgender person reduces misinterpretation of lab values and aids in the correct application of reference values consistent with the patient's affirmed gender.

h. Risk vs. Benefit of the Therapeutic Intervention: Considerations of the Laboratory Findings

When reviewing patient lab findings, the fundamental consideration is to determine an appropriate plan of care by weighing the anticipated benefit of an intervention against the potential risk to the patient. PTs should carefully anticipate the physiological changes whenever a lab value is outside of the anticipated range or varies significantly from the patient's baseline value(s). The PT must utilize clinical decision-making to determine the level of risk for adverse events based on the degree of abnormality, the trends, and the individual patient characteristics, including factors such as the acuity of the medical condition, comorbid health conditions, and age. For example, the pattern and rate of change in the lab value may provide the PT with a better sense of the risks associated with the risks and expected clinical presentation. A patient with a rapid drop in red blood cells (RBC) due to trauma is more likely to be symptomatic compared to a patient with a chronic condition that led to a more gradual decline in RBCs.[2] It may also be the case that a patient has a chronic condition that leads to the lab value outside of normal ranges for an extended period. For example, a patient with multiple myeloma

receiving chemotherapy may have low platelet counts that may take several weeks to recover. While the PT must be aware of the clinical implications of the low platelet levels, they must also consider the risk associated with prolonged bed rest and thus may decide to mobilize the patient while taking precautionary measures to minimize the bleeding risks associated with mobilization.[27] Essentially, the PT must consider the lab value within the context of all that is known about the patient when making decisions about the plan of care.

When initiating therapeutic intervention with a patient exhibiting abnormal values, the PT and PTA should closely monitor the patient's status and readily adjust the approach based on the patient's symptoms and their response to the intervention. The symptom-based approach implies that the PT or PTA may weigh the patient's signs/symptoms more than the isolated lab value finding. For example, an asymptomatic patient with a low hemoglobin and hematocrit level may be less concerning to the PT when initiating mobilization compared to a patient with a similar value but who presents with signs and symptoms of tachycardia, shortness of breath, and pallor at rest. In the latter case, the PT may decide that the risk of mobilization that would impose additional physiologic stresses would outweigh the benefits.

To fully explore the potential effects of physical therapy intervention, collaboration with other interprofessional team members is often necessary. It is prudent and congruent with standards of professionalism for PTs to assist with the development of facility policies, procedures, and protocols to aid in the clinical decision-making process regarding the use of lab values in determining the intensity level of therapeutic intervention.

2. Complete Blood Count

The **Complete Blood Count (CBC) Panel** is a group of four specific tests which provides results regarding the concentration of White Blood Cells (WBC), Red Blood Cells (RBC), Platelets, as well as the concentration of Hemoglobin and Hematocrit within a blood sample.[3]

The CBC can provide information regarding an individual's overall health and is utilized as a differential diagnosis of a variety of disease and conditions, including anemia, infection, and leukemia.[3]

Monitor vital signs (Adult Vital Sign Interpretation in Acute Care Guide 2021),[28] use a symptom-based approach, and collaborate with the interprofessional team regarding risk vs. benefit of physical therapy intervention with abnormal findings in the context of the complex clinical condition.

White Blood Cells (Leukocytes) play a crucial role in the immune system by providing protection against infectious diseases and foreign invaders. WBC testing is utilized to identify the presence of infection and conditions that cause inflammation, allergic reactions, and cancers of the blood and lymphatic system. Fluctuations of WBCs occur at all ages but are greatest in infants. Pre-term and full-term infants have physiologically higher baseline WBC count, compared to adults.[29]

Reference Ranges (per mm^3)[3]

Newborn: 9,000-30,000
Child ≤ 2 years: 6,200-17,000
Child > 2 years/adult: 5,000-10,000

Possible Critical Values: < 2,500 or > 30,000

Absolute Neutrophil Count (ANC) is the total neutrophil granulocytes present in the blood. Consider protective isolation/reverse precautions when ANC < 1,000/mm^3 as a result of severe immunocompromise and increased infection risk.[3]

ANC Guidelines[30]**:**

ANC Value	Risk for Infection
< 500/mm^3	Highest
500-1000/mm^3	Moderate
> 1000/mm^3	Low

Trending Upward	Causes[3]	Presentation[1]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Leukocytosis**	Infection Inflammation Bone marrow disease Immune system disorder Severe stress/pain	Fever Fatigue Bleeding Bruising Frequent infections	Closely assess and monitor for signs/symptoms of multisystem complication in patients presenting with hyperleukocytosis (WBC > 100,00 mm^3), as these patients are at increased risk for cardiac, pulmonary, renal, and neurologic involvement as it relates to leukostasis.[31,32] Consider the timing of physical therapy session due to early-morning low level and late-afternoon high peak.[33]

Trending Downward	Causes[3]	Presentation[34]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Leukopenia**	Chemotherapy Radiation therapy Marrow infiltrative diseases Infections (viral and bacterial) Dietary deficiency Autoimmune disease	Frequent and/or persistent infections Inflammation or ulcers in and around the mouth Headache Stiff neck Sore throat Fever/chills Night sweats	Refer to facility guidelines for neutropenic precautions, adjust therapeutic activities accordingly. Monitor for signs and symptoms of infection during physical therapy intervention. Monitor for fatigue during physical therapy intervention and educate regarding interval training and energy conservation. Consider using the Borg RPE (rate of perceived exertion) scale or dyspnea scale in addition to vital sign monitoring with activity progression and symptom presentation. Provide fall prevention screening and intervention as patients may be at risk for falls related to the underlying diagnosis and treatment. Use caution during neurogenic bowel or bladder programs, S4-S5 testing (spinal cord injury/tumors) and rectal exams, as patients may be at an increased risk for infection.[35] Notify the interprofessional team immediately if a patient with a cancer diagnosis is neutropenic and has a fever (> 100.4^{o} F or 38^{o} C). This is considered an oncologic emergency.[36] Discuss with the interprofessional team risk vs. benefit if planning to utilize dry needling, given that patients with neutropenia are at high risk for infection.[37,38]

Platelets (Thrombocytes) help stop bleeding by forming a clot. There is limited evidence to support an absolute or relative threshold to discontinue physical therapy intervention for patients that are thrombocytopenic.[39] Musculoskeletal bleeding is a key characteristic of many bleeding disorders and can result in permanent damage to the joints and muscles.[40] Thrombocytopenia in infants should be considered pathologic not physiologic.[29]

Reference Ranges (per mm^3)[3]

Premature infant: 100,000-300,000
Newborn: 150,000-300,000
Infant: 200,000-475,000
Child/adult: 150,000-400,000

Possible Critical Values: < 50,000 or > 1 million

Trending Upward	Causes[3]	Presentation[41]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Thrombocytosis & Thrombocythemia**	Cancer Polycythemia vera Splenectomy Acute/chronic inflammation Strenuous exercise Iron-deficiency anemia	Headache Dizziness Weakness Chest pain Tingling in hands/feet	Screen for venous thromboembolism (VTE) using patient diagnosis-specific evidence-based tool due to increased risk with elevated levels. Monitor for signs and symptoms of VTE and consider referral to a medical provider as appropriate. Refer to Coagulation Tests and Assays section. Collaborate with the interprofessional team regarding risk vs. benefit of physical therapy intervention with abnormal findings.

Trending Downward	Causes[3]	Presentation[3]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Thrombocytopenia**	Hemorrhage/blood loss Damage to developing blood cells (oncologic diseases, chemotherapy, and radiation) Various diseases lead to reduced platelet count *Additional Pediatric Considerations to above[29]:* Infants: ○ Birth trauma ○ Respiratory distress ○ Trisomy syndromes ○ Newborn sepsis	Petechiae Ecchymosis Oral bleeding Hematuria Epistaxis	Educate patient/caregiver regarding risks and strategies to prevent falls. There is an increased risk of spontaneous bleeding resulting from a fall. Monitor for fatigue during physical therapy intervention and educate regarding interval training and energy conservation. Consider using the Borg RPE scale or dyspnea scale in addition to vital sign monitoring with activity progression and symptom presentation. Use caution during neurogenic bowel or bladder programs, S4-S5 testing (spinal cord injury/tumors) and rectal exams, as patients may be at an increased risk for bleeding.[35]

			Discuss with the interprofessional team risk vs. benefit if planning to utilize dry needling, given patients with thrombocytopenia are at high risk for bleeding.[37,38] Refer to the recommendations by the National Hemophilia Foundation's Physical Therapy Guidelines when working with persons with bleeding and clotting disorders.[42]

Red Blood Cells (Erythrocytes) transport oxygen to the tissues throughout the body and use it to produce energy. These cells also carry carbon dioxide to the lungs. RBCs contain hemoglobin, an iron-rich protein, which gives blood its red color.[43]
Patients presenting with erythrocytosis have an increased risk for vaso-occlusive events, including myocardial infarction and stroke. This is secondary to increased viscosity of the blood and clot development risk.[43]

Reference Ranges (10^6/μL)[3]

Child:
- Newborn: 4.8-7.1
- 2-8 weeks: 4.0-6.0
- 2-6 months: 3.5-5.5
- 6 months-1 year: 3.5-5.2
- 1-18 years: 4.0-5.5

Adult:
- Male: 4.7-6.1
- Female: 4.2-5.4

Trending Upward	Causes[3]	Presentation[44]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Erythrocytosis**	High altitude Dehydration Cor pulmonale Pulmonary fibrosis Thalassemia trait Severe COPD Polycythemia vera Medications Congenital heart disease	Weakness Fatigue Headache Lightheadedness Dyspnea	Monitor for fatigue during physical therapy intervention and educate regarding interval training and energy conservation. Consider using the Borg RPE scale or dyspnea scale in addition to vital sign monitoring with activity progression and symptom presentation. Screen for VTE using patient diagnosis-specific evidence-based tool due to increased risk with elevated levels. Monitor for signs and symptoms of VTE and consider referral to a medical provider as appropriate. Refer to Coagulation Tests and Assays.

Trending Downward	Causes[3]	Presentation[43]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Anemia**	Hemorrhage Bone marrow suppression Oncologic conditions Hemoglobinopathy Renal disease Pregnancy Dietary deficiency Prosthetic valves Overhydration	Orthostatic hypotension Weakness Fatigue Dyspnea on exertion Pallor Dizziness Chest pain Leg cramps with exercise	Monitor vital signs and cardiac rhythm during physical therapy intervention. Monitor for fatigue during physical therapy intervention and educate regarding interval training and energy conservation. Consider using the Borg RPE scale or dyspnea scale in addition to vital sign monitoring with activity progression and symptom presentation. Monitor for leg cramps during physical therapy intervention. Assess and monitor for cognitive impairment due to increased risk for altered mental status. Consider referral to other providers as appropriate. Provide fall prevention screening and intervention as needed due to increased fall risk. Monitor for signs and symptoms of orthostatic hypotension during positional changes and throughout physical therapy intervention. Discuss concerns for orthostatic hypotension with interprofessional team if noted during assessment/intervention. Monitor for orthostatic hypotension. Educate patient/caregiver on recognizing symptoms, avoiding quick postural changes, and monitoring blood pressure in the presence of orthostasis or dizziness.

