

Monitoring Growth and Maturation

PLAYGROUND TO PODIUM

Planning For the Sporting Excellence and Well-being of Canadians

This growth chart supports a 7-stage Canadian model of Long-Term Athlete Development (LTAD), a training, competition, and recovery program based on developmental age — rather than chronological age. It is athlete centred, coach driven, and administration, sport science, and sponsor supported. Athletes who progress through LTAD experience training and competition in programs that consider their biological and training ages in creating periodized plans specific to their development needs. For more information on the Canadian LTAD please visit www.LTAD.ca.

When a coach considers a; training, competition and recovery program for an athlete, the age of the athlete must be considered. This is not done simply by checking the date of birth (chronological age). There are a number of ages which must be considered, including:

1. Developmental Age (Physical, Mental and Emotional)
2. Chronological Age
3. Biological Age
4. Skeletal Age
5. Relative Age
6. General Sport Training Age
7. Sport-specific Training Age

Development refers to "the interrelationship between growth and maturation in relation to the passage of time. The concept of development also includes the social, emotional, intellectual, and motor realms of the child."

Developmental Age refers to the degree of physical, mental, cognitive, and emotional maturity. Physical developmental age can be determined by skeletal maturity or bone age after which mental, cognitive, and emotional maturity is incorporated.

Chronological Age refers to the number of years and days elapsed since birth. Children of the same chronological age can differ by several years in their level of biological maturation.

Biological Age is a variable that corresponds roughly to chronological age, determined by measures of morphological, skeletal, dental or sexual age.

Skeletal Age refers to the maturity of the skeleton determined by the degree of ossification of the bone structure. It is a measure of age that takes into consideration how far given bones have progressed toward maturity, not in size, but with respect to shape and position to one another.

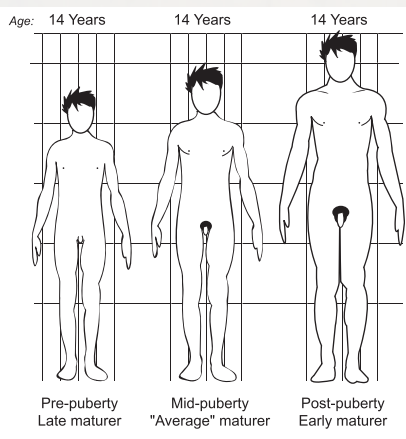
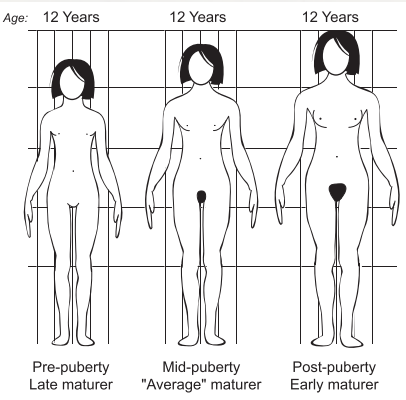
Relative Age also plays an important role in coaching decisions. "The relative age effect describes the observation that greater numbers of performers born early in a selection year are over-represented in junior and senior elite squads compared with what might be expected based on national birth rates." (19) This means that a child born on January 1st may participate in the same programs as a child born on December 31st of the same year, although one is almost a year older than the other. It is well documented that relative age has a great advantage in athletic selections. (19) The age group cut-off date for entry into organized youth sport is August 1st in English school sports and January 1st in Canadian ice hockey. In many different sports the relative age effect is clear to see.

General Training Age refers to the number of years in training, sampling different sports.

Sport-specific Training Age refers to the number of years since an athlete decided to specialize in one particular sport.

