

SLOS Growth and Development: Infancy to Adulthood

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Growth in patients with SLOS

Infants, children and adults with SLOS generally have slower growth than healthy people for many different reasons:

- Patients with SLOS may have birth defects which affect feeding and growth such as congenital heart disease or kidney disease or cleft palate
- Infants often have feeding intolerance and may not be able to feed orally
- Neurological factors such as hypotonia and incoordination of feeding can impact growth
- Gastrointestinal disease can impact feeding and growth
- Intercurrent illnesses can impact growth – historically, prior to the use of cholesterol supplementation, many of my patients were always sick and frequently hospitalized for pneumonia and other infections.

Growth parameters

There are three main growth parameters that are followed to assess a person's nutrition:

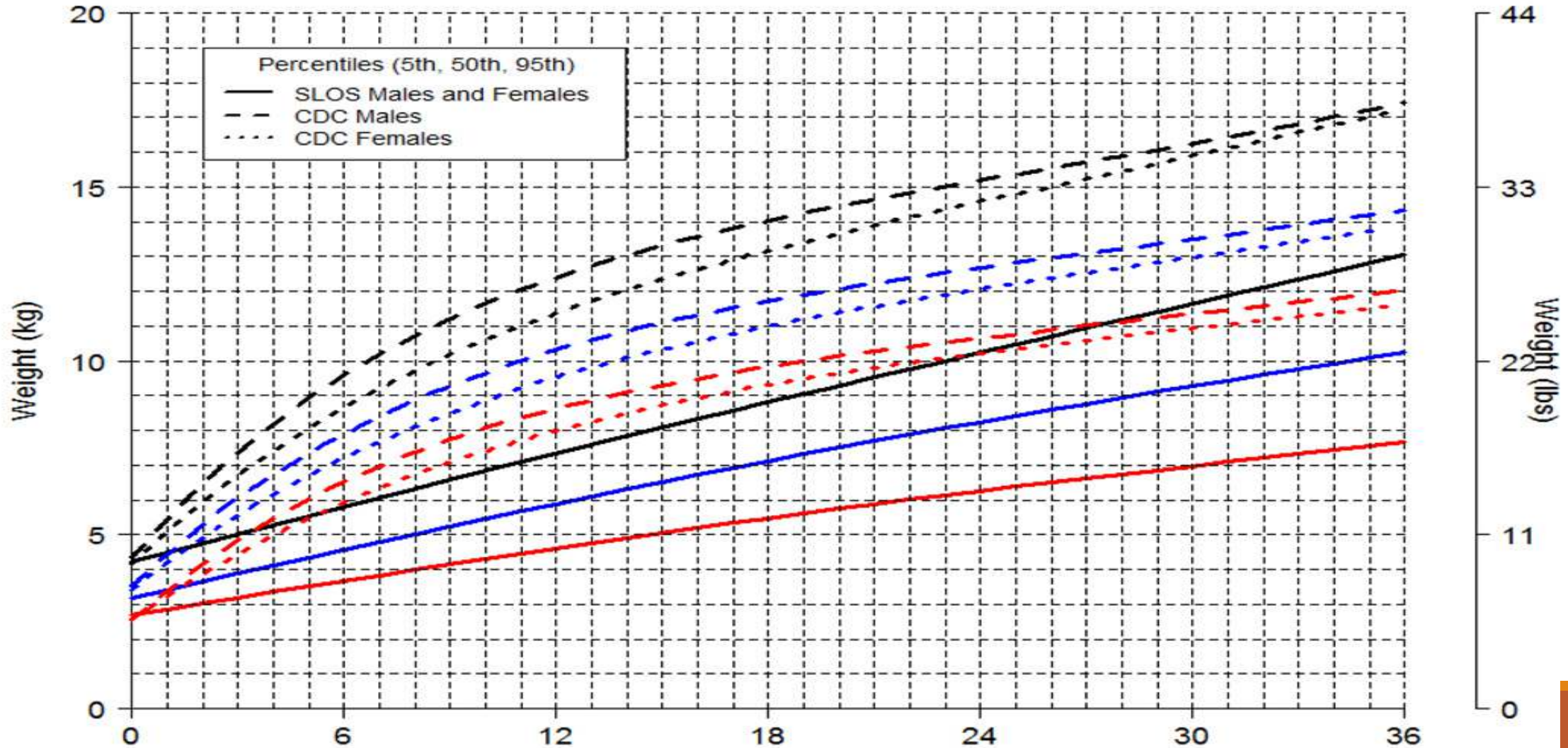
- Weight – this is usually low in a child with SLOS
- Height – patients with SLOS are generally shorter than other children
- Head circumference or OFC – the head circumference is often small, called Microcephaly

- Also important to follow are how proportionate a child may be:
 - Is the weight ok for the height of the child? This can be followed as weight/length in babies and infants and BMI (body mass index) in older patients
 - If the weight is very low compared to the height, the child might be considered to have Failure to Thrive (FTT)
 - Normally the head circumference is at about the same percentile as the length, but often the OFC is too small compared to the rest of the growth parameters