Hemoglobin is the main component of RBCs and transports oxygen and carbon dioxide. Elevated values (> 20 g/dL) can lead to clogging of capillaries because of hemoconcentration.[35] Iron deficiency anemia is the most common hematologic disorder and the most common cause of anemia among infants and children.[29]

Reference Ranges (g/dL)[3]

Child:
- Newborn: 14-24
- 0-2 weeks: 12-20
- 2-6 months: 10-17
- 1-6 years: 9.5-14
- 6-18 years: 10-15.5

Adult:
- Male: 14-18
- Female: 12-16
- Pregnant female: > 11
- *Older adult: values are slightly decreased*

Possible Critical Values: < 5 or > 20

Trending Upward	Causes[3]	Presentation[45] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Polycythemia**	Severe dehydration High altitude Smoking Congenital heart disease Chronic pulmonary disorders Heart failure	Fatigue Headache Dizziness Visual changes Transient ischemic attack (TIA) Dysrhythmias Bruising Bleeding *Additional Pediatrics Considerations to above[29]:* Newborns ○ Jitteriness ○ Cyanosis ○ Hypotonia ○ Respiratory distress	Monitor vital signs and cardiac rhythm during physical therapy intervention. Provide fall prevention screening and intervention as needed due to increased fall risk. Implement activity pacing strategies to reduce the load and prevent undue stress on the cardiovascular system.

Trending Downward	Causes[3] *unless otherwise cited*	Presentation[43]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Anemia**	Hemorrhage/blood loss Vitamin B-12 and Iron deficiency Bone marrow suppression Oncologic conditions Metabolic disorders Various diseases can impact RBC production Medications	Pallor Tachycardia Orthostatic hypotension Dysrhythmias Impaired endurance and activity tolerance *Additional Pediatric Considerations to above:* Infants may present with lethargy and poor feeding.	Collaborate with the interprofessional team regarding risks vs. benefits and the need or timing of transfusion before mobilization.[35,46] Assess and monitor all vital signs, especially SpO_2, to predict tissue perfusion. SpO_2 may not accurately represent the physiologic state in patients with severe anemia. Monitor patients with pre-existing cerebrovascular, cardiac, or renal conditions for ineffective tissue perfusion (discoloration, poor peripheral pulses, decreased temperature, and angina) related to decreased hemoglobin levels.[46] Provide fall prevention screening and intervention as needed due to increased fall risk. Monitor for orthostatic hypotension. Educate patient/caregiver on recognizing symptoms, avoiding quick postural changes, and monitoring blood pressure in the presence of orthostasis or dizziness. Implement activity pacing strategies to reduce the load and prevent undue stress on the cardiovascular system. Monitor for fatigue during physical therapy intervention and educate regarding interval training and energy conservation. Consider using the Borg RPE scale or dyspnea scale in addition to vital sign monitoring with activity progression and symptom presentation. *Additional Pediatric Considerations to above[47]:* Monitor for signs/symptoms of anemia in premature and low birth weight infants. Monitor for signs/symptoms of developmental delay in infant/child with anemia.

Hematocrit is the percentage of RBCs in the total blood volume. Abnormal values may indicate blood loss or fluid imbalance.

Reference Ranges[3]

Child:
- Newborn: 44-64%
- 2-8 weeks: 39-59 %
- 2-6 months: 35-50%
- 6 months-1 year: 29-43%.
- 1-6 years: 30-40%
- 6-18 years: 32-44%

Adult:
- Male: 42%-52%
- Female: 37%-47%
- Pregnant female: > 33%
- *Older adult: values may be slightly decreased*

Possible Critical Values: < 15% or > 60%

Trending Upward	Causes[3]	Presentation[45]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Polycythemia**	Severe dehydration Congenital heart disease Polycythemia vera Erythrocytosis Burns Eclampsia Living in high altitudes Hypoxia due to chronic pulmonary conditions (COPD, heart failure)	Fatigue Headache Dizziness Visual changes TIA Dysrhythmia Bruising Bleeding	Screen for VTE using the patient diagnosis-specific evidence-based tool due to increased risk with elevated levels. Monitor for signs and symptoms and consider referral to a medical provider as appropriate. Refer to Coagulation Tests and Assays section.

Trending Downward	Causes[3]	Presentation[48] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Anemia**	Hemorrhage Leukemia Bone marrow failure Multiple myeloma Dietary deficiency Pregnancy Hyperthyroidism Cirrhosis Rheumatoid arthritis Hemolytic reaction Hemoglobinopathy Prosthetic valve Renal disease Lymphoma	Orthostatic hypotension Dizziness Headache Pallor Cold hands/feet[1] Angina Dysrhythmia Dyspnea	Assess and monitor all vital signs, especially SpO_2, to predict tissue perfusion. SpO_2 may not accurately represent the physiologic state in patients with severe anemia. Provide fall prevention screening and intervention as needed due to increased fall risk. Monitor for orthostatic hypotension. Educate patient/caregiver on recognizing symptoms, avoiding quick postural changes, and monitoring blood pressure in the presence of orthostasis or dizziness.

			Monitor cardiac rhythm and for signs/symptoms of decreased activity tolerance during physical therapy intervention. Monitor patients with pre-existing cerebrovascular, cardiac, or renal conditions for ineffective tissue perfusion (discoloration, weak peripheral pulse, decreased temperature, and angina) related to decreased hematocrit levels.[46]

3. Electrolyte Panel

The **Basic Metabolic Panel (BMP)** consists of eight specific lab tests, including several electrolytes, with additional electrolyte levels separately ordered as indicated. Changes in sodium, potassium, and calcium alter the excitability of neurons, cardiac, and skeletal muscles that can produce dysrhythmia, weakness, muscle spasms and tremors.

Monitor vital signs (Adult Vital Sign Interpretation in Acute Care Guide 2021),[28] use a symptom-based approach, and collaborate with the interprofessional team regarding risk vs. benefit of physical therapy intervention with abnormal findings in the context of the complex clinical condition.

In many cases, electrolyte imbalances are corrected immediately after medical intervention, and the laboratory value data available may not be the actual value. In these instances, laboratory measurements must be retaken to be considered valid.

Sodium (Na)

level is primarily a determinant of extracellular fluid volume. Hypernatremia (excess sodium in the extra-cellular fluid) is relatively common with individuals (adult and children) who depend on others to control their water intake. Hyponatremia can result from extra-cellular concentration imbalances due to excess fluid (hypervolemia) and dehydration (hypovolemia). The loss of sodium ions due to severe diarrhea, emesis, and profound sweating could lead to a dehydrated state and subsequent hypovolemic concentration imbalance.

Reference Ranges (mEq/L)[3] *unless otherwise cited*

Premature infant: 132-140[35]
Newborn: 134-144
Infant: 134-150
Child: 136-145
Adult/older adult: 136-145

Possible Critical Values: < 120 or > 160

Trending Upward	Causes[3] *unless otherwise cited*	Presentation[48] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Hypernatremia	Hypovolemia (gastrointestinal and free body water loss) Sodium overload Endocrine disorders *Additional Pediatric Considerations to above[49]:* Inadequate intake in breastfeeding infants Incorrect infant formula preparation.	Thirst[3] Confusion Irritability Hyperreflexia Seizure Coma Tachycardia Hypotension Oliguria *Additional Pediatric Considerations to above[49]:* Infant: ○ High-pitched cry ○ Tachypnea Child: ○ Restlessness ○ Weakness ○ Fever	Assess and monitor cardiac rhythm, vital signs, and symptoms closely. Patients at risk for tachycardia and hypotension may have decreased activity tolerance. Assess and monitor for cognitive and neurologic impairment. Consider referral to other providers as appropriate.[48] Collaborate with the interprofessional team about fluid intake, especially for patients with difficulty communicating needs. Consider seizure precautions. *Additional Pediatric Considerations to above[49]:* Monitor infants and children with neurodevelopmental impairment for excessive urine output (frequently soaked diapers) as they may be unable to communicate thirst.

Trending Downward	Causes[48]	Presentation[48]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Hyponatremia	Hypervolemia and hypovolemia Severe GI loss Dehydration Diuretics Renal or hepatic disease Gastrointestinal disorders Hypotonic IV administration	Headache Lethargy Hyporeflexia Seizure Coma Orthostatic hypotension Pitting edema Confusion Weakness Nausea	Assess and monitor for cognitive impairment due to increased risk for altered mental status. Consider referral to other providers as appropriate.[48] Provide fall prevention screening and intervention as needed due to increased fall risk. Monitor for orthostatic hypotension. Educate patient/caregiver on recognizing symptoms, avoiding quick postural changes, and monitoring blood pressure in the presence of orthostasis or dizziness. Consider seizure precautions.

Potassium (K) is important for the function of excitable cells including nerve, muscle, and cardiac tissues. Due to limited potassium in extracellular fluid, small concentration differences can cause profound changes at the cellular level. Values outside of reference range are associated with cardiac abnormalities.[48]

Reference Ranges (mEq/L)[3]

Newborn: 3.9-5.9
Infant: 4.1-5.3
Child: 3.4-4.7
Adult/older adult: 3.5-5.0

Possible Critical Values: newborn < 2.5 or > 8 adult: < 2.5 or > 6.5

Trending Upward	Causes[48]	Presentation[48] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Hyperkalemia	Excess K supplementation (IV, oral, dietary) Renal failure Metabolic acidosis Diabetic acidosis Blood transfusion	Muscle weakness or paralysis Muscle tenderness[49] Paresthesia Dysrhythmia Bradycardia	Collaborate with the interprofessional team in the presence of critical hyperkalemia. Patients with levels > 5 mEq/L are at increased risk for dysrhythmia and acute cardiac events: Monitor cardiac rhythm, vital signs, and symptoms closely, considering possible decreased activity tolerance.[48] Assess and monitor for an acute decline in muscle strength and performance that occurs in an ascending pattern and may progress to flaccid paralysis.[49,50]

Trending Downward	Causes[48]	Presentation[48]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Hypokalemia**	Fluid overload Renal dysfunction Gastrointestinal disorders Diuretics Alcoholism Hormonal and endocrine disorders Cystic fibrosis	Extremity weakness Hyporeflexia Paresthesia Leg cramps Dysrhythmia Hypotension	Collaborate with the interprofessional team in the presence of critical hypokalemia. Patients with levels < 2.5 mEq/L are at increased risk for dysrhythmia and acute cardiac events: Monitor cardiac rhythm, vital signs, and symptoms closely, considering possible decreased activity tolerance.[50] Assess and monitor for an acute decline in muscle strength and performance that occurs in an ascending pattern and may progress to flaccid paralysis.[50,51]

Calcium (Ca) is important for bone formation, cell division and growth, blood coagulation, neurotransmitter release, and muscle contraction. As levels of phosphorus in the blood rise, levels of calcium in the blood fall because phosphorus binds to calcium reducing the available free calcium in the blood.[48]

Reference Ranges (mg/dL)[3]

Total Calcium

Infant < 10 days old: 7.6 -10.4
10 days old-2 years: 9-10.6
Child > 2 years: 8.8-10.8
Adult: 9-10.5

Possible Critical Values: < 6 or > 13

Trending Upward	Causes[48]	Presentation[48] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Hypercalcemia**	Excessive release of calcium into the blood Dehydration Endocrine and hormonal disorders Gastrointestinal disorders Excessive vitamin D Supplements/Antacids Cancer Immobilization	Hyporeflexia Muscle weakness Ventricular dysrhythmia Lethargy Constipation Nausea/vomiting Bone pain *Additional Pediatric Considerations to above[52]:* ○ Hypotonia ○ Poor feeding ○ Abdominal pain ○ Failure to thrive ○ Polyuria ○ Seizures ○ Psychiatric symptoms (older children and adolescents)	Assess and monitor cardiac rhythm, vital signs, and symptoms closely. Patients at risk for cardiac events may have decreased activity tolerance. Assess and monitor for acute decline in muscle strength and performance. Patients undergoing cancer treatment are at risk for hypercalcemia. Alert the interprofessional team if there are concerning signs or symptoms, this is deemed an oncologic emergency. Consider seizure precautions. *Additional Pediatric Considerations to above[52]:* Assess and monitor for developmental delay.