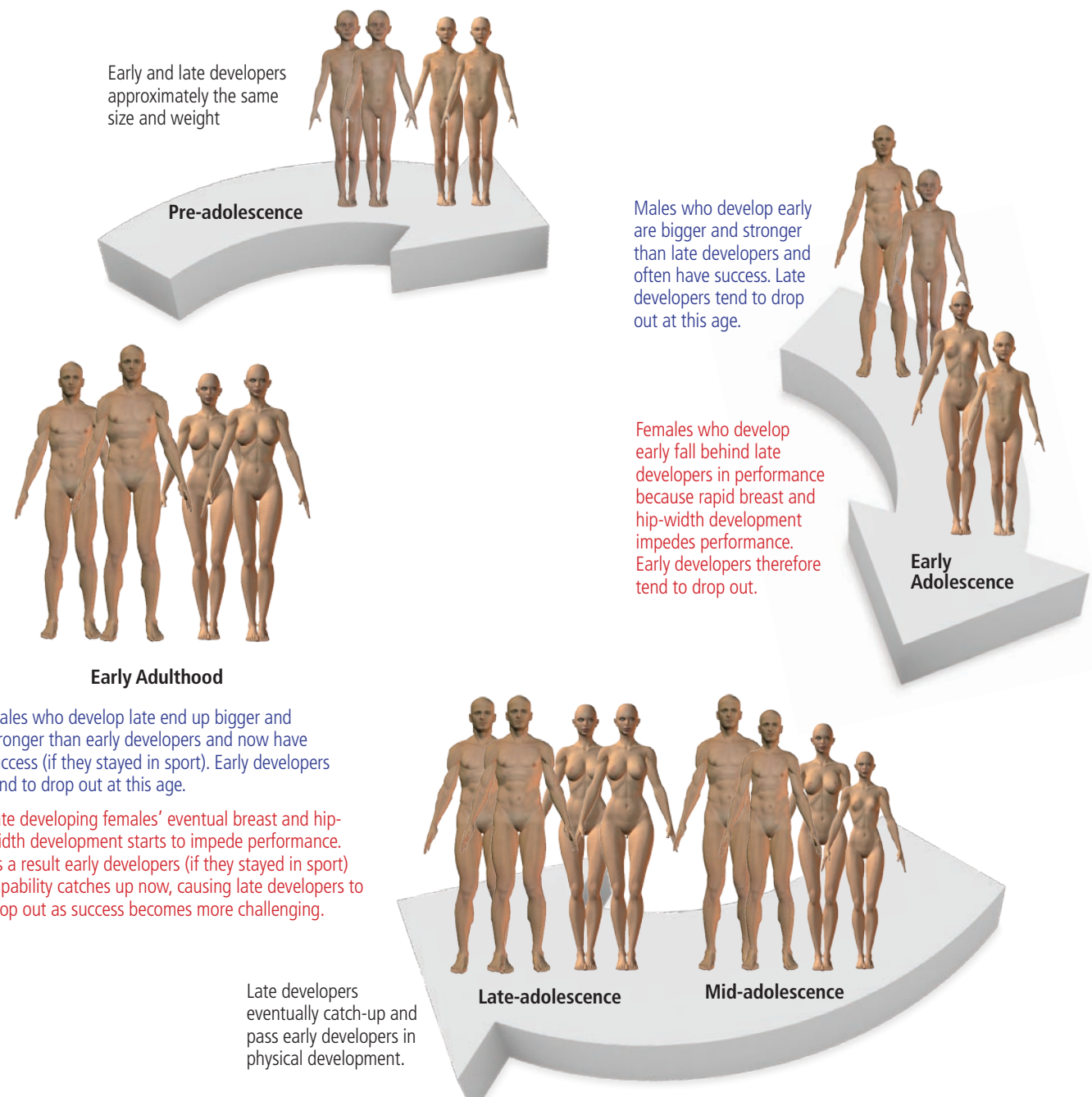
If relative age, a 10-12 month difference, can have such a big impact on selection, participation and performance, it is quite obvious that the domain of early and late maturers needs very special attention, which points out the possible 4-5 years of maturation differences. Thus, the understanding of the maturation process and its consequences is crucially important for athletes, coaches, parents, teachers and sport administrators.