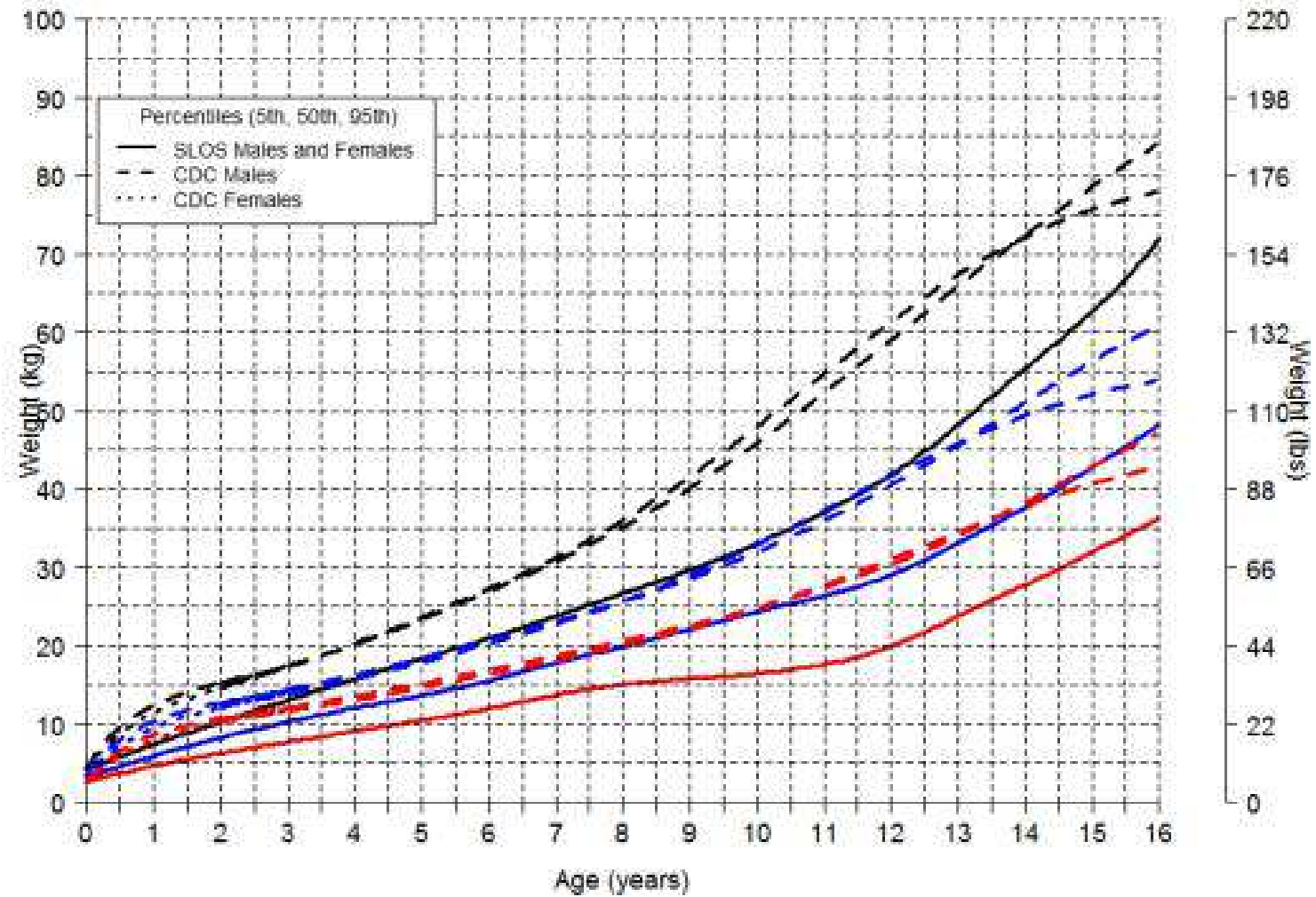
- There are special growth curves for children with SLOS

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Smith-Lemli-Optiz Syndrome, Weight vs. Age (0-3 Years) with CDC Curves