Trending Downward	Causes[48] *unless otherwise cited*	Presentation[48] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Hypocalcemia	Chronic kidney disease (CKD) Sepsis Malnutrition Malabsorption Pancreatitis Laxative use *Additional Pediatric Considerations to above*[3] *unless otherwise cited :* ○ Hyperalbuminemia ○ Rickets ○ Vitamin D deficiency ○ Osteomalacia ○ Alkalosis ○ Hyperphosphatemia due to renal failure or cytotoxic drugs[35]	Confusion Muscle cramps Hyperreflexia Dysrhythmia Paresthesia Agitation Seizure Fatigue *Additional Pediatric Considerations to above:* ○ Impaired skin and bone growth[53] ○ Poor feeding[52]	Monitor cardiac rhythm, vital signs, and symptoms closely, considering possible decreased activity tolerance. Assess and monitor for acute decline in muscle strength and performance. Cognitive and sensory impairments may decrease independence and safety and increase fall risk. Provide patient/caregiver education to mitigate risk. Consider referral to other providers as appropriate. Long-term deficiency can lead to cataracts and impaired vision. Consider associated fall risk. For patients with osteopenia, utilize safe handling precautions (hand placement, minimize torque, maintaining alignment) due to increased fracture risk. Consider seizure precautions.

Chloride (Cl) is important for fluid balance and acid base status. Renal function plays an important role in the regulation of chloride concentration through a variety of transport mechanisms.

Reference Ranges (mEq/L)[3]

Premature infant: 95-110
Newborn: 96-106
Child: 90-110
Adult: 98-106

Possible Critical Values: < 80 or > 115

Trending Upward	Causes[3]	Presentation[48]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Hyperchloremia	Dehydration Renal impairment Endocrine and hormonal disorders Multiple myeloma Hyperosmolarity	Lethargy Weakness Edema Hypertension Tachycardia Tachypnea Dyspnea	Assess and monitor cardiac rhythm, blood pressure, and respiratory status. Patients at risk for tachycardia, hypertension, dyspnea, and tachypnea may have decreased activity tolerance. Assess and monitor for an acute decline in muscle strength and performance. Assess and monitor the level of consciousness. Consider referral to other providers as appropriate.[48]

Trending Downward	Causes[3] *unless otherwise cited*	Presentation[3] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Hypochloremia**	Fluid overload Low salt diet Diuretics Burns Heart Failure Aldosteronism Excessive GI loss Syndrome of inappropriate antidiuretic hormone secretion (SIADH) Addison disease Respiratory acidosis *Additional Pediatric Considerations to above[54]:* Diuretics for treatment of bronchopulmonary dysplasia and other pulmonary conditions of preterm infants.	Agitation Irritability Muscle cramping Hypertonia Hyperreflexia Tetany Hypotension *Additional Pediatric Considerations to above[54]:* ○ Failure to thrive ○ Lethargy ○ Poor cognitive function and at risk for deficient language skills.	Assess for neuromuscular impairments and associated decreased muscle strength and performance. Monitor vital signs including blood pressure and patient symptoms due to risk for hypotension.

Phosphate (PO_4) is necessary for bone formation, acid-base balance, storage, and transfer of energy. The majority of total body phosphate resides in bone as part of the mineralized extracellular matrix. As levels of phosphorus in the blood rise, levels of calcium in the blood fall because phosphorus binds to calcium reducing the available free calcium in the blood.

Reference Ranges (mg/dL)[3]

Newborn: 4.3-9.3 Child: 4.5-6.5 Adult: 3.0-4.5 *Older adult: values slightly lower than adult*

Possible Critical Values: < 1.0

Trending Upward	Causes[3] *unless otherwise cited*	Presentation[48]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Hyperphosphatemia**	Renal impairment Excessive laxatives with PO_4 Rhabdomyolysis Tumor lysis syndrome Hypoparathyroidism Hypocalcemia *Additional Pediatric Considerations to above[35]:* ○ Healing fractures ○ Vitamin D toxicity in breastfed infants	Often asymptomatic Confusion Muscle weakness Muscle cramps Paresthesia Subcutaneous nodules	Assess for neuromuscular impairments and associated decreased muscle strength and performance. Cognitive, sensory, and motor impairments may decrease safety and independence and increase fall risk. Provide patient and caregiver education to mitigate risk. Consider referral to other providers as appropriate.

Trending Downward	Causes[3] *unless otherwise cited*	Presentation[48]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Hypophosphatemia**	Malnutrition Alcoholism Hyperparathyroidism Antacids Diabetic acidosis Vitamin D deficiency Sepsis *Additional Pediatric Considerations to above[3,35]:* Rickets	Often asymptomatic Confusion Fatigue Muscle weakness (proximal skeletal myopathy) Dysphagia Bone and muscle pain	Cognitive and neuromuscular impairments may decrease safety and independence and increase fall risk. Provide patient/caregiver education to mitigate risk. Consider referral to other providers as appropriate. Monitor pain level. Provide multimodal treatment and patient education.

Magnesium (Mg) is concentrated in bone and muscle tissues and is primarily regulated by the kidneys. It is important for blood pressure control, bone strength, and heart rhythm.

Reference Ranges (mEq/L)[3]

Newborn: 1.4-2 Child: 1.4-1.7 Adult: 1.3-2

Possible Critical Values: < 0.5 or > 3

Trending Upward	Causes[3] *unless otherwise cited*	Presentation[48] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Hypermagnesemia**	Renal Failure Oliguria Increased magnesium intake (IV, oral, enema) Endocrine disorders Diabetic ketoacidosis	Nausea/vomiting Hyporeflexia Hypotonia Somnolence Bradycardia Dysrhythmia Hypotension Respiratory depression[35] *Additional Pediatric Considerations to above[35]:* Decreased GI motility	Monitor cardiac rhythm, SpO_2, and vital signs closely, considering possible decreased activity tolerance. Patients may be at risk for acute cardiopulmonary events. Assess for neuromuscular impairments and associated decreased muscle strength and performance.

Trending Downward	Causes[3] *unless otherwise cited*	Presentation[48] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Hypomagnesemia	Malnutrition Malabsorption Chronic alcohol use Diuretics Chronic renal disease[35] Diabetic acidosis[35]	Hypertonia[55] Hyperreflexia Tremors Muscle cramping[55] Seizures Apathy Nystagmus Dysrhythmias *Additional Pediatric Considerations to above[56]:* Jitteriness	Monitor cardiac rhythm, vital signs, and symptoms closely, considering possible decreased activity tolerance. Patients may be at risk for dysrhythmias and acute cardiac events. Assess for neuromuscular impairments and associated decreased muscle strength and performance. Consider seizure precautions.

4. Muscular Disorders

Creatine Kinase (CK) is an enzyme found in skeletal and cardiac muscle, with lesser amounts in the brain. CK is released into the blood when the skeletal muscle (CK-MM), cardiac muscle (CK-MB), or brain tissue (CK-BB) is injured. A CK test is used to diagnose and monitor muscular injuries and diseases, including rhabdomyolysis and muscular dystrophy. In the past, CK-MB was used to diagnose acute MI but is now largely replaced by troponin. CK-BB has a limited clinical application; this value is elevated with injury or disease to the brain or lung tissue.[3]

Creatine Kinase (CK) is commonly used to diagnose and monitor muscle disease or injury. Rhabdomyolysis is a condition that is characterized by muscle necrosis and the release of CK into circulation (primarily CK-MM). It can be caused by traumatic injuries, and metabolic etiologies, such as drugs, toxins, and myopathies.[57] Exertional rhabdomyolysis is caused by intense, prolonged, or repetitive muscle overload and is suspected in patients with elevated CK in the setting of recent exercise. Severe cases of exertional rhabdomyolysis may result in complications such as compartment syndrome, renal failure, disseminated intravascular coagulation, and cardiac dysrhythmia.[58] With rhabdomyolysis, CK levels are typically over five times the normal value range (> 5 times the upper limit of normal.[3,58] CK may rise within 12 hours of injury, peak within 24-72 hours, and return to normal in approximately 5 days depending on the type and severity of the injury.[57]

CK-MB for the assessment of acute MI has largely been replaced by troponin. When troponin is available, CK-MB is not recommended for use, given that it is less sensitive and specific.[3,59]

When determining the appropriateness for physical therapy intervention, consult with the interprofessional team as needed, assess vital signs (Adult Vital Sign Interpretation in Acute Care Guide 2021),[28] and use a symptom-based approach to treatment.

Reference Ranges[35]

Infants: two to three times adult values
Men: 38-174 U/L
Women: 26-140 U/L

MM (CK_3): 96%-100% or 0.96-1.00
MB (CK_2): 0%-6% or 0.00-0.06
BB (CK_1): 0%-0.00

Trending Upward	Causes[3]	Presentation[3] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Creatine Kinase 	**Total CK level** Disease or injury affecting the heart, skeletal muscle, or brain **CK-MM** Rhabdomyolysis Muscular dystrophy Myositis Drug-induced myopathies Hypothyroidism **CK-MB** Acute MI and cardiac ischemia Cardiac surgery Arrhythmia, defibrillation, cardioversion Inflammatory myopathy Muscular dystrophy	Weakness[60] Muscle pain Myoglobinuria (tea-colored urine)	Discuss overall medical management with interprofessional team to determine optimal timing for initiation of physical therapy. Avoid overexertion and use a symptom-based approach to treatment in patients with rhabdomyolysis, prioritize preserving range of motion.[61] Monitor the patient for complications of rhabdomyolysis, including compartment syndrome (pulses, neurological function, and reports of increasing pain.)[58] Consider overall medical status, including vital signs and other medical conditions, location of dialysis catheter and type of dialysis provided in patients with renal failure.

	CK-BB CNS diseases Adenocarcinoma (breast and lung) Pulmonary infarction		Monitor vital signs and cardiac rhythm during physical therapy intervention because rhabdomyolysis can be associated with electrolyte disturbances. Collaborate with the interprofessional team regarding cardiac evaluation and stability. Monitor vital signs and cardiac rhythm throughout the physical therapy intervention.

5. Kidney Function

The **Kidney Function Tests** are included in the Basic Metabolic Panel (BMP) to identify a person at risk of developing kidney disease or to follow individuals with known diseases.

Monitor vital signs (Adult Vital Sign Interpretation in Acute Care Guide 2021),[28] use a symptom-based approach, and collaborate with the interprofessional team regarding risk vs. benefit of physical therapy intervention for patients with abnormal findings in the context of the complex clinical condition.

Blood Urea Nitrogen (BUN) is the nitrogen portion of urea. Measurement evaluates the metabolic function of the liver and excretory kidney function of urea.

Reference Ranges (mg/dL)[3]

Newborn: 3-12 Infant/child: 5-18 Adult: 10-20

Possible Critical Value: > 100 indicates serious impairment in renal function.

- Adult BUN/creatinine ratio is 6-25 mg/dL
- Older adult may be slightly higher.
- For pediatrics: BUN will be stable in chronic renal disease and rise with acute kidney injury.[62]

Trending Upward

Causes[3] *unless otherwise cited*	Presentation[63] *unless otherwise cited*	Clinical Implications
Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
High-protein diet Enteral/Total parenteral nutrition[62] Heart failure Chronic kidney disease Hypovolemia[64] GI Bleed[62] Sepsis[62] Shock[62] Increased protein catabolism[62] Burns[62] Ureteral obstruction Nephrotoxic medications[62] *Additional Adult Consideration to above:* Myocardial infarction	Edema[64] Hypertension[64] Fatigue Weakness Oliguria Polydipsia Bruise (easily) Pruritis Poor appetite Nausea/Vomiting Confusion Muscle cramps	Assess integumentary system, inspecting for edema, skin lesions, and wounds. Assess and monitor for cognitive impairment due to increased risk for altered mental status. Consider referral to other providers as appropriate.[63] Adjust mode of communication and education as needed for patients with impaired cognition.[1] Monitor for fatigue during physical therapy intervention and educate regarding interval training and energy conservation. Consider using the Borg RPE scale or dyspnea scale in addition to vital sign monitoring with activity progression and symptom presentation.[63] Educate regarding lifestyle modification to promote health, wellness, and movement.[63] Provide fall prevention screening and intervention as indicated due to increased fall risk associated with strength and cognitive impairments.[63]

Trending Downward	Causes[3]	Presentation[48]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
	Hepatic disease Malnutrition and/or malabsorption Syndrome of inappropriate antidiuretic hormone secretion	Nausea/vomiting Headache Confusion Weakness Fatigue	Collaborate with the interprofessional team regarding fluid intake and recording output.