Maturation in Girls and Boys



Adapted from "Growing Up" by J.M. Tanner Scientific American 1975

Early and Late Maturing Children Drop Out of Sport at Different Times For Different Reasons



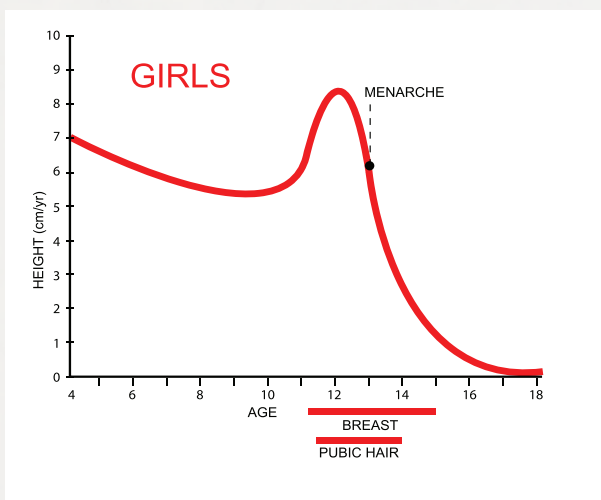
Peak Height Velocity (PHV)

PHV is the maximum rate of growth in stature during growth spurt. The age of maximum velocity of growth is called the age at PHV.

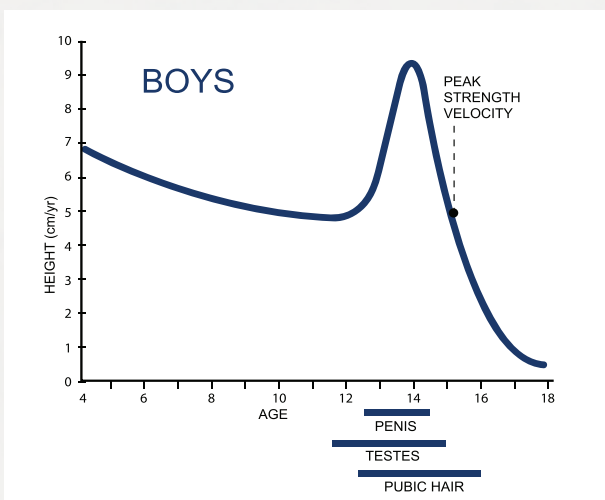
PHV in girls occurs at about 12 years of age. Usually the first physical sign of adolescence is breast budding, which occurs slightly after the onset of the growth spurt. Shortly thereafter, pubic hair begins to grow. Menarche, or the onset of menstruation, comes rather late in the growth spurt, occurring after PHV is achieved. The sequence of developmental events may normally occur 2 or even more years earlier or later than average.

PHV in boys is more intense than in girls and on average occurs about 2 years later. Growth of the testes, pubic hair and penis are related to the maturation process. Peak Strength Velocity (PSV) comes a year or so after PHV. Thus, there is pronounced late gain in strength characteristics of the male athlete. As with girls, the developmental sequence for male athletes may occur 2 or more years earlier or later than average. Early maturing boys may have as much as a 4-year physiological advantage over their late-maturing peers. Eventually, the late maturers will catch up when they experience their growth spurt.

Maturity Events in Girls (Modified after Ross et al. 1977)



Maturity Events in Boys (Modified after Ross et al. 1977)



How to Measure PHV

Tools and equipment for measuring

When considering the equipment needed for measurement, one must look at how much emphasis is going to be put on the measurement of stature. If stature data is going to be heavily incorporated into training plans, data must be very accurate, and thus, the more expensive the purchased equipment should be.

Ideal equipment:

- A free standing or wall mounted stadiometer (pictured)
- This stadiometer would need to have sliding headboards and a dial or digital (or digital read outs), which would aid in the ease of use

Acceptable equipment includes:

- An anthropometer or retractable steel measuring tape
- A headboard
- A smooth floor with a straight flat wall at 90 degrees

Unacceptable equipment includes:

- A cloth measuring tape
- Flexible material
- Carpeted floor
- An uneven floor
- No backboard



What to Measure?

Determining the rate of growth is dependent on accurate measurements; therefore, measurements need to be made to the nearest 0.1 cm. Each athlete should be measured and recorded twice, but these measurements should not differ by more than 0.4 cm. If they do not differ by more than 0.4 cm, the mean of the two measurements should be taken. If they do differ by more than 0.4 cm, a third measurement should be taken, and the median of all three measurements should be calculated.

