Child Foot and Shoe Sizes

Summary of a Small Study

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The Question

"The missing subject is a three year old male. How large of a track are we looking for?"

How Does One Proceed

- When searching for a missing child we often hear a variation of this question.
- The answers we hear are myriad.
- Often there is no known PLS, no shoe description, or other important information
- Are there parameters that one could use to help identify possible relevant tracks?

Other Common Questions

- Can you identify a barefoot size from a recently worn shoe?
- Can wear patterns on older shoes help identify a missing subject wearing another set of shoes?
- Can you use shoes in the child's closet to obtain a size range for the currently worn shoe?

Purpose of Original Study

- To challenge assumptions about the relationship between foot size and age.
- To learn information that may be helpful when following the trails of missing children.

The Study

- 55 Children, ages 1.5-12 years
- Prints taken: barefoot, standing position, weight-bearing; shoe measured then printed.
- Measurements: Length, sole width, heel width, height and weight.
- Volunteer tracker's comparative analysis test regarding size and wear patterns.

Starting with the Conclusions

- The are very few studies that describe the relationship between foot length, foot width, and height as they relate to age. (1)
- Existing studies have found no consistent association between foot print symmetry, age, height and body weight, or shoe size. (2)
- I concur with these scientific studies!

So Where Does This Leave Us?

- It is difficult to answer the question, “The missing subject is a three year old male. How large of a track are we looking for?”
- You could stop right here! Or you could read further.
- Perhaps there is something here that you will find helpful, or simply find better questions to ask while in the field.

The Child's Developing Foot

Important Information

Foot Construction

- 26 small bones/35 joints
- Tendons coming from large muscle groups
- Ligaments and muscles
- Circulatory arteries and veins
- Lymph nodes and nerves
- This makes for a small area with a lot going on.

Foot Configurations

- Feet have an endless variety of configurations.
- Variations can occur in overall shape, toe and ball length, width, bone structure, muscle mass.

Comparison

Note differences in:

- Position of second toe in relation to big toe
- Spacing of toe grouping
- Size to toe pads in relation to rest of foot
- Shape of sole
- Orientation of heel to overall print
- Similarity in size despite gender and 1.5 year age difference
- Others?

Individual Foot Characteristics

- Can change as a result of different:
  - Activities (ex. Running v. walking)
  - Mediums (sand v. dirt)
  - Landscapes (flat v. steep)
  - Times of day (ex. Foot tends to be longer in the morning)

An Overview of Changes

- As child ages, there are increases in step and stride length, and decreases in cadence.(3)
- The length and width of children's feet increase linearly as child ages (4)
  - from age 3 to 12 in girls,
  - From age 3 to 15 in boys.

Growth of Children's Feet

- Children's feet grow quickly during their first year of life.
- By end of 12 months, feet are typically ½ of their adult size.(5)
- Usually start walking between 12-15 months
- Tend to be "flat-footed"

“Flat Feet” due to (6)

- Poor muscle tone in the foot
- Generous padding of fat.
- Weak ligaments in the medial arch.
  - Permit the foot to lean inwards
  - Will begin to strengthen as child learns to walk
  - Normal arch appears by age 5

The Walking Child

- Children begin walking by 12-15 months
- Walking gait erratic
  - Due to posture and leg alignment
  - Speed and rhythm variable
- Wide base
- Reciprocal arm swing usually absent
- Difficulty running, falls a lot

12-18 Months After Walking

- Base narrows
- Cadence and rhythm of movement becomes more regular
- Stance and swing pattern of legs more predictable
- Child learns to run, jump, etc.

Other Developments

- Age 4, most can stand, hop on one foot, and arm swing is regular
- Age 5: Normal arches usually developed
- Age 6: Develops approximation of their mature gait. Stride lengths become equal, and arm swing is balanced. Each leg contacts the ground for same length of time, and forward motion is smooth.

- Age 6: Child's trunk usually centered over legs. Until that time:
  - Children can appear as "toe walkers".
  - Function of anatomy
    - Poor muscle control
    - Trunk not centered over legs
    - Abdomen forward

- Age 12: Foot is usually 90% of adult length.