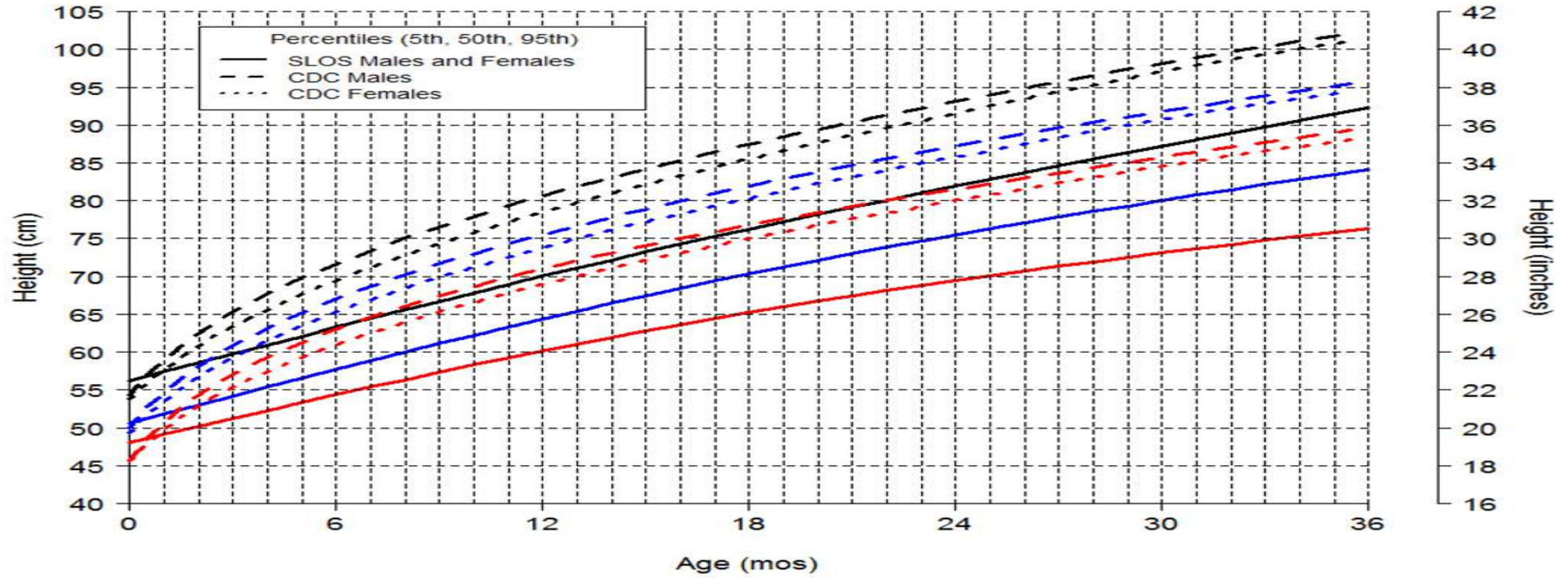


Smith-Lemli-Optiz Syndrome, Weight vs. Age (0-16 Years) with CDC Curves



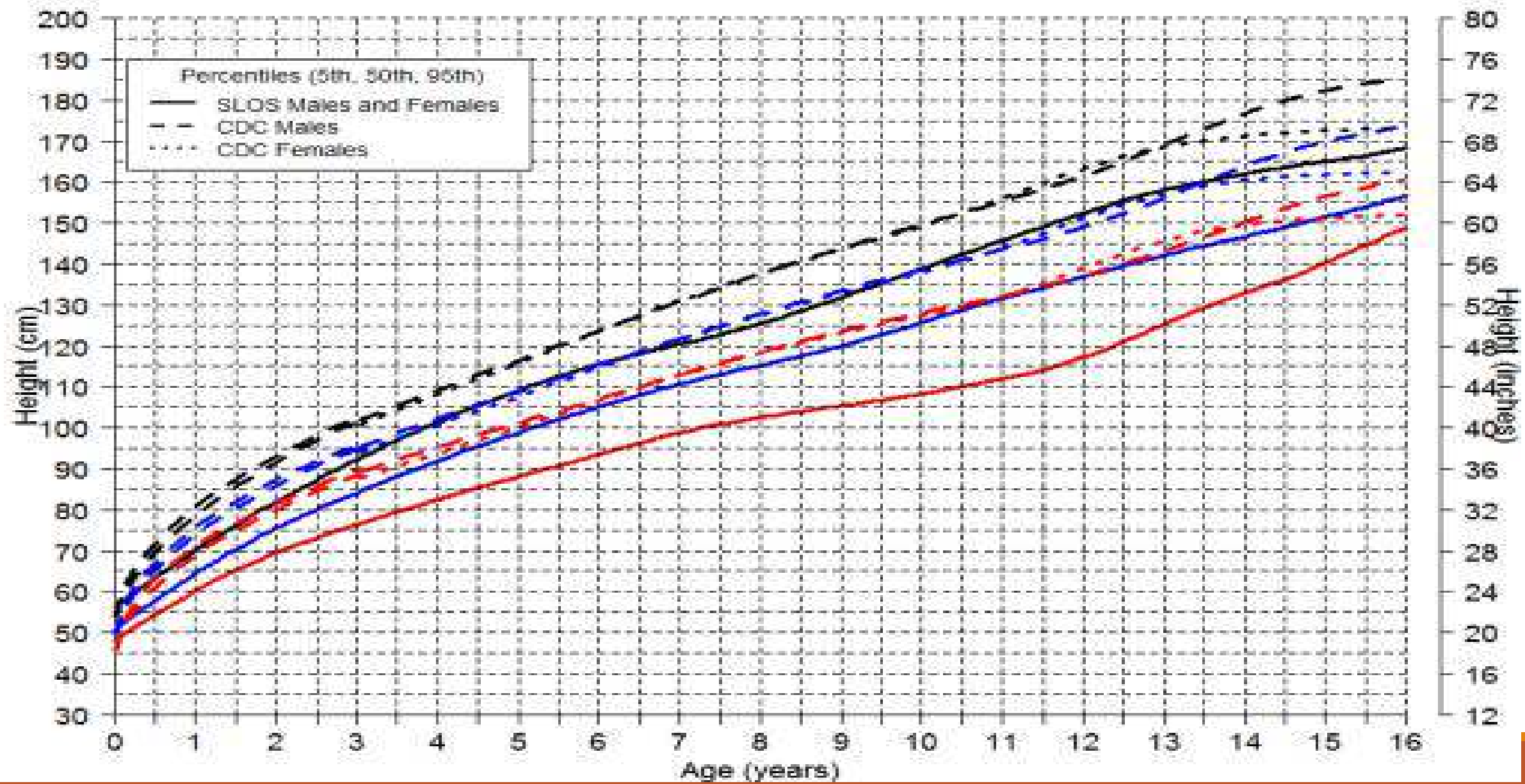
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Smith-Lemli-Optiz Syndrome, Height vs. Age (0-3 Years)