Example 1 – Two measurements within 0.4 cm of each other
Stature measurement #1 - 166.2 cm
Stature measurement #2 - 166.3 cm

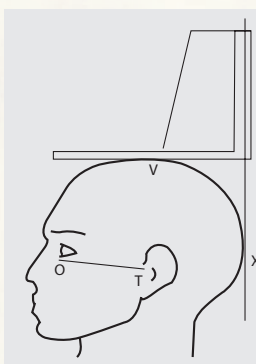
The above two measurements are within the acceptable range and the mean measurement recorded as 166.3 cm.

Example 2 – Two measurements not within 0.4 cm each other
Stature measurement #1 - 158.2 cm
Stature measurement #2 - 162.9 cm
Stature measurement #3 - 162.6 cm

The above two measurements are not within 0.4 cm of each other; therefore, the median of the three scores needs to be used, and the recorded score is 162.6 cm.

Determining a Velocity Curve

To determine the velocity curve, the increase in stature from one measurement time period to the next consecutive measurement time period is subtracted one from the other. For example, from 9 years to 10 years the increase in stature is 5.0 cm. By plotting the velocity curves it will be possible to clearly distinguish the rate of growth from one point in time to another. The velocity curve will immediately show distinctive growth points (for example, the onset of the acceleration in the curve, the peak in the curve and the deceleration in the curve).



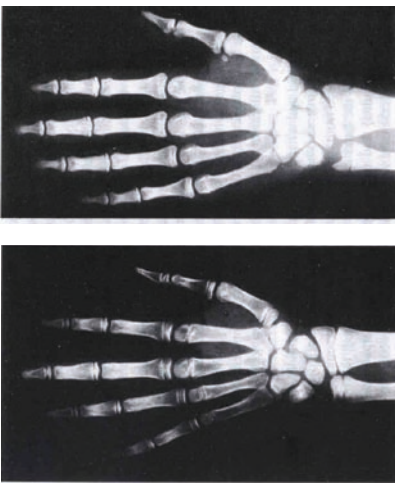
When measuring a child's height, it is important to pay special attention to technique, if results are to be of use. Ideally, two measurers should be present; one to perform the positioning of the athlete, while the other records the actual measurement. If a second measurer is not available, it is still possible to get valid results; however, extra attention to technique should be paid.

Proper Measuring = Measuring Height

The orbitale (O) is located on the lower or most inferior margin of the eye socket. The tragion (T) is the notch above or superior to the tragus or flap of the ear, at the superior aspect of the zygomatic bone. This position corresponds almost exactly to the visual axis when the subject is looking directly ahead.

Developmental Age

Radiographs of two 14 year old boys: (bottom) bone age 12 'years'; (top) bone age 16 'years'.

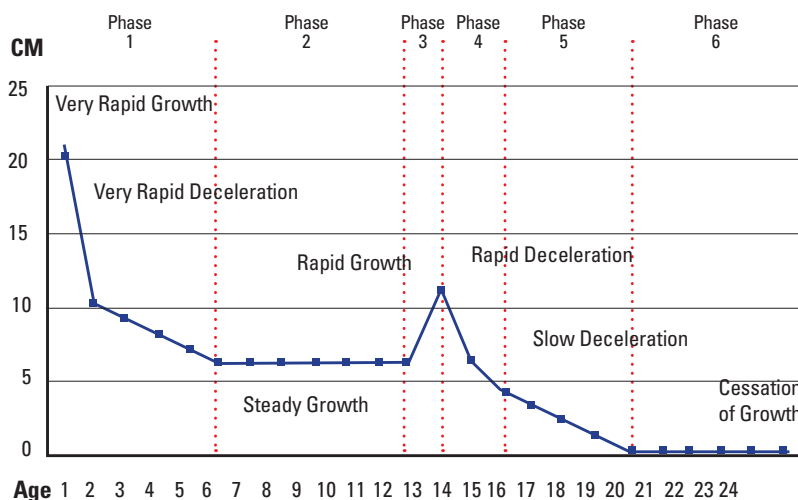


The Six Phases of Growth

PHV is the fastest rate of growth during the adolescent growth spurt; it can be used as a guide to growth and physical maturity during adolescence, and can be used to identify the maximum growth rates of children. In order to track PHV, data must be collected on a longitudinal basis, with the analysis of models and graphs (13,14). Somatic (musculo-skeletal) growth in the form of PHV follows six phases:

1. Very rapid growth and deceleration in infancy and early childhood
2. A steady growth during middle childhood
3. A rapid growth during adolescent spurt (PHV can be identified)
4. Rapid deceleration after the peak
5. Slow deceleration
6. Cessation of growth

For Phase 2, 3, and 4 all three measurements should be taken every 3 months.