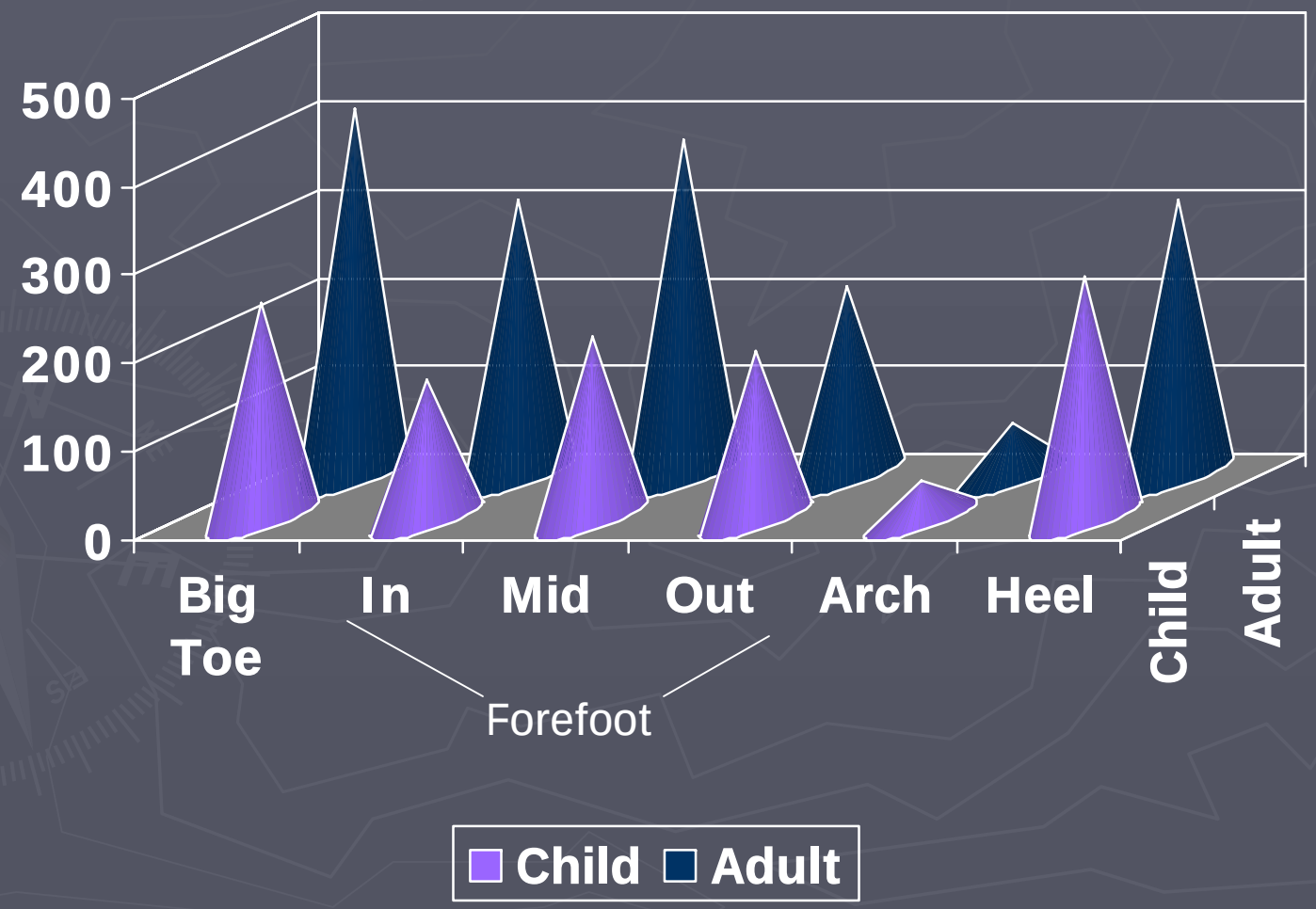
Changes in Shoes Size and Age (7) Recommendations based upon proper fitting:

- 12 - 18 months: every 2 months
- 1.2 - 2.5 years: every 3 months
- 2.5 - 4 years: every 4 months
- 4 - 6 years: every 6 months
- 6 years and up: variable

Studies

Changes in Pressure and Velocity:
Just some interesting data to digest.