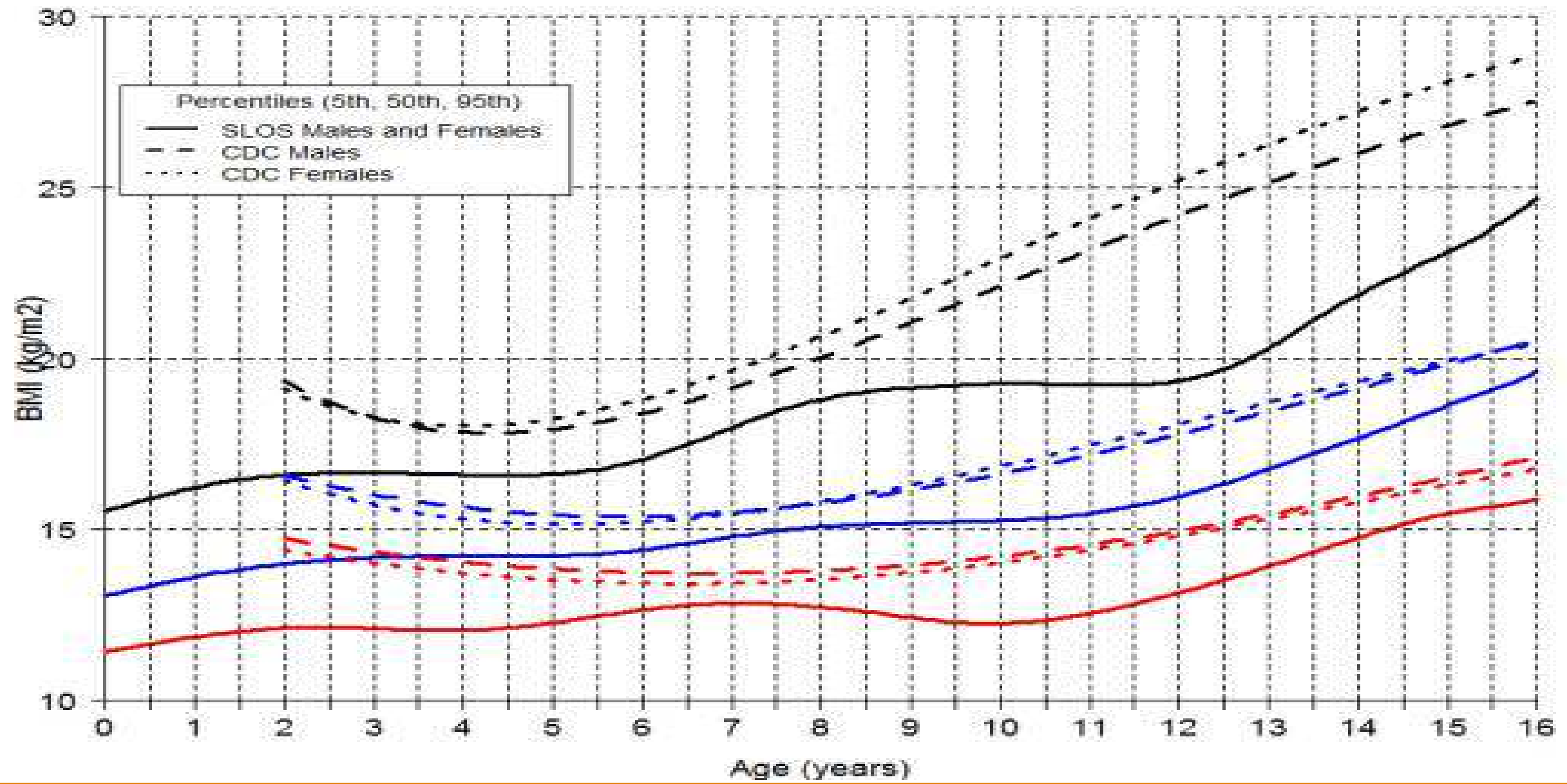


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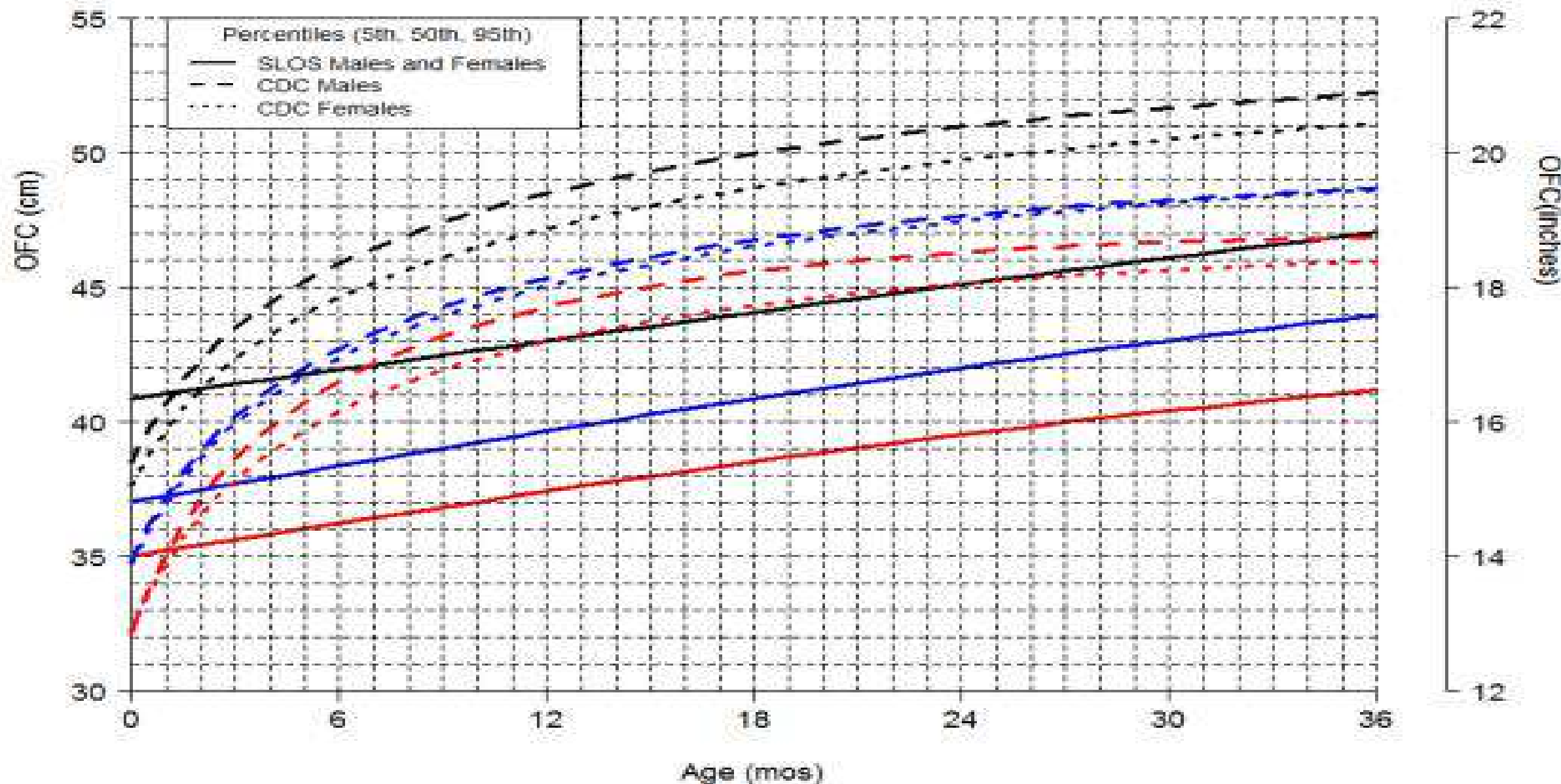
Smith-Lemli-Optiz Syndrome, Height vs. Age (0-16 Years) with CDC Curves



Smith-Lemli-Optiz Syndrome, BMI vs. Age (0-16 Years) with CDC Curves



Smith-Lemli-Optiz Syndrome, OFC vs. Age (0-3 Years) with CDC Curves



Gastrointestinal (GI) problems in patients with SLOS

There are many gastrointestinal issues which can impact growth in patients with SLOS:

- Gastroesophageal Reflux Disease (GERD): common symptoms of this are vomiting and heartburn which may manifest as irritability with feeding in young children
- Intestinal Dysmotility with either diarrhea or severe constipation: the lining of the GI tract is often fragile, especially in patients with more severe SLOS, which can lead to abdominal discomfort and feeding programs with slow weight gain
- Malabsorption of Nutrients due to cholesterol deficiency – if severe enough, than the child cannot make sufficient bile acids and cannot absorb fats and fat soluble vitamins
- Multiple food allergies are common and can lead to a condition called Eosinophilic Esophagitis (EoE). This can be especially difficult to manage as allergy to eggs and other high cholesterol foods is extremely common, making cholesterol supplementation more difficult. Patients with EoE have symptoms which mimic GERD, but the treatment is different.

Does my child need a special formula?

Breast milk is best for all infants, and especially infants with SLOS, as breast milk contains more cholesterol than all other formulas. However, breast feeding is more challenging for infants with SLOS and feeding issues. Moms may need to pump rather than nurse from the breast.