Plotting a Velocity Curve

Standing Height (Example - See Velocity Curve Below)

Age	8-9	9-10	10-11	11-12	12-13	13-14
Growth in cm	5	6	0.9	1.3	3	1.5
Total Growth in cm	5	6	6.2	8.6	12	7.7

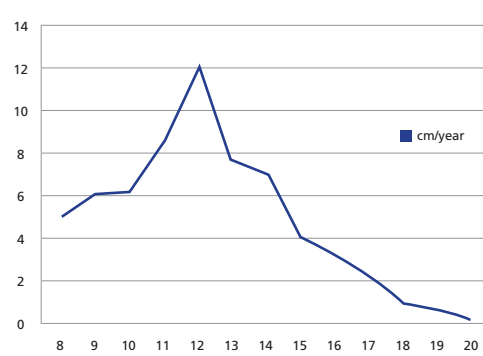
Age	14-15	15-16	16-17	17-18	18-19	19-20
Growth in cm	1.6	2.1	2.0	1.6	1.4	0.7
Total Growth in cm	7.00	4.00	3.2	2.1	0.8	0.5

Standing Height

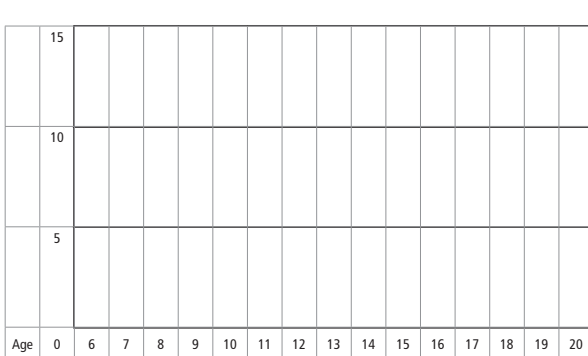
Age	8-9	9-10	10-11	11-12	12-13	13-14
Growth in cm						
Total Growth in cm						

Age	14-15	15-16	16-17	17-18	18-19	19-20
Growth in cm						
Total Growth in cm						

Plotted Velocity Curve (Example) - Standing Height



Plotting the Growth Velocity Curve for Standing Height



Sitting Height

Age	8-9	9-10	10-11	11-12	12-13	13-14
Growth in cm						
Total Growth in cm						

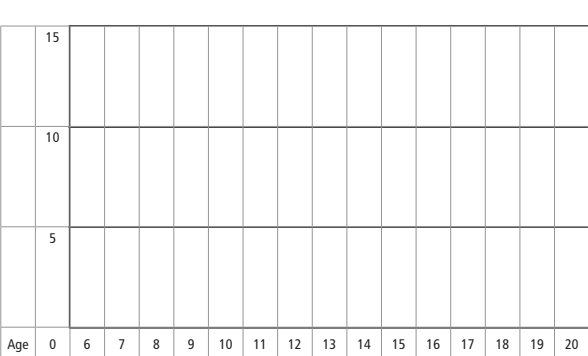
Age	14-15	15-16	16-17	17-18	18-19	19-20
Growth in cm						
Total Growth in cm						

Arm Span

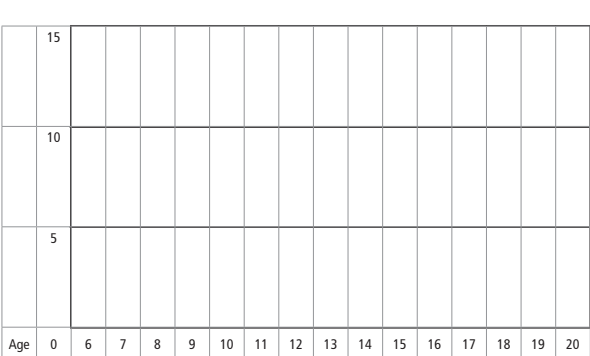
Age	8-9	9-10	10-11	11-12	12-13	13-14
Growth in cm						
Total Growth in cm						