Serum Creatinine is a catabolic product of creatine phosphokinase which is used in skeletal muscle contraction. Excreted entirely by the kidneys, serum creatinine is a direct measurement of glomerular filtration rate and renal function.

Reference Ranges (mg/dL)[3]

Newborn: 0.3-1.2
Infant: 0.2-0.4
Child: 0.3-0.7
Adolescent: 0.5-1.0

Adult:
Male: 0.6-1.2
Female: 0.5-1.1

Possible Critical Value: > 4 indicates serious impairment in renal function.

>/= 0.3 mg/dL or >/= 50% increase from baseline indicates acute kidney injury in pediatric population but is a less sensitive indicator to identify reduced glomerular filtration.[62,64,65]

Trending Upward	Causes[3] *unless otherwise cited*	Presentation[64,66] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
	Renal disease[35,64] Diabetic nephropathy Rhabdomyolysis Muscle trauma induced by seizure or surgery[66] Dehydration[66] Medications Urinary tract obstruction Renal transplant rejection Endocrine disorders[66] Polymyositis[62,66] Acute effects of exercise[66] Heart failure[66]	Edema Dyspnea Abdominal/back pain Arthralgia Myalgia Myopathy Fatigue/malaise[62] Insomnia Headache Confusion Pruritis	Monitor for fatigue during physical therapy intervention and educate regarding interval training and energy conservation. Consider using the Borg RPE scale or dyspnea scale in addition to vital sign monitoring with activity progression and symptom presentation.[63] Auscultate lungs due to fluid retention and utilize the dyspnea scale for safe exercise prescription. Collaborate with the interprofessional team regarding fluid intake and/or restriction.[64,66] Assess and monitor for cognitive impairment due to increased risk for altered mental status change. Consider referral to other providers as appropriate.[63] Adjust mode of communication and education as needed for patients with impaired cognition.[1] Monitor pain level. Provide multimodal treatment and patient education.

Trending Downward	Causes[3] *unless otherwise cited*	Presentation[3]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
	Debilitation Decreased muscle mass (aging, muscular dystrophy, myasthenia gravis)[64]	Fatigue (this is uncommon; can be a precursor to autoimmune disease)	Monitor for fatigue and modify physical therapy intervention and educate regarding interval training and energy conservation. Consider using the Borg RPE scale or dyspnea scale in addition to vital sign monitoring with activity progression and symptom presentation.[63]

6. Endocrine Function

Many **Endocrine Function Tests** are used as screening tools to assess hormonal function when an individual has symptoms of fatigue and weakness. These hormones are essential for mental and physiological well-being and govern energy metabolism. Glucose, hemoglobin A1c (HbA1c) and thyroid function will be covered in this document. For other endocrine function tests which impact the care of the patient, collaborate with the interprofessional team.

Monitor vital signs (Adult Vital Sign Interpretation in Acute Care Guide 2021),[28] use a symptom-based approach, and collaborate with the interprofessional team regarding risk vs. benefit of physical therapy intervention for patients with abnormal findings in the context of the complex clinical condition.

Glucose is the body's major energy source primarily obtained from the diet but can also be synthesized from amino acids. A fasting plasma glucose (FPG) test is a measure of blood sugar level during a fasting state or over a designated time period. Collaboration with the interprofessional team is needed as ongoing management should be guided by the assessment of overall health status, diabetes complication, cardiovascular risk, and hypoglycemia risk. Patients with hyperglycemia in acute care with or without a prior diagnosis of diabetes, demonstrate increased risk of complications and mortality, longer hospitalizations and higher admission rates to the intensive care units.[67] Hyperglycemia can be a result of underlying disease but also stress and inflammation may contribute to increased glucose levels. Therefore, the American Diabetes Association (ADA) has updated the glucose target recommendations for better management of hyperglycemia while addressing concerns for hypoglycemia.[68] Less stringent HbA1c goals may be necessary for patients who cannot articulate symptoms of hypoglycemia, multiple comorbidities, cognitive impairment, or functional dependence. Due to an increasing incidence in type 2 diabetes in children, the interprofessional team should monitor for signs/symptoms of diabetes, such as increased thirst and urination. Individuals with cystic fibrosis may be asymptomatic, so it is essential to collaborate with the interprofessional team regarding blood glucose levels for safe exercise prescription. In collaboration with the interprofessional team, PTs and PTAs should monitor glucose levels before and after exercise. Additionally, PTs and PTAs should observe for signs and symptoms of hypoglycemia, especially in individuals with newly diagnosed or poorly controlled glucose levels. Blood glucose monitoring and continuous glucose monitoring can be useful to guide physical activity and prevent hypoglycemia.

Reference Ranges (mg/dL)[3]

Premature infant: 20-60
Neonate: 30-60
Infant: 40-90
Child < 2 years: 60-100

Child > 2 years to adult:
Fasting (no caloric intake for at least 8 hours): 70-110
Casual (any time of day regardless of food intake): < 200
Adult: 74-106
Older adult: 60-90 years: 82-115 > 90 years: 75-121

2-Hour Postprandial Glucose (PPG):
0-50 years: < 140
50-60 years: < 150
> 60 years: < 160

1-Hour Glucose Screen for Gestational Diabetes: < 140

Glycemic targets for Hospitalized Patients[69]
- Target glucose range (majority of critically ill and noncritically ill patients): 140-180
- More stringent goals without significant hypoglycemia: 110-140

Levels of Hypoglycemia[70]
- Level 1: < 70
- Level 2: < 54
- Level 3: severe hypoglycemic event characterized by altered mental and/or physical status that requires assistance for resolution

Possible Critical Values[3]: newborn: < 30 or > 300 infant: < 40 child/adult: < 50 or > 400

Hemoglobin A1c (HbA1c) shows the average level of blood glucose control over the previous 120 days.

Reference Ranges[71] *unless otherwise cited*

Normal: < 5.7%
Pre-diabetes mellitus: 5.7%-6.4%
With diabetes mellitus: > 6.5%

Healthy older adults[72]: < 7.0-7.5%
Older adults with multiple comorbidities, physical, or cognitive impairments[72]: < 8.0-8.5%

Criteria for the Diagnosis of Pre-Diabetes and Diabetes[71]

Prediabetes:
FPG 100-125 mg/dL OR
2-hour plasma glucose 140-199 mg/dL during oral glucose tolerance test OR HbA1c 5.7%-6.4%

Diabetes:
FPG ≥ 126 mg/dL OR 2-hour plasma glucose ≥ 200 mg/dL during oral glucose tolerance test OR HbA1c ≥ 6.5% OR a patient with classic symptoms of hyperglycemia OR hyperglycemic crisis, random plasma glucose ≥ 200 mg/dL

Trending Upward	Causes[3]	Presentation[1] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Hyperglycemia**	Diabetes mellitus Acute stress response (general anesthesia, stroke, MI, strenuous exercise, burns) Cushing syndrome Cystic fibrosis Chronic kidney disease IV fluids Acute pancreatitis Medications	**Types 1 and 2:** Polyuria Polydipsia Blurred vision Weakness Fatigue Dizziness **Type 1:** Ketonuria Weight loss Excessive hunger Type 2 often asymptomatic detected through labs, non-healing wounds, or infection[72] **Diabetic Ketoacidosis:** Nausea/vomiting Fruity breath Confusion Weak/rapid pulse Kussmaul respiration **Chronic hyperglycemia:** Chronic kidney disease Peripheral neuropathy Retinopathy Cardiovascular disease (myocardial infarction, stroke) Peripheral vascular disease Non-traumatic amputations	Due to the increased risk of hyperglycemia, monitor glucose levels in patients receiving immunosuppressants following organ transplantation, as well as with patient who are initiating or altering antiretroviral therapy.[71] Assess for peripheral arterial disease prior to initiation of compression or sharp debridement.[72] Assess integumentary system for edema, skin lesions, and wounds.[73–75] Assess for loss of protective sensation.[72,74] Educate regarding appropriate footwear and foot self-care.[72] Educate regarding lifestyle modifications, including exercise (aerobic, muscle/bone strengthening), glucose control, as well as monitoring blood glucose before, during, and after exercise.[71,72,74,76] Due to risk of ketoacidosis, it is recommended to collaborate with the interprofessional team to test for ketones if blood glucose is > 250 mg/dL. Intense exercise in the presence of moderate to large amounts of ketone (per facility guidelines) in the urine may exaggerate hyperglycemia.[77]

			Additional Pediatric Considerations to above[78,79]*:* Collaborate with the interprofessional team regarding blood glucose targets prior to physical activity to mitigate hypoglycemic response. Blood glucose targets for pediatrics should be 126-180 mg/dL prior to initiation of exercise, however, should be individualized based on the type, intensity, and duration of activity.
Trending Downward **Hypoglycemia**	**Causes**[35]	**Presentation**[1]	**Clinical Implications**
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
	Excess insulin Hypopituitarism Hypothyroidism Addison's disease Malnutrition Alcoholism	Perspiration Weakness Pallor Nervousness Seizure Lethargy Irritability Tachycardia Palpitation Altered mental status Hunger Headache Shaking Blurred vision Loss of consciousness	Consult with the interprofessional team if blood glucose < 100 mg/dL prior to physical therapy intervention. May need to ingest 15-30g of fast acting carbohydrate prior to activity.[74,76,77] Educate patient/caregiver to monitor blood glucose before, during and after exercise. May also include strategies to prevent, detect, and treat hypoglycemia.[74,76] Monitor blood glucose prior to the activity as some patients may experience hypoglycemia unawareness.[70] Provide fall prevention screening and intervention as indicated due to increased fall risk.[74] Assess and monitor for cognitive impairment due to increased risk for altered mental status. Consider referral to other providers as appropriate.[70,72] Monitor patients who cannot articulate their symptoms, have hypoglycemia unawareness, lack access to analog insulins, advanced insulin delivery technology, and/or continuous glucose monitoring. Less stringent HbA1c goals (such as 7.5%) may be appropriate.[76]

Thyroid Function Tests diagnose or monitor patients with known or new-onset hypothyroidism or hyperthyroidism. Additionally, these tests screen for changes in thyroid hormone levels which can have a direct effect on energy metabolism, muscle strength, and metabolic function. TSH, T3, and T4 are important markers which affect the musculoskeletal and cardiovascular systems and can differentiate between hyperthyroidism, primary, and secondary hypothyroidism. Serum TSH levels peak as much as 70 mIU/L within the first 24 hours of life due to stress and then rapidly drop to less than 10 mIU/L within the first 3 days. After the neonatal period, TSH levels are less than 6 mIU/L. Serum TSH levels are often mildly abnormal (≤ 7 mIU/L) in children and adolescents who are morbidly obese.

Thyroid Stimulating Hormone (TSH) is an important marker to differentiate between primary (associated with thyroid gland) and secondary (associated with hypothalamus and pituitary) hypothyroidism.

Reference Ranges

Newborn[3,64]: 3-18 mIU/L
Child/Adult[80–82]: 0.4-4.5 mU/L

Thyroxine (T4) includes free and bound T4. Most of the T4 hormone is bound to plasma protein (thyroid binding globulin) while the remaining is free T4 hormone.