There are many formulas available to feed infants and children with SLOS who have feeding and growth problems

Formulas – which one is best?

- For birth-one year, the traditional formulas are 20 cal/oz (22 cal for premies). Many formulas have been designed to help with food allergies, and to present the nutrients in a more broken down form.
- Children with slow growth often need extra calories– can concentrate formula or add supplements such as duocal
- Important to make sure you are meeting fluid needs of child as well as calorie needs. Giving more concentrated formulas can lead to constipation.
- Some kids need elemental formulas or soy, especially kids with food allergies

Formulas are designed to have the proper balance of protein/fat and carbohydrates, and also have added vitamins and other nutrients such as iron.

HOWEVER – NONE OF THE COMMON FORMULAS CONTAIN SUFFICIENT CHOLESTEROL TO TREAT CHOLESTEROL DEFICIENCY.

Special formulas

Formulas for older kids:

After a year of age or when the child gets closer to 8-10 kg in size, can switch to 30 kcal formulas such as Pediasure or Nutren Jr.

Caloric additives can be added to these too

Newer formulas that are 45 cal per oz for older kids who need fluid restriction

Other high calorie products for oral feeders:

- Instant breakfast – this one is particularly helpful for families with private insurance which won't pay for expensive high cal formulas
- Enlive juices
- Flavored formulas

Does my child need a feeding tube?