Age	14-15	15-16	16-17	17-18	18-19	19-20
Growth in cm						
Total Growth in cm						

Plotting the Growth Velocity Curve for Sitting Height



Plotting the Growth Velocity Curve for Arm Span

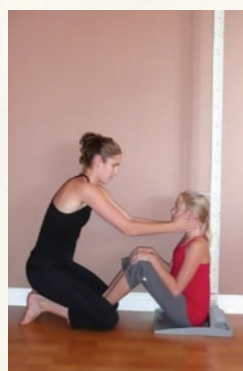


Protocols For Measurement



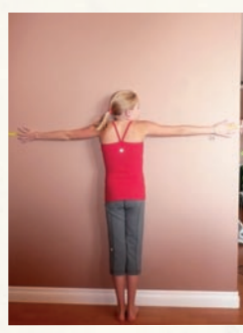
Standing Height Measurement

- The student stands erect in bare feet with heels, buttocks and shoulders pressed against the stadiometer.
- Heels together with arms hanging freely by the side (palms facing thighs).
- The tester applies gentle upward traction to the skull behind the ears.
- The student should look straight ahead, take a deep breath and stand as tall as possible.
- Draw down the measuring bar to the student's head and record standing height to the nearest 0.1cm.



Sitting Height Measurement

- Student sits on the base of the stadiometer with knees slightly bent. Hands rested on knees.
- The buttocks and shoulders rest lightly against the stadiometer, which is positioned vertically behind the student. Ensure there is no gap between buttocks of student and stadiometer.
- The tester applies gentle upwards traction to the skull behind the ears to ensure the trunk is fully stretched.
- Draw down the measuring bar to the students head and record sitting height to the nearest 0.1cm.
- Once sitting height is calculated, it can be subtracted from the stature score, in order to derive the leg length height.



Arm Span Measurement

- Mount a tape measure on the wall about shoulder height of the students being tested. Ensure the starting point of the tape measure is fixed to a corner of a wall. This is where the student's fingers must be fixed.
- The student stands erect with their stomach and toes facing the wall, feet together and head turned to the right.
- The arms are extended laterally at shoulder level (horizontal) with palms facing forwards. Fingers stretched.
- The tip of the middle finger is aligned with the beginning of the tape measure (corner of wall) and arms are out-stretched along the tape measure.
- Use a ruler held vertically to the tape measure to record total arm span to the nearest 0.1cm.

Creating a Simple Measurement Tool For Standing Height

1. Put a strip of tape vertically on the wall or door edge at about head height.
2. Stand the child with their back to the flat surface, with their heels and head touching the surface.
3. Place a cereal box on their head, long side against the flat surface.
4. With the child looking straight ahead, mark the height on the flat surface [tape] using the underside of the box as a guide.
5. Measure the distance from the floor to the mark on the flat surface. Zero point of tape on the floor. Record the distance as height.

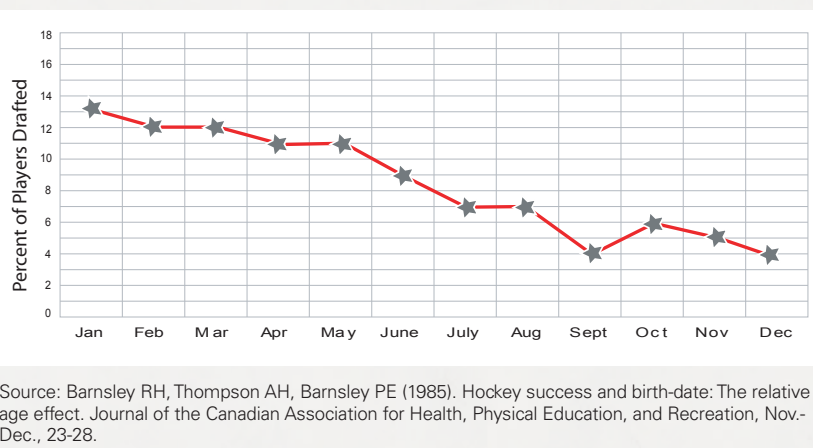
Protocols Adapted & Modified From British Diving