Reference Ranges (mcg/dL)[3]

Child:
- 1-3 days: 11-22
- 1-2 weeks: 10-16
- 1-12 months: 8-16
- 1-5 years: 7-15
- 5-10 years: 6-13
- 10-15 years: 5-12

Adult < 60 years:
- Male: 4-12
- Female: 5-12

Adult > 60 years: 5-11

Pregnancy: 9-14

Free T4 is the amount of hormone not bound and able to affect body systems. Free T4 level is a more accurate tool for measuring how the thyroid gland is functioning.[83]

Reference Ranges (ng/dL)

Child[3,64]:
- 0-4 days: 2-6
- 2 weeks-20 years: 0.8-2

Adult[83]: 0.75-1.50

Triiodothyronine (T3) measurement is used to diagnose hyperthyroidism.

Reference Ranges (ng/dL)

Child[64]:
- 1-3 days: 100-740
- 1 month-5 years: 105-270
- > 5 years: 80-215

Adult[3]:
- 20-50 years: 70-205
- > 50 years: 40-180

HYPERTHYROIDISM	Causes[3]	Presentation[1] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Trending Down TSH  **Trending Up T3 and T4** 	Grave's disease Thyroiditis Thyroid adenoma	Tremors Nervousness Muscle weakness Muscle atrophy Chronic periarthritis Fatigue Tachycardia Atrial fibrillation Respiratory muscle weakness Tachypnea Hypotension Weight loss Dysphagia Polyuria Diarrhea Photophobia Heat intolerance Goiter *Additional Pediatric Considerations to above[64]:* Newborns: ○ Irritability ○ Wide-eye stares ○ Poor feeding and weight gain ○ Insomnia ○ Hepatosplenomegaly ○ Jaundice ○ Craniosynostosis Children: ○ Developmental delays ○ Behavior changes ○ Poor academic performance ○ Poor weight gain ○ Increased appetite ○ Frequent stools ○ Vomiting	Monitor cardiac rhythm due to increased risk for atrial fibrillation with trending up T4 levels.[83] Monitor for symptoms of palpitations and nervousness. Consider modification of physical therapy intervention and referral to other providers as appropriate. Educate patients to avoid exercise in hot settings, including outdoors and indoor pools. Assess for multisystem impairments as a hypermetabolic state may result in dysrhythmia, hypotension, weakness, muscle atrophy, and unintentional weight loss. Educate about signs and symptoms and safe exercise prescription. Consider referral to other providers as appropriate.[84] *Additional Pediatric Considerations to above[64]:* Monitor for signs/symptoms of developmental delay in infant/child with hyperthyroidism

HYPOTHYROIDISM	Causes[3]	Presentation[1] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
PRIMARY **Trending Down T4** ↓ **Normal or Trending Up TSH** ↑ **SECONDARY** **Trending Down T4 & TSH** ↓	**Primary:** Thyroiditis (Hashimoto's) Congenital disease Large doses of iodine Radiation to head and neck region Severe and chronic illness **Secondary:** Pituitary tumor Pituitary dysfunction	Proximal muscle weakness Myalgia/trigger points Poor wound healing Delayed glucose uptake and absorption Weight gain Constipation Bruising easily Dyspnea Respiratory muscle weakness Severe atherosclerosis Angina Hypertension Fatigue Slow mental function Headache Anxiety/depression Cold intolerance Carpal Tunnel Syndrome *Additional Pediatric Considerations to above[64]:* Newborns: ○ Decreased cognitive functioning if left untreated ○ Protuberant tongue ○ Widened posterior fontanels ○ Dry skin ○ Hypotonia ○ Bradycardia ○ Cool extremities ○ Difficulty feeding ○ Hoarse cry Children: ○ Delayed puberty ○ Poor growth velocity ○ Decreased pulse strength ○ Bradycardia ○ Delayed bone age on radiograph	Monitor for signs of hyperthyroidism if the patient is on thyroid replacement therapy. Assess integumentary system, inspecting for edema, skin lesions, and wounds. Dry, edematous skin is prone to breakdown. Provide fall prevention screening and intervention as indicated for older adult patients, as long-term thyroid replacement therapy may increase the risk for osteoporosis. Assess for multisystem impairments as a hypometabolic state may result in elevated blood pressure, respiratory impairment, weakness, myalgia, cold intolerance, poor glycemic control and weight gain. Educate regarding safe exercise prescription. Consider referral to other providers as appropriate.[84]

7. Arterial Blood Gases (ABGs)

Arterial Blood Gases (ABGs) measure acid-base balance and oxygenation status. ABGs may be used to identify and monitor acid-base disturbances, measure the partial pressures of oxygen and carbon dioxide, and assess the patient's response to medical interventions. Primary acid-base disturbances are defined as metabolic or respiratory based on the clinical context and whether the change in pH is due to an alteration in serum HCO_3 or in $PaCO_2$. There are four primary acid-base disorders: respiratory alkalosis, respiratory acidosis, metabolic alkalosis, and metabolic acidosis.

Acid-base disturbances result in compensation to normalize the pH and maintain homeostasis. There are limited signs and symptoms noted with mild acid-base disturbances. However, severe uncompensated acid-base disturbances can result in cardiovascular, respiratory, neurologic, and metabolic consequences.[85]

When determining the appropriateness for activity, assess vital signs (Adult Vital Sign Interpretation in Acute Care Guide 2021)[28] and use a symptom-based approach to treatment. Collaborate with the interprofessional team regarding risk vs. benefit of physical therapy intervention for patients with abnormal findings in the context of the complex clinical condition.

Arterial Blood Gases (ABGs) are used to evaluate a patient's ventilatory, acid-base, and oxygenation status. ABGs may be used to monitor patients on mechanical ventilation and those with critical illness.

Reference Ranges[3]

pH:
Newborn: 7.32-7.49
2 months-2 years: 7.34-7.41
Child/adult: 7.35-7.45
pH (venous): 7.31-7.41

$PaCO_2$ (mmHg):
Child < 2 years: 26-41
Child/adult: 35-45
$PaCO_2$ (venous): 40-50

HCO_3 (mEq/L):
Newborn/infant: 16-24
Child/adult: 21-28

PaO_2 (mmHg):
Newborn: 60-70
Adult: 80-100
PaO_2 (venous): 40-50

Possible Critical Values: pH: < 7.25 or > 7.55 $PaCO_2$: < 20 or > 60 HCO3: < 15 or > 40 PaO_2: < 40
Base excess: ± 3

Uncompensated Acid Base Disturbances	pH	$PaCO_2$ mmHg	HCO_3 mEq/L	Causes[3] *unless otherwise cited*	Presentation[86]	Clinical Implications
				Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Respiratory Alkalosis	↑	↓	**Normal**	Hyperventilation (emotions, pain, fever, excessive mechanical ventilation) Salicylates[86]	Lightheaded Dyspnea Paresthesia Chest tightness Seizure	Monitor vital signs, breathing pattern, and respiratory status for any signs of clinical deterioration. Consider underlying cause, ABG trend, and medical stability when developing a plan of care.
Respiratory Acidosis	↓	↑	**Normal**	Respiratory depression (medications, CNS trauma) Pulmonary disease (pneumonia, COPD, cystic fibrosis, asthma)	Anxiety Confusion Fatigue/lethargy Tachypnea Coma Seizure	Monitor vital signs, breathing pattern, and respiratory status for any signs of clinical deterioration. Consider underlying cause, ABG trend, and medical stability when developing a plan of care.

Uncompensated Acid Base Disturbances	pH	$PaCO_2$ mmHg	HCO_3 mEq/L	Causes[3] *unless otherwise cited*	Presentation[87] *unless otherwise citied*	Clinical Implications
				Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Metabolic Alkalosis	↑	**Normal**	↑	Sodium bicarbonate overdose Prolonged vomiting Nasogastric drainage Cystic fibrosis[86]	Confusion Delirium Dysrhythmias Hypotension Muscle cramping	Monitor vital signs and cardiac rhythm throughout the physical therapy intervention. Assess and monitor for cognitive impairment due to increased risk for altered mental status. Consider referral to other providers as appropriate. Adjust mode of communication and education as needed for patients with impaired cognition.[1]
Metabolic Acidosis	↓	**Normal**	↓	Diabetes Shock Renal failure Intestinal fistula	Dyspnea (Kussmaul breathing)[88] Fatigue Nausea/vomiting Tachyarrhythmias Hypotension	Monitor breathing pattern, respiratory status, vital signs, and cardiac rhythm during physical therapy intervention; take a symptom-based approach to treatment. Consider using the Borg RPE scale or dyspnea scale in addition to vital sign monitoring with activity progression and symptom presentation.[63] Collaborate with the interprofessional team to determine if a patient on dialysis is appropriate for intradialytic intervention.[89–92]

Anion Gap is a blood test to determine the difference between free cations and free anions. The anion gap is often used to identify the cause of metabolic acidosis. Most metabolic acidotic states are associated with an increased anion gap. Conditions that cause decreased anion gap are rare.[3]
The major free cations are Sodium (Na+) and Potassium (K+).
The major anions are Chloride (Cl-) and Bicarbonate (HCO3-).

Reference Ranges (mEq/L)[3]

16 ± 4 if potassium is used in the calculation
12 ± 4 if potassium is not used in the calculation

Abnormal Values	Causes[3]	Presentation	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Anion Gap ↑	Ketoacidosis (diabetic, alcoholic, fasting, ketogenic diet) Lactic acidosis Renal failure	Dependent on the underlying disorder.	Consider the underlying cause of the elevated anion gap. Collaborate with the interprofessional team to determine if a patient on dialysis is appropriate for intradialytic physical therapy intervention.[90–93]

8. Liver Function/Hepatic Panel

The **Liver Function/Hepatic Panel** serum tests check the hepatocytes' enzyme levels in the blood and the liver's effectiveness in clearing bilirubin, total protein, and albumin.[1] The panel is utilized to measure the extent of liver damage, monitor the side effects of certain medications on the liver, and aid in the differential diagnosis of the liver.[93]

The significance of liver function/hepatic panel abnormality must be interpreted within the context of the patient's medical condition and presentation.[94]

Monitor vital signs such as blood pressure (Adult Vital Sign Interpretation in Acute Care Guide 2021),[28] use a symptom-based approach, and consult with the interprofessional team as needed when determining the appropriateness of physical therapy intervention in patients with abnormal liver function/hepatic panel.

Serum Albumin is a protein which is synthesized in the liver and excreted into the blood plasma. Low levels of this protein can indicate kidney and liver dysfunction, poor nutrition, and impaired wound healing.[1] Albumin's primary physiologic function is to maintain colloidal osmotic pressure in the blood. It also carries hormones, medications, and enzymes throughout the body so low albumin levels could affect serum concentration of medication. It is the less sensitive marker in assessing nutritional status due to its longer half-life of 12-18 days.[3,95]

Reference Ranges (g/dL)[3]

Premature infant: 3-4.2
Newborn: 3.5-5.4
Infant: 4.4-5.4
Child: 4-5.9
Adult/older adult: 3.5-5

Possible Critical Value[35]: < 1.5

Serum Prealbumin is a marker for measuring changes in protein synthesis and catabolism. This test routinely ordered to monitor the effectiveness of total parenteral nutrition (TPN) in critically ill patients. When compared to albumin, it is the more sensitive marker in assessing nutritional status due to its shorter half-life of 1.9 days.[3,95]

Reference Ranges (mg/dL)[3]

< 5 days: 6-21
1-5 years: 14-30
6-9 years: 15-33
10-13 years: 22-36
14-19 years: 22-45
Adult/older adult: 15-36

Possible Critical Value (adult): < 10.7 severe nutritional deficiency

Trending Upward	Causes[3] *unless otherwise cited*	Presentation[35]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
	**Hyperalbuminemia:** Dehydration[35] **Increased Prealbumin:** Nephrotic syndrome Hodgkin disease Chronic kidney disease Pregnancy	**Hyperalbuminemia:** Orthostatic hypotension Dizziness Fatigue	Provide fall prevention screening and intervention as needed due to increased fall risk. Monitor for orthostatic hypotension. Educate patient/caregiver on recognizing symptoms, avoiding quick postural changes, and monitoring blood pressure in the presence of orthostasis or dizziness.