Many patients with SLOS are not able to take in sufficient fluids/calories/nutrients to sustain good growth.

A Modified Barium Swallow can be done to show if the child is aspirating and getting food down into the lungs. If there is aspiration seen with all textures, than a feeding tube would be recommended.

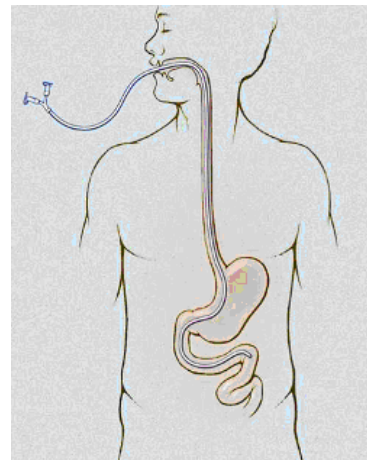
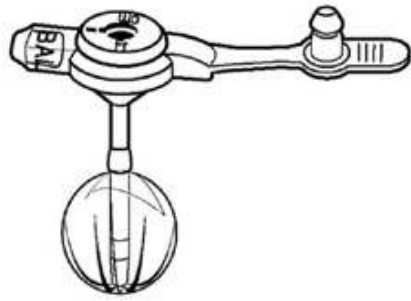
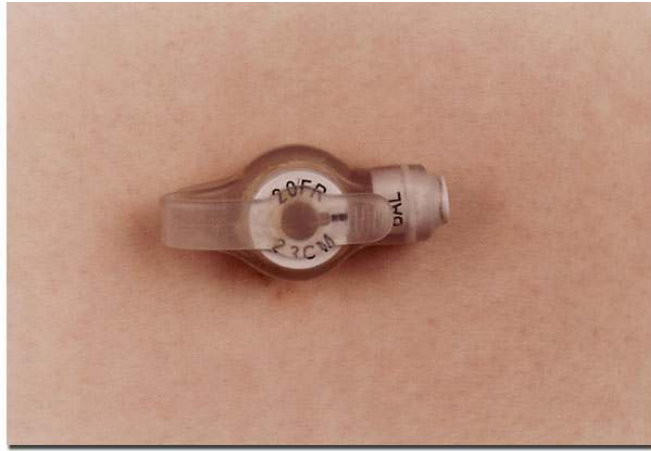
Thickening the formula may help a child who aspirates thin liquids, but may make the formula less tolerable.

Some patients are able to take solid foods safely by mouth, but need a feeding tube for liquids.

Feeding gastrostomy tubes are the most common form of tubes used. This is a tube that goes directly into the stomach and can be closed in between feedings. Bolus feeds can be used during the day and nighttime continues feeds can provide supplemental calories.

Jejunostomy tubes are sometimes needed in those patients with bad vomiting. However, feeds through a J tube have to be given continuously rather than as a bolus, which can affect quality of life.

Types of Feeding tubes



Would my child benefit from cholesterol supplementation?

My answer to this question is YES!!!

Why do we need cholesterol? – the body needs it to make sterol hormones, to stabilize cell membranes, and to make bile acids necessary for the absorption of nutrients in the gut.

If the body senses that the cholesterol level is low, the liver will try to make more cholesterol. But if you have SLOS, the liver will succeed in making more cholesterol precursors, and not be able to make enough cholesterol to meet all the body's needs for it. Higher levels of cholesterol precursors can be turned into toxic substances called oxysterols, which can be harmful to the brain, the eye, the skin and the liver.

How can I give my child more cholesterol?

If your child can eat by mouth, you can give foods which contain high amounts of cholesterol.

A yolk of an egg contains approximately 200 mg cholesterol. Other foods including meat and dairy products also contain cholesterol. Liver contains the highest amount of cholesterol, but most people do not like eating liver.

There are a number of cholesterol supplements currently available—

- Cholesterol powder
- Cholesterol flakes
- Cholesterol suspension which I helped invent contains pure pharmaceutical grade cholesterol put into a soy oil suspension by a pharmacist, to the concentration of 200 mg/ml (or the equivalent of 5 eggs per tsp). This was invented in 1994, to get cholesterol into my patients who were not able to eat food and were allergic to eggs. I have used it successfully for the past 25 years.
- Aqueous Cholesterol solution has been used in the past and may still be available.

Other nutritional concerns

Children with feeding problems are often at risk for having other nutritional deficiencies. There are three main ones that I routinely screen for:

- **Low iron stores** – the test is called Ferritin. The perfect ferritin level is 50. Many of my patients have levels in the teens and twenties. This can affect growth if it is long term and can lead eventually to anemia. Also, low iron commonly presents as bad sleep in my patients. Giving iron medication can be enormously helpful. The main side effect of iron medicine is constipation – some forms of iron medicine are worse than others in this regard. Iron should not be given with dairy products which prevent absorption and should be given with Vit C.
- **Low Vitamin D** – vitamin D is important for healthy bones and normal calcium. It is very easy to supplement and comes in many forms. The normal level is 30-96.
- **Low Serum Zinc** – low zinc levels are associated with poor appetite and rashes which look like eczema. Treating zinc deficiency can be very helpful in improving appetite and feeding tolerance. A normal zinc level is 0.6-1.2.