How to Use the Growth Information

- Measuring PHV is a tool to monitor growth and maturation.
- Monitoring growth velocity curves and recognizing the timing and tempo of growth is essential to coaches when training adolescent athletes (pre-pubertal and pubertal).
- By monitoring growth and plotting the patterns of growth can help coaches in decision making how to adjust training, competition and recovery programs according to the velocity of growth.
- By measuring standing height, sitting height and arm span every three months after the onset of the PHV will help to determine what part of the body is growing and what velocity. (Usually the foot and the hand; the legs after, the arms after and the trunk finally and with Peak Weight Velocity the body will fill out).
- The parent/coach will have a better understanding of the impact of growth on skill, on speed and on flexibility.
- Although the trainability of skill, speed and suppleness is based on chronological age, biological markers can identify the sensitive periods of trainability to exploit the adaptation to training for stamina and strength.

For Further Information On Measuring Growth Go To www.LTAD.ca

Month and Birth of Elite Hockey Players

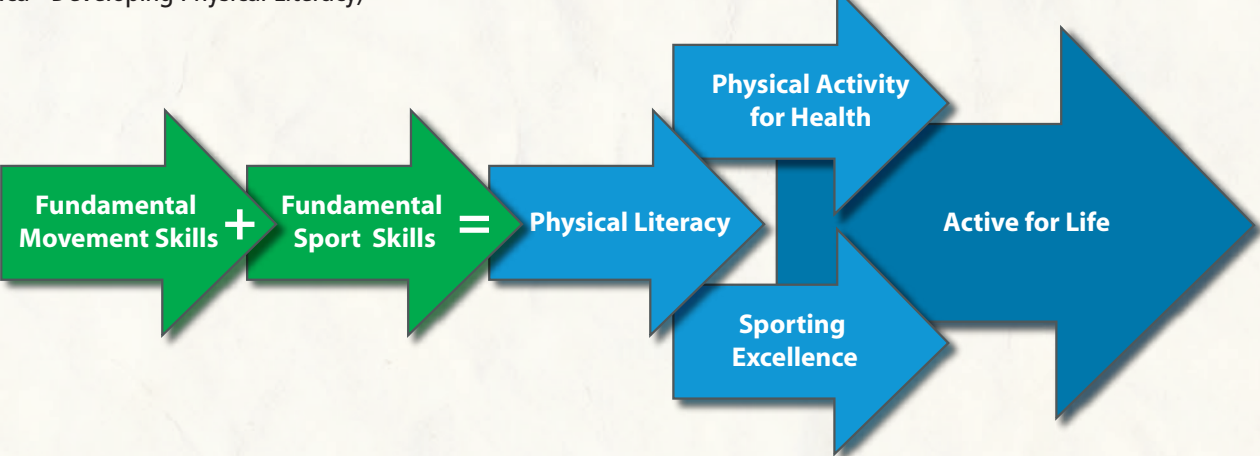


Source: Barnsley RH, Thompson AH, Barnsley PE (1985). Hockey success and birth-date: The relative age effect. Journal of the Canadian Association for Health, Physical Education, and Recreation, Nov-Dec, 23-28.

The Figure at left shows the distribution of birth-months of players in two Canadian major junior hockey leagues (the Ontario Junior Hockey League and the Western Hockey League). The data indicate that the probability of success in high calibre hockey is dramatically reduced for those born at the end of the year. Furthermore, among National League Hockey Players who were active in the early 1980s, about 40% were born in the first quarter of the year, 30% in the second, 20% in the third, and less than 10% were born in the final quarter.

In terms of playing at a high level, boys born in the last part of the year have a much lower chance than those born at the beginning of the year. The fact that January and December, which are juxtaposed, show such dissimilar results, suggests that it is not the weather during conception or birth that has made the difference.

Physical Literacy is the Foundation For Lifelong Physical Activity and Podium Performances (www.LTAD.ca - Developing Physical Literacy)



Influence of Maturation