Trending Downward	Causes[3]	Presentation[48] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
	**Hypoalbuminemia:** Acute and chronic inflammatory condition (infection, surgery, MI, severe burns) Rheumatoid diseases (i.e., systemic lupus erythematosus) Nephrotic syndrome Cirrhosis Pregnancy (levels progressively decrease throughout pregnancy until delivery) **Decreased Prealbumin:** Malnutrition Liver damage Burns Inflammation Infection	Non-healing wound[96] Peripheral edema and ascites Hypotension	Assess integumentary system, inspecting for edema, ascites, skin lesions, and wounds. Consider risk and benefit of different wound/edema management strategies based on impaired wound healing and possible poor nutrition. Provide patient education on the following topics: skin inspection, footwear inspection, skin protection, including frequent position changes, and the importance of proper nutrition to promote wound healing. This education is of particular importance when other comorbidities are present, including diabetes, peripheral neuropathy, and the aging integumentary system.[1,97] Collaborate with the interprofessional team regarding nutritional needs to ensure optimal wound healing, muscle strengthening, and improved functional capacity. *Additional Pediatric Considerations to above[98]:* Monitor newborn infants for necrotizing enterocolitis (NEC) and neonatal sepsis.

Serum Bilirubin is a blood test commonly used to assess liver health and detect and investigate newborn and adult jaundice. Bilirubin is the yellowish substance produced during the normal breakdown of red blood cells. Bilirubin passes through the liver before leaving the body, so this test measures the effectiveness of the liver in clearing a product from the blood or detecting possible obstructions.[1] Elevated bilirubin levels may lead to clinical signs of jaundice in the eyes or skin. Other laboratory panels like complete blood count (CBC) may also be ordered if elevated bilirubin is noted and excessive red blood cell destruction is suspected due to anemia.

Reference Ranges (mg/dL)[3] *unless otherwise cited*

Newborn: 1.0-12.0
Child/adult/older adult: 0.3-1.0

Possible Critical Values: Newborn: > 15 Infant[99]: > 25 (severe hyperbilirubinemia) Adult: > 12

Trending Upward	Causes[3] *unless otherwise cited*	Presentation	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Hyperbilirubinemia**	Hemolytic anemia Resolution of large hematoma Hepatitis Extrahepatic duct obstruction (tumor, inflammation, gallstones, scarring, or surgical trauma) Following blood transfusions Medications *Additional Pediatric Considerations to above[99]:* Risk factors for infant ○ Jaundice in first 24 hours of life ○ Hemolytic disease ○ Gestational age < 37 weeks ○ Significant bruising from birth trauma ○ Suboptimal breastfeeding	Yellow discoloration of body tissue (jaundice) including skin, mucus membranes, and sclera of eyes occurs when total serum bilirubin exceeds 2.5 mg/dL.[3] Jaundice usually progresses in a cephalocaudal direction.[99] Urine turns darker and stool is pale, return to normal color indicates resolution of jaundice.[1] Abdominal pain and bloating.[100] Neurologic: confusion, sleep disturbances, muscle tremors, hyperreactive reflexes, asterixis.[1] *Additional Pediatric Considerations to above[101]:* Acute bilirubin encephalopathy caused by hyperbilirubinemia presents as: ○ Early signs: lethargy, hypotonia, and poor suck ○ Intermediate signs: hypertonia, high-pitched cry, fever, irritability ○ Advanced signs: apnea, fever, seizures, coma, hypertonicity	Adjust mode of communication and education as needed for patients with impaired cognition.[1] Promote weight-bearing activities and screen for fall risk as patients with advanced disease are at risk for osteoporosis and bleeding due to deficiencies in fat-soluble vitamins.[1,102,103] Heed caution in providing high-intensity exercise during jaundice or any active liver disease. Utilize symptom-based approach.[1] *Additional Pediatric Considerations to above[99]:* Phototherapy of neonatal hyperbilirubinemia, incorporation of neuroprotective care measures into practice and handling may include: ○ Assess/monitor temperature throughout treatment. ○ Maintain eye protection. ○ Ensure most of skin is exposed under the light source unless facilitating transfers to a mother for breastfeeding. ○ Cluster therapy interventions with nursing care times. ○ Promote developmentally appropriate positioning without impacting the infant's exposure to the light source.

Ammonia (NH_3) is a waste product of protein digestion in the body and is converted to urea by the liver. It evaluates liver function and metabolism. If the liver is damaged, then increased ammonia levels are noted.[3] Elevated ammonia levels can damage the brain and other systems of the body; therefore, clinicians need to be aware of the signs and symptoms of encephalopathy.

Reference Ranges (µg/dL)[3]

Newborn: 90-150 Children: 40-80 Adult/older adult: 10-80

Trending Upward	Causes[3]	Presentation[1] *unless otherwise cited*	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
 **Hyperammonemia**	Liver disease Portal hypertension GI bleed or GI tract obstruction in mild liver disease *Additional Pediatric Considerations to above:* ○ Reye's syndrome ○ Hemolytic disease of the newborn ○ Urea cycle disorder	Hepatic encephalopathy Speech impairment Daytime sleepiness Breakdown of fine motor skills Peripheral nerve impairment *Additional Pediatric Considerations to above[104]:* Signs/symptoms of hyperammonemia usually begin 24-48 hours after feeding begins in infants and can include: ○ Lethargy, somnolence ○ Refusal to feed ○ Vomiting ○ Tachypnea with respiratory alkalosis ○ Seizures Infantile, childhood, and adult onset of hyperammonemia may present with chronic neurocognitive deficits and can include: ○ Developmental delay ○ Ataxia ○ Spasticity ○ Learning disabilities ○ Cognitive deficits ○ Unexplained seizures	Assess and monitor for cognitive impairment due to increased risk for altered mental status. Consider referral to other providers as appropriate.[48] Adjust mode of communication and education as needed for patients with impaired cognition.[1] Provide fall prevention screening and intervention as needed due to increased fall risk with encephalopathy. Patients are at higher risk for injurious falls with bleeding complications due to reduced liver production of coagulation factors. *Additional Pediatric Considerations to above[104]:* Monitor for developmental delay.

Transaminases (serum enzymes)[1,3]

Transaminases are released into the bloodstream and body tissues from hepatocytes (liver cells) after liver damage. Tests of these enzymes are not specific to liver function but provides information about hepatic injury and helps establish a differential diagnosis.

- **AST (aspartate aminotransferase)** – persistently high AST levels could indicate chronic hepatocellular disease.
- **ALT (alanine aminotransferase)** – high ALT levels assist in the diagnosis of hepatocellular disease and detection of acute liver damage from hepatitis.
- **LDH (lactate dehydrogenase)** – due to its presence in almost all tissues, LDH test elevation indicates other tissue damage or disease but is not a specific marker for liver damage.
- **GGT (gamma-glutamyl transferase)** – most sensitive test to detect liver cell dysfunction but not the specific cause.
- **ALP (alkaline phosphatase)** – sensitive test for detecting common liver and bone disorders. A marker for detecting metastatic liver tumors. Compared to adult ALP levels, elevated values may be reflective of growth and development in children.

Liver Transplantation Considerations

Model for End-Stage Liver Disease (MELD) and MELD-Na[105–107]

Serum bilirubin, serum creatinine, and international normalized ratio (INR) are laboratory measurements that are utilized to determine a score on the traditional Model for End-Stage Liver Disease (MELD) equation. The MELD score accurately predicts the three-month survival for adult patients with advanced liver disease. An increasing score is associated with severity of hepatic dysfunction and mortality. MELD scores are one of the considerations for allocation of liver transplants.[108–110]

A variation on the MELD includes the addition of sodium to the laboratory measures above and is referred to as the MELD-Na. This is used for those individuals with a MELD score of greater than 11 and aids in prognostic accuracy. The United Network for Organ Sharing (UNOS) began using the MELD-Na in prioritizing allocation of organs for those awaiting liver transplantation. [111,112]

Pediatric End-Stage Liver Disease (PELD) Statement[112]

The Pediatric End-Stage Liver Disease (PELD) predicts 90-day pre-transplant mortality for pediatric liver transplant candidates. It has been shown that patients with a PELD score of >/=17 and a UNOS status 1 have improved survival benefit within the first-year post-transplant.[113] The PELD score calculation uses Albumin, Bilirubin, INR, growth failure and age at listing whereas the MELD score uses Serum Creatinine, Bilirubin, INR and Serum Sodium for calculation.

Other Transplantation Considerations

FK Trough (Tacrolimus/Prograf test)[114]

Tacrolimus is an immunosuppressant administered with other medications to decrease the risk of organ transplantation rejection. This test is performed with solid organ transplantation. The drug is essentially fully metabolized in the liver and intestinal wall, with multiple factors affecting the pharmacokinetic and metabolic profile (age, sex, other organ impairment, diet, and concomitant medications). Physical therapists should review the FK trough (Tacrolimus/Prograf Test) to assess trends (spikes) that would create challenges for safe exercise and mobility. While the physician is establishing dosing, patients might show tremors, seizures, elevated heart rate, hypertension, blurred vision, nausea and vomiting, and ataxia with increasing trends. Therapeutic range: 6-15ng/mL

9. Lipid Panel

The **Lipid Panel** usually includes cholesterol, triglyceride, and lipoprotein levels. At healthy levels, lipids provide metabolic energy, serve as precursors to steroid hormones and bile acids, and are important for cell membrane development.[35] Abnormal levels can have detrimental systemic vascular effects. Dyslipidemia is the elevation of plasma cholesterol and/or triglycerides or a low HDL cholesterol level. As part of the lipid profile, these tests are performed to identify persons at risk for developing cardiovascular disease (heart disease, stroke, peripheral arterial disease). Monitoring lipid panel values over time identifies responses to lifestyle modifications (diet, exercise, stress management) and medications (statins). The total cholesterol/HDL ratio should be at least 5:1, with 3:1 being ideal for minimizing cardiovascular disease risk.[3] For patients at risk for cardiovascular disease, monitoring of vital signs is essential. For more information on vital signs please refer to the Adult Vital Sign Interpretation in Acute Care Guide 2021.[28]

Lipid profiles were previously deemed "unnecessary" testing in children. However, with increases in sedentary behaviors and childhood obesity, a lipid profile is recommended among children.
Recommendations for testing can be found in the table below:

Screening Recommendations for Children and Adolescents[115]:

Below age 2 years	→	No screening recommended
Age 2-9 years	→	Selective screening with fasting lipid panel if child has established risk factors
Age 9 to 11 years	→	Universal screening strongly recommended with nonfasting non-HDL-C
Age 11 to 18 years	→	Selective screening
Age 18 years	→	Universal screening

https://www.nationwidechildrens.org/family-resources-education/700childrens/2016/02/cholesterol-screening-for-kids-when-should-your-child-be-tested

High-Density Lipoprotein (HDL) helps to remove excess cholesterol deposits from the arterial lining. Higher levels can reduce the incidence of cardiovascular disease.[3]

Reference Ranges (mg/dL)[3]

Child/Adult:
Male**:** > 45
Female: > 55

HDL > 60 mg/dL may protect against cardiovascular disease.
HDL < 35 mg/dL may increase risk for cardiovascular disease.