Note: Iron, Vitamin D and Zinc are often not covered by your insurance and you need to pay out of pocket.

Summary of Growth in patients with SLOS

There are many issues which impact growth and adequate nutrition in patients with SLOS:

- Feeding issues are common and may require the input of specialists including Pediatricians, Dietitians, and GI specialists
- Patients may require special formulas and supplements
- Patients may require feeding tubes
- Multiple food Allergies are common and may lead to EoE. If food allergies are documented, and symptoms are not better with traditional approaches to GERD management, seeing a specialist knowledgeable about treating EoE may be helpful.
- Striving for weight that is appropriate for a patient's height is important.
- Optimizing nutrition is important to ensure optimal developmental progress and good sleep.

QUESTIONS

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Development in Patients with SLOS

There is a spectrum of developmental progress and ultimate intellectual function in patients with SLOS:

this spectrum ranges from a fairly mild developmental lag to very severe disabilities.

How does one assess developmental progress and level of function?

I think about four main areas of development:

- **Gross Motor:** gross motor skills are those that you do with the whole body such as rolling, sitting, standing, walking, running, jumping.
- **Fine Motor:** fine motor skills are what you do with your hands. These include reaching, grabbing, picking up small objects (pincer), feeding your self, dressing yourself, tying your shoes, scribbling and writing.
- **Language:** Language is divided into 2 main areas –
 - Expressive language includes sounds that you make and what you can say or signs that you make
 - Receptive language is what you understand
- **Social/Adaptive skills:** these skills include how you play and interact, such as clapping, waving, playing peek a boo, learning your age and gender, being toilet trained, and later how you interact with your peers and learn in school.

Kinds of Developmental Delay

Some children have delay in all spheres of development, which is called Global Delay

Other children have some areas in which they are not that far behind their peers, and other areas where they are much weaker.

Patients with isolated motor delays, may be more typical in their use of language and social skills but have more issues with movement. Malformations of the brain can lead to this problem. This is a less common pattern in SLOS. Physical Therapy can help address issues with Gross motor development.

Fine motor issues often go together with gross motor issues and can be helped by an Occupational Therapist.

Language development is the best predictor of future intelligence! Language development can be impacted by hearing status. Hearing loss is very common in patients with SLOS and keeping on top of hearing status is very important. A Speech and Language Pathologist is the kind of therapist who helps in this area.

Kinds of Developmental Delay, cont.

Abnormalities in Social Development, coupled with Language Delay and Behavioral Issues are seen in patients who are diagnosed with **AUTISM SPECTRUM DISORDER (ASD)**.

Autism is extremely common in SLOS, and seen in more than half of patients.

The diagnosis of Autism can be confirmed by administering a test called the ADOS, which is done by a specially trained psychologist.

Interventions including special classrooms which have fewer students, and are run by teachers who are particularly trained to help children with autism can be helpful.

Behavioral interventions including ABA, both at home and in the classroom, can also be helpful.

Severity of Developmental/Intellectual Delay

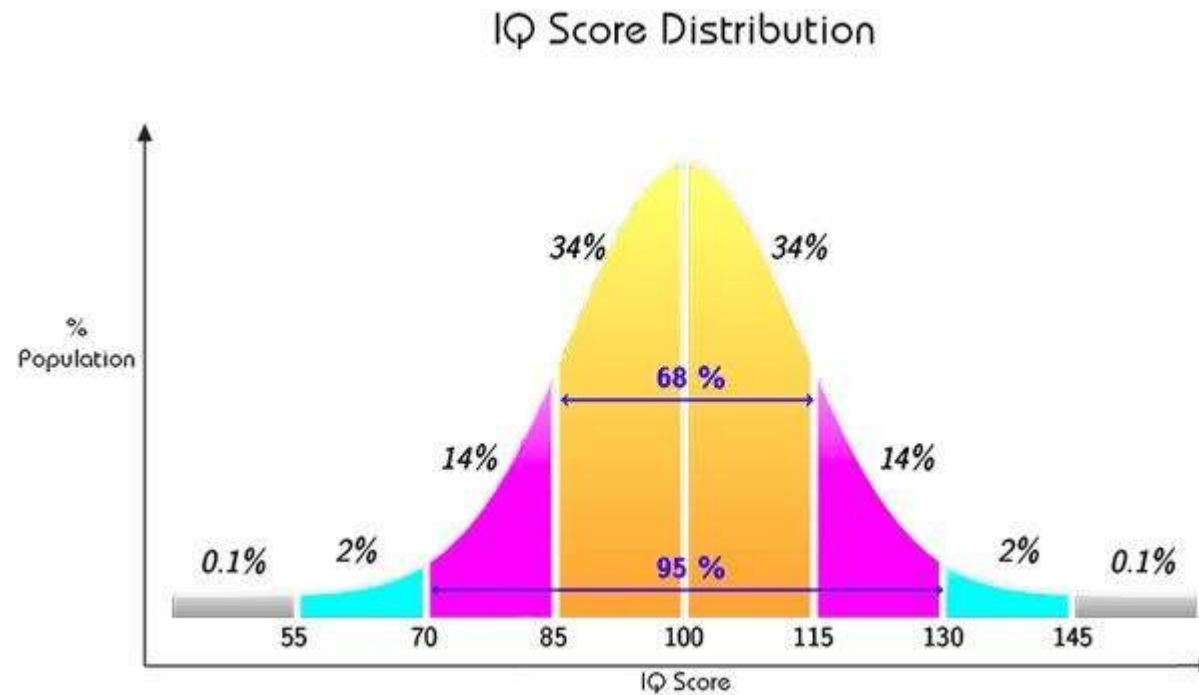
After determining what types of developmental delay (ie which spheres of development are affected), it is then helpful to determine how mild or severe the delay is.