Peak Pressure (kP2) Differences: Children lower than adults, age shifting from mid to fore foot, from outer to inner, as muscle control develops. (8)



Changes: Age and Velocity (9)

Age/Speed of Walk	Step Length (inches)	Steps per minute
3-6 fast	20	190
7-11 fast	24.8	175
12-18 fast	31.2	138
3-6 normal	17.2	150
7-11 normal	21.2	132
12-18 normal	26.8	116
3-6 slow	14.8	124
7-11 slow	19.2	105
12-18 slow	24.0	99

Measurements

Barefoot, Shoe, Conversions

Before We Begin...

- Your child's shoe is 7 inches in length. How old is your child?
- Interesting observation: When asking mothers this question, they often looked at their open hand.

- Your guess?

The Answer

- This is a common shoe length measurement for a child ages 2.5 years old.
- Most guess a child age 6-7 years.

Measurements In General

- The best source of child foot and shoe measurements are often shoe companies.
- The published shoe company findings are generally consistent, and based upon average ranges for different age groups.
- I found many examples of children outside of the average.

Barefoot Measurements

Age in years	Published Lengths (10)	My Findings
2-3	6 1/8” to 6 ½”	5 1/8”-5 ½”
3-4	6 ½” to 6 13/16”	None in Study
4-6	6 13/16” to 7 ½”	6 ¼” to 7 ½”
7-8	7 ½” to 8 ½”	7” to 8 1/8”

Barefoot Measurements

Age in years	Published Lengths (10)	My Findings
8-9	8 ½” to 9 1/8”	7” to 8 ¾”
9-10	9 1/8” to 9 13/16”	7 ½” to 8 ½”
10-11	Begins at 9 1/3”	Begins at 7 and 3/8”

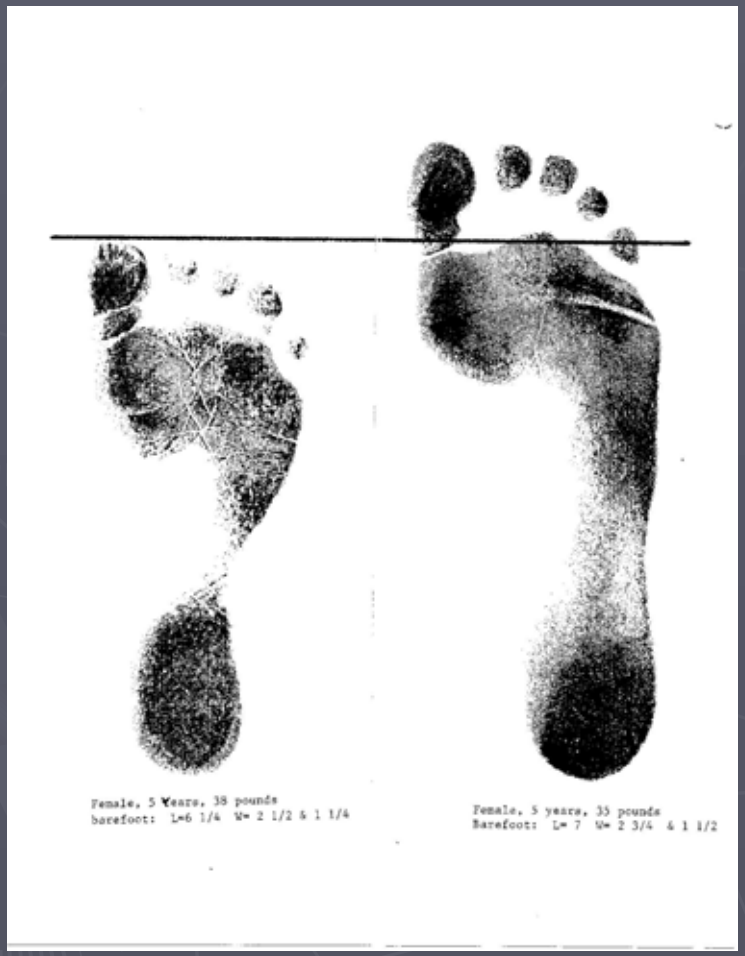
Shoe Size Ranges from Study Smallest/Largest Length by Age