Trending Upward	Causes[3] *unless otherwise cited*	Presentation	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
↑	Familial HDL lipoproteinemia Long-term aerobic or vigorous exercise Chronic liver disease[35]	No specific presentation identified.	No specific presentation identified.

Trending Downward	Causes[3]	Presentation	Clinical Implications[35]
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
	Familial low HDL Metabolic syndrome Hepatocellular disease (Hepatitis, cirrhosis) Hypoproteinemia (Nephrotoxic syndrome, malnutrition)	No specific presentation identified.	Educate regarding lifestyle modification to promote health, wellness, and movement. Low HDL levels can be raised by diet management, exercise, weight loss, and smoking cessation.

Low-Density Lipoprotein (LDL) deposits in blood vessels create plaque and occlusions, compromise circulation, and increase risk for atherosclerotic cardiovascular disease. Direct LDL measurement is limited, resulting in the development of several formulas for risk assessment.[3]

Friedwald formula: *LDL = Cholesterol – [HDL + (TG/5)]*

Reference Ranges (mg/dL)[35]

Child:
- Desirable: < 110
- Borderline high risk: 110-129
- High risk: > 130

Adult:
- Optimal: < 100
- Near optimal: 100-129
- Borderline high: 130-159
- High: 160-189
- Very high: > 190

Trending Upward	Causes[3] *unless otherwise cited*	Presentation[116]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
	Familial LDL lipoproteinemia Hypothyroidism Liver or kidney disease Multiple myeloma Diet high in cholesterol, saturated fat and alcohol[35]	Lipid deposits on skin, eyes (arcus corneae), or tendons (tendinous xanthomas)	Monitor for cardiovascular disease (heart disease, stroke, peripheral arterial disease). Educate regarding lifestyle modification to promote health, wellness, and movement.[117] Monitor for neurodegenerative disease (Alzheimer's disease) due to increased risk. Consider referral to other providers as appropriate.[118] Assess integumentary system, inspecting for lipid deposits and signs of circulatory compromise.[116]

Trending Downward	Causes[3]	Presentation	Clinical Implications[3,117]
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
	Familial hypolipoproteinemia Hypoproteinemia (e.g., malabsorption, severe burns, malnutrition) Hyperthyroidism	No specific presentation identified.	Educate regarding lifestyle modification to promote health, wellness, and movement. Diet, exercise, and physical activity may lower levels and decrease CVD risk.

Very Low-Density Lipoprotein (VLDL) are predominant carriers of blood triglycerides. It may be converted to LDL and contribute to increased cardiovascular disease risk.[3]

Reference Ranges (mg/dL)[3]

Child/adult: 7-32

Trending Upward	Causes[3]	Presentation	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
	Hypothyroidism Alcoholism Chronic liver disease Multiple myeloma Cushing syndrome	No specific presentation identified.	Monitor for cardiovascular disease risk. VLDL levels more than 25% to 50% of total cholesterol are associated with increased risk. Educate regarding lifestyle modification to promote health, wellness, and movement. Consider referral to other providers as appropriate.[3] Consider referral to other providers as appropriate due to risk for multisystem presentations/conditions (pancreatitis, cardiovascular disease, integumentary impairments).[119]

Trending Downward	Causes[3]	Presentation	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
	Hypoproteinemia Burns Malabsorption Malnutrition) Hyperthyroidism	No specific presentation identified.	No specific presentation identified.

Triglycerides are produced in the liver and transported to fatty tissues by LDL and VLDL if not used for energy.[3] Account for > 90% of dietary fat intake and tissue fat stores. Assesses the body's ability to metabolize fat and cardiovascular disease risk.[35]

Reference Ranges (mg/dL)[3] *unless otherwise cited*

Child/adolescent:
- 0-5 years
  - Male: 30-86
  - Female: 32-99
- 6-11 years
  - Male: 31-108
  - Female: 35-114
- 12-15 years
  - Male: 36-138
  - Female: 41-138
- 16-19 years
  - Male: 40-163
  - Female: 40-128

Adult:
- Male: 40-160
- Female: 35-135

Triglyceride level classification[35,119]:
- Desirable: < 150
- Borderline high: 150-199
- High: 200-499
- Very high: > 500

Trending Upward	Causes[3]	Presentation[116]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Hypertriglyceridemia	Glycogen storage diseases Hypothyroidism Diet high in carbohydrates and/or alcohol) Pregnancy Myocardial Infarction	Lipid deposits on skin, eyes (arcus corneae), or tendons (tendinous xanthomas) Paresthesia	Consider referral to other providers as appropriate due to risk for multisystem presentations/conditions (pancreatitis, hepatosplenomegaly, integumentary impairments).[116] Assess integumentary system for abnormalities including lipid deposits and signs of circulatory compromise.[116] Assess and monitor for cognitive impairment due to increased risk detrimental neurologic implications of long-term elevated levels. Consider referral to other providers as appropriate.[48]

Trending Downward	Causes[3] *unless otherwise cited*	Presentation	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Hypotriglyceridemia	Malabsorption Malnutrition Hyperthyroidism COPD[35] Ischemic stroke[35]	No specific presentation identified.	No specific presentation identified.

Total Cholesterol is the main lipid associated with cardiovascular disease. Measured to assess cardiovascular disease risk. Also frequently included in hepatic, renal, and endocrine studies. Nearly 75% of the cholesterol is bound to LDLs and 25% is bound to HDLs. Acute myocardial infarction may have as much as a 50% reduction in cholesterol level for as many as 6 to 8 weeks.[3,35]

Reference Ranges (mg/dL)[3] *unless otherwise cited*

Newborn: 53-135 Infant: 70-175 Child: 120-200 Adult: < 200

Child[35]:
- Desirable: < 170
- Borderline high: 170-199
- High: > 200

Adult[35]:
- Desirable: 140-199
- Borderline high: 200-239
- High: > 240

Adult total cholesterol/HDL ratio[3]:
- recommended: > 5:1
- optimal: > 3.1

Adult optimal low CVD risk[117]: < 140

Trending Upward	Causes[3]	Presentation[116]	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Hypercholesterolemia	Familial hypercholesterolemia Familial hyperlipidemia Hypothyroidism Diabetes Nephrotic syndrome High-cholesterol diet Hypertension Myocardial infarction Pregnancy	Lipid deposits on skin, eyes (arcus corneae), or tendons (tendinous xanthomas)	Monitor for cardiovascular disease (heart disease, stroke, peripheral arterial disease). Educate regarding lifestyle modification to promote health, wellness, and movement.[117] Monitor for neurodegenerative disease (Alzheimer's disease) due to increased risk. Consider referral to other providers as appropriate.[118] Assess integumentary system for abnormalities including lipid deposits and signs of circulatory compromise.[116]

Trending Downward	Causes[3]	Presentation	Clinical Implications
	Items below are for adults and pediatrics (birth to 18 years) unless otherwise specified.		
Hypocholesterolemia	Malnutrition Hyperthyroidism Sepsis Stress Liver disease Acute myocardial infarction	No specific presentation identified.	No specific presentation identified.

10. Coagulation Tests and Assays

Coagulation tests measure the blood's ability to clot as well as the length of time it takes. Prolonged bleeding may be the result of acquired coagulation disorders and less commonly by inherited factor deficiencies. Coagulation factor assays assess the function of coagulation factors which are named by a Roman numeral or a name such as fibrinogen.[120] These tests and assays are used for pre-operative testing, to assess unexplained bleeding, and to monitor anticoagulation therapies. Not all coagulation tests and assays will be captured in this section.

The coagulation system is dynamic and complex involving the extrinsic, intrinsic, and common pathways.[120] To assess clot formation or fibrinolysis multiple tests and assays are used to determine the cause of the balance disruption to the system. Activated partial thromboplastin time (aPTT) assesses clotting time that does not have factor activity (intrinsic and common pathways) and prothrombin time measures the time to clot when exposed to tissue factor (extrinsic and common pathways). Historically, aPTT has been used to monitor patient response to unfractionated heparin. There is no standardization of aPTT by laboratory and reagent making it difficult to monitor and compare values across settings. To correct these deficiencies, the anti-factor Xa assay is becoming widely recognized as it can provide a more consistent and reliable measure of anticoagulation in hospitalized patients requiring unfractionated heparin (UFH). Prothrombin also varies by laboratory and reagent. To reduce the variations between laboratories, the international normalized ratio (INR) calculates the patient prothrombin divided by the control prothrombin. This allows comparable monitoring between laboratories of warfarin and other vitamin K antagonists.

Therapeutic and prophylactic anticoagulation ranges are patient-specific and dependent on the patient's acute condition, prescribed medications, and past medical history. When a patient is prescribed anticoagulation therapy, the PT and PTA should monitor the patient-specific recommended ranges. The PT and PTA should observe for signs of increased bruising and bleeding as well as advocate for safety during mobility.[121]

PTs should screen patients based on risk factors, signs and symptoms, and anticoagulation status for deep vein thrombosis (DVT) and pulmonary embolism (PE). Virchow's triad identifies three factors that can result in thrombosis which include hypercoagulability, stasis, and endothelial injury. PTs should be aware of these factors to identify individuals at risk.[122] PTs and PTAs should refer to the *Role of Physical Therapists in the Management of Individuals at Risk for and Diagnosed with Venous Thromboembolism* for recommendations regarding risk assessment tools for acute care.[121] The 2022 Clinical Practice Guideline provides physical therapists with 19 key action statements to improve patient outcomes. For example, based on the evidence, the authors recommended the Well's Criteria, if a patient presents with pain, tenderness, edema, warmth/discoloration in the lower extremity or the Constans criteria if symptoms are in the upper extremity to establish the likelihood of a DVT. If a patient presents with dyspnea, chest pain, presyncope/syncope, or hemoptysis, the guideline development group recommends the revised Geneva score as a standardized screening tool for pulmonary embolism.

Plasma D-Dimer is a protein fragment as a result of a clot breakdown. Causes of elevated plasma D-dimer are thromboembolism, inflammation (COVID-19, sepsis), malignancy, trauma, pregnancy, vascular disorders, kidney and liver disease. Additionally, older age, infections, burns, and heart failure can result in an elevated D-dimer test. For patients with DVT, PE, or disseminated intravascular coagulation symptoms, a D-dimer test may be ordered. Due to the D-dimer test's high sensitivity and poor specificity, a positive test (>400-500 ng/mL) will require the patient to undergo further imaging to diagnose venous thromboembolism (VTE) conclusively. If a patient has a high pretest probability (Well's Clinical Prediction Rules) of a DVT, anticoagulant therapy is initiated, regardless of D-dimer test results. If a patient has a low pretest probability and has a high D-dimer, further testing (duplex ultrasound) is warranted.[3,123]

Reference Ranges[3]

< 250 ng/mL or < 0.4 mcg/mL

Anti-Factor Xa Assay provides a more consistent and reliable measure of anticoagulation monitoring of unfractionated heparin (UFH) and low molecular weight heparin (LMWH). LMWH is largely replacing UFH in treatment and risk mitigation for venous thromboembolism due to its predictable pharmacokinetic profile.[124] UFH is recognized as standard heparin, while some examples of LMWH include dalteparin and enoxaparin.