In young infants and children, development is looked at with a Developmental Quotient (DQ), whereas in older children and adults, one can look at an Intellectual Quotient (IQ). How these are derived is dividing the developmental level of function by the chronological age x 100.

For example, for a 2 year old child who is functioning most like a 6 mo old, the developmental quotient would be 25%.

A 10 year old child who is functioning most like a 4 year old, would have an IQ of 40.

Levels of developmental/intellectual disabilities



Levels of Disabilities

If the IQ is less than 70, the person is considered to have intellectual disabilities. Within this there are big differences, from

Mild – functioning in the range of about 55-70, and learning at about $\frac{2}{3}$ the typical rate

Moderate – functioning in the range of about 40-55 and learning at about half the typical rate

Severe – functioning in the range of 20-40, and learning at about $\frac{1}{3}$ the typical rate

Profound – functioning at <20 , and never making progress beyond the skills of an infant.

However, these fractions don't continue throughout life– ie a 40 year old with moderate intellectual disabilities does not function like a normal 20 year old!

At what age do you reach your highest level of cognitive abilities?

This is a scary question!!!

First of all, one never stops learning, no matter what your age! Never stop going to conferences, reading or listening.

For most people, you obtain the ability to think abstractly and understand complex information in your mid teens when you are in High School. That is why you can read Shakespeare, and take Calculus or Physics or Philosophy in HS, but can't do this in Elementary school.

How to predict what level of function a person with disabilities might attain?

If you have mild disabilities and are learning at about 2/3 the typical rate: As an adult you might achieve a level of $\frac{2}{3}$ x 15-16 years or around 10-12 year skills. Or to think about this a different way, you might be like a 5th-6th grader. This is a person who is walking/talking/reading/independent for activities of daily living such as dressing/bathing/toileting. A person with mild disabilities can usually have a job in the community with minimal supervision

If you have moderate disabilities and are learning at about 1/2 the typical rate:As an adult you might achieve a level of $\frac{1}{2}$ x 15-16 years or around 6-8 year skills, or have skills like a child who is in 1st-3rd grade. This is a person who is walking/talking/has early academic skills and can read simple things and do simple math and is usually independent for activities of daily living such as dressing/bathing/toileting with more supervision and assistance. A person with moderate disabilities can sometimes have a job in the community but requires a higher level of supervision

How to predict what level of function a person with disabilities might attain?

If you have severe disabilities and are learning at about 1/3 the typical rate:As an adult you might achieve the level of 1/3 x 15-16 years or around 3-5 year skills, or have skills like a child who is in preschool. This is a person who is much older when they have learned to walk and talk and may not use sophisticated language. Usually, this person does not develop any academic skills such as reading or writing or mathematics, and is usually dependent for many activities of daily living such as dressing/bathing/toileting. A person with severe disabilities can rarely have a job in the community and requires a high level of assistance and supervision

If you have profound disabilities, you require care for feeding/dressing/use diapers, and have no language skills.

MOST OF MY PATIENTS WITH SLOS FALL IN THE MILD/MODERATE TO SEVERE RANGE. Some patients are more mild and have IQ's above 70. If the patient has Autism, often the functional abilities are worse than those patients who do NOT have Autism.

What kind of Developmental Educational services will your child need?

Early Intervention programs: Starting from birth through age 3 years, your child is eligible to receive services through EI. These are often home based services at first, and may evolve into center based services when your child is close to 3. These services may include:

A developmental specialist (often a pediatrician or psychologist), as well as PT, OT and ST. Many EI programs often have other services including social work, and family support groups.

Which program you are assigned to is based on your address. These programs are State funded and insurance authorization is not required.

Special Education Services: Your child is eligible for this starting at age 3 and running through age 21. A plan will be developed called an **Individualized Education Plan (IEP)** in which it will be clearly defined what kind of services and therapies your child will receive. Your child might spend a percentage of time in the Special education class, which usually has a much smaller number of students and teachers with specialized training. There are often aides or para's in the class to assist the teacher. Your child might also be included into the typical class for certain activities. Have the aide or para assist your child with this is important. Your child might also receive therapies including PT, OT and ST.

In addition to these services, your child might receive other services at school including diaper changes, and Gtube feeds. A **504 Plan** can help address the medical needs your child might have.

Behavioral supports from a behavioral specialist or psychologist are often helpful.

What happens after age 21?

There are many different kinds of programs to help adults with disabilities which are usually community based.

Don't forget that at age 18, you would have needed to go through the **Guardianship process**.

When your child graduates from school at age 21, some options include:

- Work programs with different levels of supervision, depending on the person's needs and abilities
- Social activities with peers

These programs are often found through the local **Community Center Boards (CCB's)**.

Different living arrangements may also be necessary, depending on the patient's issues and the health and abilities of the parents. These may include group homes, adult foster homes, and adult residential facilities. In my state, many of these programs have long waiting lists and it is important to start looking at them while the patient is still in HS, so that the transition is less abrupt.

QUESTIONS

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