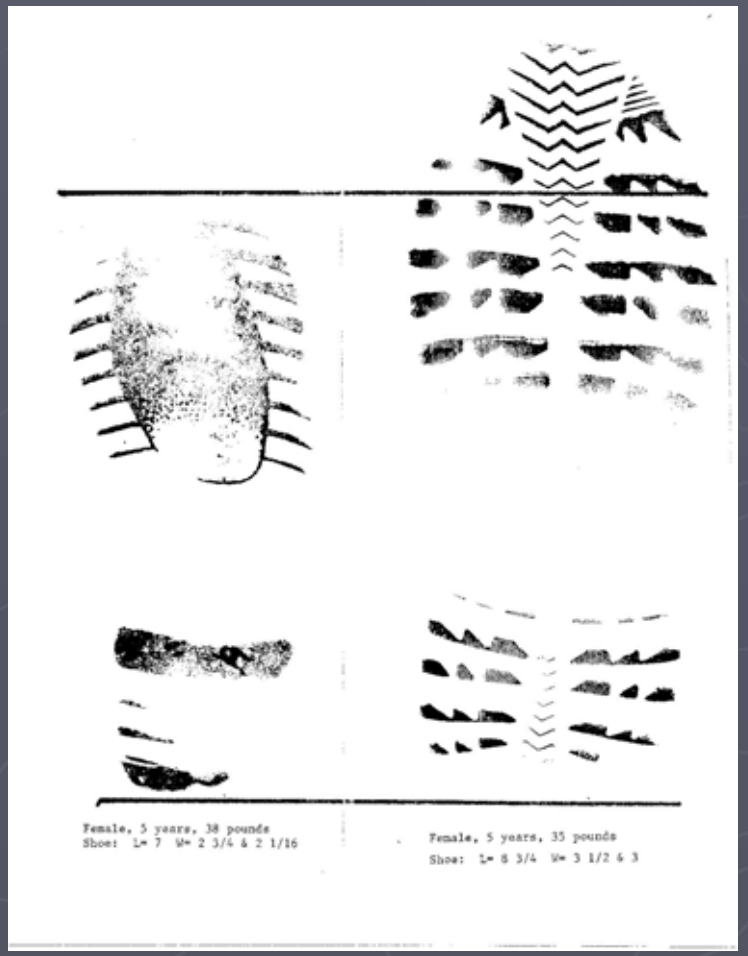
Age	Smallest	Largest
1	L=6 3/4, SW=2 ½, HW=1 ¾	L=7, SW=3, HW=2 ½
2	L=6 ¼, SW= 2 ½, HW=2 ¼	L=6 ½, SW=2 ¾, HW=2 ½
3	L=7; SW=2 ¾, HW=2 ¼	L=7 7/8, SW=3 ¼, HW= 2 ½
5	L=7, SW=3 ¾, HW= 2 1/16	L=8 ¾, SW= 3 ½, HW=3
6	L= 7 6/8, SW=3, HW=2	L=8, SW=3 ½, HW=2 5/8
7	L=8 ½, SW=3, HW=2	L=10, SW= 3 ½, HW= 2 ¾
8	L=7 ¼, SW=3, HW=2	L= 9 ½, SW=4, HW=3
9	L=8 ¼, SW=3, HW=2 ½	L=8 ¼, SW= 3 5/8, HW=2 ½
10	L=8, SW=3 ½, HW=3 work boots	L=10 ¼, SW=3 ½, HW=3
11	L=8 ¾, SW=3 ¼, HW=2 ¼	L=10 ½, SW= 3 ¼, HW=3
12	L=10 ½, SW=3 ½, HW=3	L= 10 ¾, SW=4, HW=3 ¼

Study Excerpt: Variability in Age Group 7 year olds males (inches)

Subject	Foot L	Sole W	Heel W	Shoe L	Sole W	Heel W
1	7 ½	2 7/8	1 5/8	8 1/8	3 ½	2 ¾
2	7 ¼	3	1 ½	8 1/8	3 ½	2 ¾
3	8	2 ½	1 ¼	8 ½	3 1/8	2 ½
4	7 ¼	3	1 ½	8 ½	3	2
5	7 1/8	2 7/8	1 ¾	9	3	2 ¼
6	7 5/8	2 7/8	1 ½	10	3 ½	2 ¾
7	7	2 ½	1 5/8	9	3 ½	3
8	7 5/8	2 5/8	1 ¾	9	3 ½	2 ½