Reference Ranges (IU/mL)[3]

Prophylactic Ranges

Children < 8 weeks
UHF: not listed
LMWH: 0.1-0.3

Adults/children > 8 weeks
UFH: 0.2-0.5
LMWH: 0.1-0.4

Therapeutic Ranges

Children < 8 weeks
UFH: 0.5-0.7
LMWH: 0.5-1.0

Adults/children > 8 weeks
UFH: 0.5-1.2
LMWH: 0.3-0.7

Elevated Levels	Causes[3]	Presentation[3]	Clinical Implications
Anti-Factor Xa Assay 	Heparin administration Heparin resistance Renal failure Hemophilia Lupus anticoagulant	Increased bleeding tendency Bruising Oozing from wounds Mucosal bleeding	Due to increased risk of bleeding: ○ Provide fall prevention screening and intervention as needed due to increased risk of injury with falls. ○ Apply prolonged pressure to the site if bleeding occurs. ○ Examine skin for bruising, petechiae, or blood in urine. • Bruising may result from blood pressure cuff or other medical devices. ○ Monitor for changes in neurological condition due to increased risk of intracranial bleeding. Educate the patient that falls or contact sports may increase trauma-induced bleeding risk. Collaborate with the interprofessional team if levels are outside the therapeutic range to determine safe exercise prescription and intensity of activity.

Activated Partial Thromboplastin Time measures the time it takes plasma to clot when exposed to clotting factors of the intrinsic and common pathways.[125] There is no standardization, and it varies by laboratory and reagent. It is used to monitor heparin therapy. A shortened time is rare and warrants further testing.

Reference Ranges (seconds)

Infant[126]:
1 day: 34.3-44.8
3 days: 29.5-42.2
1-12 months: 35.1-46.3

Child[126]:
1-5 years: 33.6-46.3
6-10 years: 31.8-43.7
11-16 years: 33.9-46.1

Adult[3]: 30-40

Therapeutic ranges for effectiveness of anticoagulant[3]: 1-5-2.5 times normal range

Possible Critical Values[3]: > 70 seconds (increased risk for spontaneous bleeding)

Prolonged Time	Causes[35] *unless otherwise cited*	Presentation[3]	Clinical Implications
Activated Partial Thromboplastin Time 	Inherited clotting factor deficiency (von Willebrand disease, hemophilia) Inherited deficiency of prothrombin, fibrinogen, factor V, factor X[125] Acquired inhibitor of prothrombin, fibrinogen, factor V, factor X[125] Disseminated intravascular coagulation Liver disease Hypofibrinogenemia Anticoagulation therapy Vitamin K deficiency	Increased bleeding tendency Bruising Oozing from wounds Mucosal bleeding	Due to increased risk of bleeding: ○ Provide fall prevention screening and intervention as needed due to increased risk of injury with falls. ○ Apply prolonged pressure to the site if bleeding occurs. ○ Examine skin for bruising, petechiae, or blood in urine. • Bruising may result from blood pressure cuff or other medical devices. ○ Monitor for changes in neurological condition due to increased risk of intracranial bleeding. Educate the patient that falls or contact sports may increase trauma-induced bleeding risk. Collaborate with the interprofessional team if levels are outside the therapeutic range to determine safe exercise prescription and intensity of activity.

Prothrombin Time is a measurement of the time it takes for a clot to form when exposed to tissue factor in the extrinsic and common pathways. This measure is used to determine the efficacy of the anticoagulant Coumadin (warfarin). Due to variability in laboratories and reagents there can be inconsistencies.[125]

Reference Ranges (seconds):

Infant[126]:
1 day: 14.4-16.4
3 days: 13.5-16.4
1-12 months: 11.5-15.3

Child[126]:
1-5 years: 12.1-14.5
6-10 years: 11.7-15.1
11-16 years: 12.7-16.1

Adult[3]: 11-12.5

Therapeutic range for effectiveness of anticoagulant[3]: 1.5-2.5 times normal

High risk for bleeding into tissue[3]: > 20 seconds; utilize caution and discuss with interprofessional team.

Prolonged Time	Causes[125]	Presentation[3]	Clinical Implications
Prothrombin 	Alcohol Anticoagulation therapy Liver disease Bile duct obstruction Vitamin K deficiency Inherited factor VII deficiency Disseminated intravascular coagulation Inherited deficiency of prothrombin, fibrinogen, factor V, factor X Acquired inhibitor of prothrombin, fibrinogen, factor V, factor X	Increased bleeding tendency Bruising Oozing from wounds Mucosal bleeding	Due to increased risk of bleeding: ○ Provide fall prevention screening and intervention as needed due to increased risk of injury with falls. ○ Apply prolonged pressure to the site if bleeding occurs. ○ Examine skin for bruising, petechiae, or blood in urine. • Bruising may result from blood pressure cuff or other medical devices. ○ Monitor for changes in neurological condition due to increased risk of intracranial bleeding. Educate the patient that falls or contact sports may increase trauma-induced bleeding risk. Collaborate with the interprofessional team if levels are outside the therapeutic range to determine safe exercise prescription and intensity of activity.

International Normalized Ratio (INR) is an international standard for the prothrombin time test. INR results are independent of reagents or laboratories. INR is individualized for each patient. Allows monitoring Coumadin (warfarin) at different times and comparable between laboratories. For individuals who are not in the therapeutic range they are at risk for bleeding (supratherapeutic) and thrombotic (subtherapeutic) events.[127]

Reference Ranges

Infant[126]:
- Day 1: 1.15-1.35
- Day 3: 1.05-1.35
- 1-12 months: 0.86-1.22

Child[126]:
- 1-5 years: 0.92-1.14
- 6-10 years: 0.87-1.2
- 11-16 years: 0.97-1.3

Adult[3]: 0.8-1.1

- Preferred Pediatric Range according to indication for anticoagulation[128–130]:
  - DVT Prophylaxis: 1.5-2.0
  - Pulmonary Hypertension: 1.5-2.5
  - Cardiomyopathy, atrial fibrillation, DVT, pulmonary embolism, aortic valve replacement: 2.0-3.0
  - Kawasaki disease: 2.0-3.0
  - Fontan procedure: 2.0-2.5
  - Kawasaki disease: 2.0-3.0
  - Prosthetic mitral valve: 2.5-3.5
- Preferred Adult Range according to indication for anticoagulation:
  - DVT prophylaxis[3]: 1.5-2.0
  - History of TIA or CVA and aortic valve replacement[127]: 2.5-3.5
  - Pulmonary embolism[3]: 2.5-3.5
  - DVT, atrial fibrillation, mitral or aortic valve replacement, orthopedic surgery[3,127]: 2.0-3.0

Possible Critical Value INR[3]: > 5.5

Above Normal	Causes[3]	Presentation[3]	Clinical Implications
INR 	Alcohol Anticoagulation therapy Liver disease Bile duct obstruction Vitamin K deficiency Hereditary factor deficiency	Increased bleeding tendency Bruising Oozing from wounds Mucosal bleeding	Due to increased risk of bleeding: ○ Provide fall prevention screening and intervention as needed due to increased risk of injury with falls. ○ Apply prolonged pressure to the site if bleeding occurs. ○ Examine skin for bruising, petechiae, or blood in urine. • Bruising may result from blood pressure cuff or other medical devices. ○ Monitor for changes in neurological condition due to increased risk of intracranial bleeding. Educate the patient that falls or contact sports may increase trauma-induced bleeding risk. Collaborate with the interprofessional team if levels are outside the therapeutic range to determine safe exercise prescription and intensity of activity.

11. Cardiovascular-Specific Labs

Cardiac biomarkers are essential for the diagnosis, management, and prognosis of cardiovascular disease; most commonly for the evaluation of suspected acute coronary syndrome and heart failure.

The section reviews cardiovascular-specific tests that are utilized for patients at risk for or with known cardiovascular conditions, including cardiac troponin and brain natriuretic peptide (BNP).

When determining the appropriateness for physical therapy intervention, consult with the interprofessional team as needed, assess vital signs (Adult Vital Sign Interpretation in Acute Care Guide 2021),[28] and use a symptom-based approach to treatment.

Troponins (Cardiac Troponin T [cTnT], Cardiac Troponin I [cTnI], High-Sensitivity Cardiac Troponin [hsTnT])

Cardiac troponins are important biomarkers for cardiac disease, particularly in the evaluation of suspected acute coronary ischemic syndromes. Given their high specificity for myocardial cell injury and prolonged time course of elevation, troponins are the preferred blood test for in the evaluation of patients with chest pain. In acute myocardial infarction, troponins may become elevated within 2-3 hours after myocardial injury. Many protocols recommend 2 to 3 sets of troponin measurements to diagnose myocardial infarction. Levels may remain elevated for up to 14 days.[3]

High sensitivity cardiac troponins (hsTnT) have increased sensitivity for cardiac cell necrosis. This assay detects cardiac troponin levels at lower concentrations and is useful to rule out myocardial infarction. Levels of high-sensitivity cardiac troponin can be detected more readily after symptom onset leading to a faster serial testing timeline.[3]

An elevation of troponin is evaluated by the medical team in context of the patient's clinical picture, associated signs and symptoms, additional diagnostic testing, the lab value trend over time, and the percent change.[131,132] Elevation of Troponin T may occur in other disease states including cardiac trauma, heart failure, HTN, hypotension, PE, renal failure, and myocarditis. Severe skeletal muscle injury may cause false elevation in cardiac troponin T.[3] The diagnostic reliability of cardiac troponins has been suboptimal in patients with CKD due to possible decreased clearance of troponin.[133]

Reference Ranges (ng/mL)[3]

Cardiac Troponin T: < 0.1 Cardiac Troponin I: < 0.03

Reference Ranges (ng/L)[3]

High-Sensitivity Cardiac Troponin: Women: < 14 Men: < 22

Trending Upward	Causes[3]	Clinical Implications
Troponins 	Myocardial injury Myocardial infarction Additional disease states (as listed above)	Initiate physical therapy intervention when troponins are stable and/or down trending. Monitor closely for indicators of unstable cardiac status including medical team diagnosis, pending diagnostic testing, dysrhythmias, unstable vital signs, and supportive medications. Monitor vital signs continuously. Refer to Adult Vital Sign Interpretation in Acute Care Guide 2021 pg. 15, (Acute coronary syndrome/myocardial infarction) and for a list of reasons to stop physical therapy intervention including respiratory rate of > 40, a drop in HR > 10 bpm, a drop in SBP of > 10 mmHg, and an SpO2 of < 90%.[28]

Natriuretic Peptides (Brain natriuretic peptide [BNP], N-terminal fragment of pro-brain natriuretic peptide [NT-pro-BNP])

Natriuretic peptides (NPs) are substance made by the heart and used in the diagnosis and stratification of patients with heart failure. Brain natriuretic peptide (BNP) is linked to the pathophysiology of hypertension, heart failure, and atherosclerosis. BNP is released into the blood stream in response to atrial and/or ventricular stretch. Higher BNP is associated with more severe heart failure. Persistent elevation is linked with higher hospital readmission and mortality. Furthermore, individuals who present with SOB and normal BNP levels are unlikely to have heart failure.[3]

BNP levels typically increase throughout the lifespan and are higher in older adults and in women.[3] Obesity is associated with lower BNP levels.[134]

In some laboratories BNP is measured in a fragmented form and reported as NT-pro BNP.

Reference Ranges (pg/mL)[3]

BNP < 100

NT-pro-BNP < 300

BNP > 400 (Heart failure likely)

Trending Upward **Natriuretic Peptides** 	**Causes**[3]	**Clinical Implications**
	Heart failure Myocardial infarction Systemic HTN Cor pulmonale Heart transplant rejection	Monitor the patient for worsening signs and symptoms of heart failure. Signs of exertional intolerance include onset of an S3 heart sound, chest pain, inability to speak comfortably, new onset/worsening pulmonary crackles, and change in heart rhythm (ECG, auscultation, and/or pulse.) Monitor for signs and symptoms of hypotension. Consider using the Borg RPE scale or a dyspnea scale for patients with heart failure. Refer to the Adult Vital Sign Interpretation in Acute Care Guide 2021, page 16 (Heart failure)[28] and Physical Therapist Clinical Practice Guidelines for the Management of Individuals with Heart Failure.[135]

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