Variability Sample: Females, 5 years, 38 & 35 Pounds

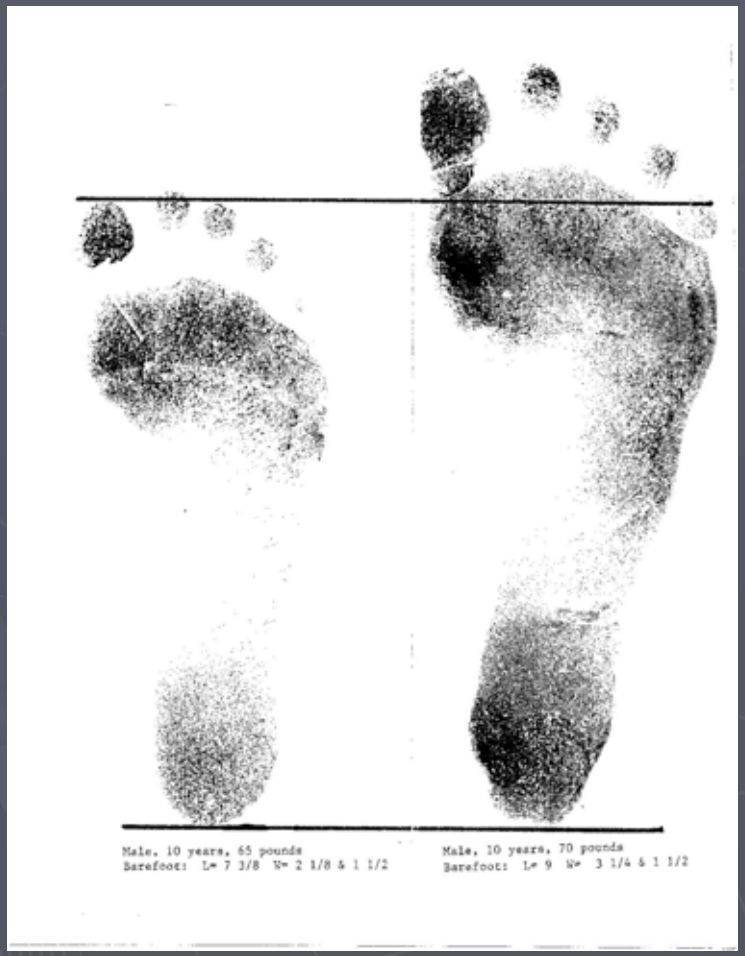


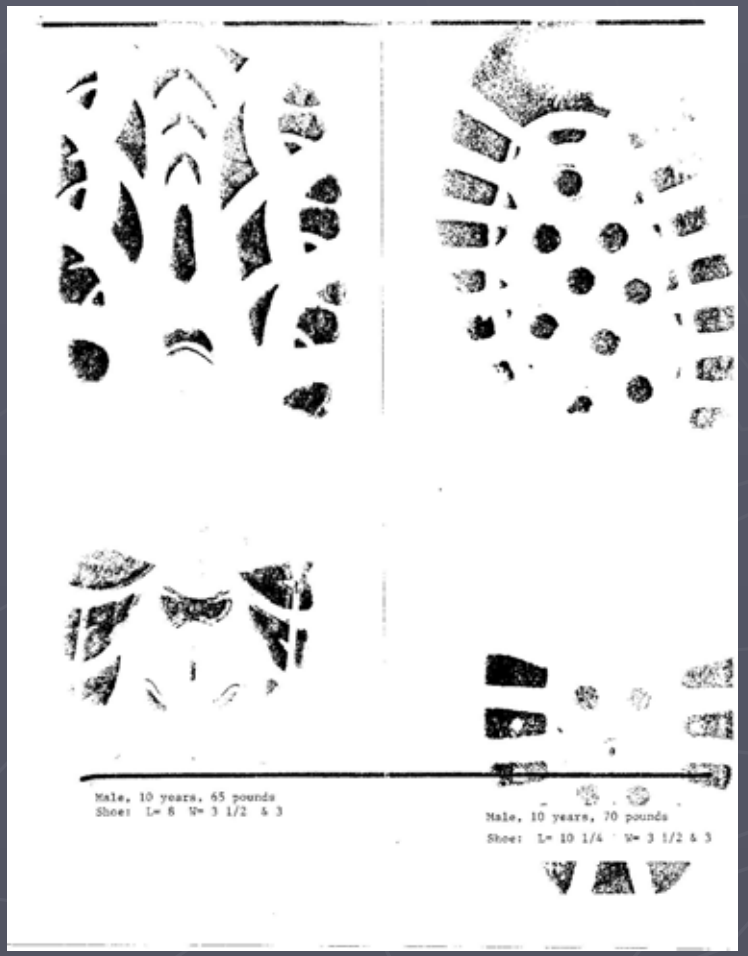


Study Excerpt: Males Height/weight/shoe size

Age	Height	Weight	Shoe L	Sole W	Heel W
10	56”	68	8 1/2	3 ½	3
10	56”	70	10 ¼	3 ½	3
10	52”	65	8	3 ½	3
11	60”	112	10	3 ¼	2 ½
11	56”	65	8 ¾	3 ¼	2 ¼
11	57”	70	10 ½	3 ¼	3

Variability Sample: Males, 10 years, 65 and 70 pounds





Currently Worn Shoes by Two Subjects (Brothers)

Age	Shoe	Length	Sole Width	Heel Width
9.5 years	1	9 ½	3	2 ½
	2	9 ½	4	3 ¼
	3	10 1/8	3 ¾	3 1/8
13.4 years	1	10 ¼	3 ½	2 ¾
	2	10 ½	4	3
	3	10 5/8	4	3 ½

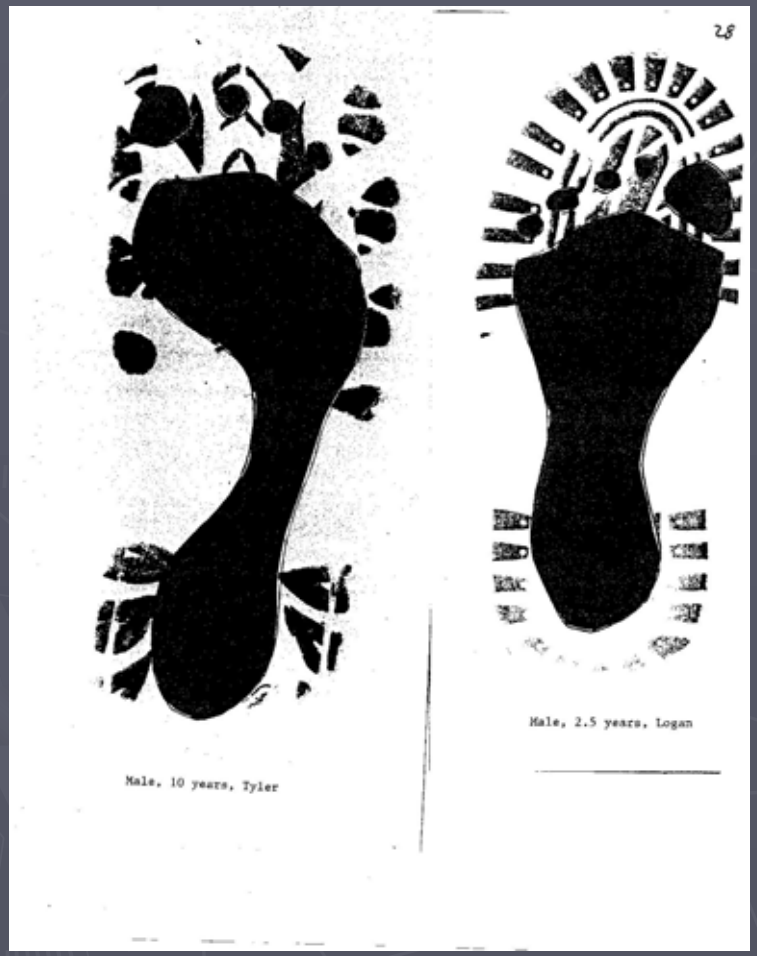
Visual Comparison: Currently Worn Shoes of 9 year old

- Note the variations in size and shape.
- Currently worn shoes help establish a possible range only
- One can never be sure of the measurements of shoes currently worn by missing subject.

A Comment About Shoe Fit

- Children wear shoes of various sizes based upon a number of factors, including:
  - They like the look or feel
  - The person in the store identified a proper fit
  - The parents wanted “room to grow”
- This can cause a significant difference in barefoot versus shoe measurements.

Visual Comparison: Foot v. Shoe Size



- Check insole of recently worn shoe for child barefoot measurements.

Conclusions Thus Far

Not Definitive, but Helpful

Conclusions

- While average ranges are helpful guides, the missing subject may not be “average”.
- Age groups have wide variations of foot and shoe size. Examples: 10 year old male with foot size of 8 year old female.
- In the absence of a confirmed track, it is dangerous to use average ranges alone to confirm potential tracks as the missing subject.

- Shoe size changes rapidly as child grows. A recently outgrown shoe can provide a bottom size range for ruling out smaller tracks found in the field. Caution: Children moving from an ill-fitting to properly fitting shoe may show significant increase in track size.
- Measuring all the child's currently worn shoes can result in significant variability in measurements. Proceed with caution.

“Reverse Logic”

- If the subject is barefoot, can the foot size be deduced from a recently worn shoe?
- Yes, remove the insert, which will often retain an impression of child’s barefoot.
- In theory, one could also obtain an average barefoot size by obtaining shoe size, and comparing it to a chart (not advisable).

Conversion to Shoe Size (11)

Barefoot Measurement	Shoe Size and Age App.
6 1/8” to 6 ½”	Toddler 9-10 (2-3 years)
6 ½” to 6 13/16”	Toddler 10-11 (3-4)
6 13/16” to 7 ½”	Youth 11-1 (4-6)
7 ½” to 8 ½”	Youth 1-3 (5-7)
8 ½” to 9 1/8”	Youth 3-5 (7-8)
9 1/8” to 9 13/16”	Youth 5-7 (9-10)
8 ½” to 9 1/8” +	Adult size (10+)

Why Not Advisable?

- Most charts are based upon averages, and assume the child's shoe is properly fitted.
- Children's feet grow rapidly, often the foot has outgrown the shoe, and no new shoe has been purchased.

Tracker Tests

Thanks to the Participants!

Tracker Tests

- Test 1: Provided 10 barefoot prints and 10 shoe prints to trackers. Trackers asked to match the barefoot to the proper shoe.
- Results: Range of 40-100% proper match.
- Often mismatched: 12 year old boy and 44 year old female; small but older males with younger females.

Conclusion for Test 1

- When presented with an assortment of choices, trackers have varying levels of success at matching barefoot prints and shoe prints.
- This skill may be helpful when looking for subject who has lost his or her shoes, but results are not encouraging.

Tracker Tests

- Test 2: Two sets of recently worn shoes from 9 children of similar size, resulting in 9 pairs. Trackers asked to match sets to individual children based upon wear patterns.

- Results: Experienced trackers: 8/9 correct, non trackers or beginning trackers 3/9.

Sample Match: Easy
Notice distinct wear pattern on right foot. Explanation?

Child regularly drags right foot as break when riding bike.

Conclusion for Test 2

- Wear patterns comparison can be helpful in wearer identification. However, difficulties were noted in test when:
  - Different types of shoes (“tennis shoe” v. boot) were used. Soles wear at different rates.
  - One set was significantly older, and had deeper wear patterns, than the other set. The newer set did not clearly register the individual wear characteristics found in the older shoes.

Any Helpful Hints?

- The first is to accept published study findings: there is no consistent association between foot print symmetry, age, height and body weight, or shoe size.
- Go to the PLS if possible to establish foot print.
- In the absence of a PLS, go to an area the child is know to frequent (backyard swing-set, for example). Find his or her track.

- Ask for multiple sets of shoes the child recently wore to establish lower measurement size parameter, but use with caution.
- Look for idiosyncratic wear patterns across available shoes. It may help in the field.
- Establish barefoot measurements from insole. It may be helpful if child looses his or her shoes (it has happened on searches).
- Others?

Please Note:

- This was a simple, non-scientific study, based upon a question that emerged on a search for a missing three year old. I simply wanted to answer the question for myself. The conclusions contained herein should therefore be considered as informative, but not conclusive. This Power-point is based upon a more extensive live presentation of data.

Thanks

- The Search and Rescue Tracking Institute (SARTI) for the opportunity to present the study as a training topic (January, 05).
- A. Leeper and R. Burleson, SARTI, for motivating the study.
- For Study Subjects: Staff of NWCS and parents of the Bright Beginnings Day Program, Front Royal, Virginia; Senseny Road Elementary Cub Scouts and Daisies Troop 704, Winchester, Virginia; Relatives and Neighbors.

Reference and Resources

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NOTE: References not made for information coming from multiple resources, and therefore assumed as common knowledge.