Swimming Proficiency

An Alternative Performance Metric for Competitive Swimmers

Validation Report

March 11, 2010

By Lawrence A. Marrington

A 6 Sigma Black Belt Project

Swimming Proficiency – An Alternative Performance Metric For Competitive Swimmers

By Lawrence Marrington, Original Sports Research, Black Belt Project, 11 March 2010

Abstract:

Background. As a performance indicator, swimming times measure speed but do not measure swimming proficiency. Consider this, two swimmers swim the same time, one swimmer is 5 feet tall and the other is 6 feet tall. If we use times as a proficiency indicator we conclude the two swimmers equal, however, clearly the smaller swimmer here would be the more proficient. Fortunately there is a simple ratio that can define swimming proficiency, namely, the speed you swim your own body length.

Swimming Proficiency (SP) = Time (seconds) / Number of Body Length's in the event

What has become crystal clear is that any performance metric based on times alone will fail as a proficiency metric. Height is such a significant factor in unearned swimming speed, that it must be considered in any measure of proficiency. Dividing time by the number of BL's essentially normalizes height as a performance factor. Consider the difference in body lengths in a 100 yard event for a 5 foot and 6 foot swimmer. The 5 foot swimmer swims 60 BL's, while the 6 foot swimmer swims only 50 BL's. That is a 10 BL difference. Although this is an extreme example, height differences less than 1 inch can easily add up to 4 to 5 feet in the effective race distance.

In order for the SP equation to be valid, it must not favor tall or short swimmers. Validation of the SP equation is reported here.

Research Methods. NCAA Div I times and team bios with height data were used to assess the relationships between times & height, and SP & height. USA Swimming databases were used for SP trending and correlation. Historical 40 year times/heights, motivational time standards, and Hy-Tek Power Point time lines were paired with US National height and age data. International height and time data was used along with US height and time data in the construction of SP Standards.

Results/Findings.

- For NCAA Div I: 65% come from the tallest 25%. 3% come from the shortest 25%.
- For NCAA Div I: The fastest 1% come from the tallest 5%(>74.25" men, >68.55" for women).
- For NCAA Div I: Taller swimming groups are faster on average than smaller swimming groups.
- For NCAA Div I: SP parity exists across all height groups.
- The average height of motivational performance groups gets taller as the performance group gets faster.
- SP improves for all motivational performance groups as swimmers age-up.
- SP parity exists for each age group regardless of the performance group.
- SP highly correlates with the Hy-Tek Point System time lines. SP parity exists across all height groups.

Conclusions. The SP equation is a scientifically valid performance indicator for competitive swimmers. SP does not favor tall or short swimmers. SP Standards are based on world-wide height and time data.

ABOUT THE AUTHOR

Lawrence A. Marrington lives in Farmington Connecticut has a BSCE from Bucknell University, an MBA from Rensselaer Polytechnic Institute and has been in engineering for 30 years as of this writing. Of those 30 years, 25 have been in aerospace practicing a wide variety of disciplines including product support, project, program, test, quality and industrial engineering. The other 5 years were spent in research and development for an equipment manufacturer.

Lawrence has been a lifetime athlete whose first sport at the age of 6 was competitive swimming. Wrestling, soccer, and track came later during the school years. And in post school years came running, adult soccer, triathlons, and as much swimming as possible.

Lawrence has two children with his wife Betsy. Both are competitive swimmers presently at the college level.

As the owner of Original Sports Research, Lawrence has published two websites, namely swimmingpotential.com, and swimmingproficiency.com.

Lawrence is presently working towards his Six Sigma Black Belt Certification.

TABLE OF CONTENTS

INTRODUCTION:
A fundamental notion in competitive sport is that the rules of the sport ensure each competitor an equal chance of winning. The competition then becomes a contest of performance factors each competitor has control over, such as skill development, conditioning, nutrition, and psychology. The rules are written to control performance factors outside the control of competitors. Factors such as equipment, or physical factors like size and weight are controlled by the rules to assure a fair contest. In baseball, everyone plays with the same type of bat and ball. In most sports men and women do not compete against each other.

As a voice for sport, this report looks at competitive swimming and it's well known yet little understood lack of competitive fairness. It reveals the bias towards taller swimmers and offers a way to remove the bias via a performance ratio called Swimming Proficiency (SP). SP is a practical, simple, unbiased approach toward understanding inch for inch who the better swimmer is. Finally, a level playing field for competitive swimming. This report validates SP as a performance metric.

We know that the fastest swimmers tend to be the tallest swimmers. How tall are they? In 2008, the average height of the Men's top 10 NCAA teams was 6 feet 2 inches. This ranks at the 94th percentile per the US Growth Charts[1] . For Women it was 5 feet 9 inches ranking as the 97th percentile. There are over 20,000 NCAA male swimmers (D1, 2, and 3) from which the top 10 teams represent about 1 percent. The same is true for the women. A general gage for understanding speed and height follows: The fastest 1% come from the tallest 5%.

The slower the group of swimmers, the shorter they get. Looking at the NCAA Division 1 MAAC Conference you will find excellent swimming, but not a single person qualifies for the Nationals. How tall are they? The men on average are 5 feet 11 ½ inches, ranking at the 75th percentile. The women on average are 5 feet 5 ½ inches, ranking at the 68th percentile.

And so it goes. Every sample group studied follows this trend. From adults to age groupers, height and speed are related. The faster groups are the taller groups.

Individuals studied also follow this same trend. As an individual, you get faster as you grow taller. This doesn't mean that getting taller is the only reason for more speed. However, when you consider the all too common plateau experience among matured swimmers, you realize that getting taller is a very significant factor in getting faster and in many cases is the only reason. The first season swimmers do not make a personal best time is typically the start of the dreaded plateau. The plateau is almost always accompanied by the fact that the swimmer did not get any taller since last season. Women experience the plateau a few years before the men because they stop growing a few years before men. Once accomplished swimmers stop growing taller, they find out how hard it is to swim faster. Many realize that the same seasonal routine of workouts and level-of-effort simply produces the same result. In order to swim faster in seasons

[1] National Center for Health Statistics (11/21/2000)

after the growth years, swimmers must work significantly harder or smarter than they did previously during the growing years.

The Plateau Prediction

By definition, the plateau has occurred when the swimmer has both stopped growing and stopped getting faster. The question is: how much was growth a factor in swimming faster before the plateau? What if workouts and work ethic for many swimmers does not improve season to season, but instead remains the same season to season. Sadly, for this group of swimmers, getting taller is the sole reason for getting faster. If the quality of the swimming does not improve while the swimmer is growing, then the probable reason for swimming faster is the growth! This group of swimmers is an excellent baseline group to study to see how much height contributes to speed. For these swimmers, times will drop as they grow and times will stop dropping when they stop growing.

The Hy-Tek Point System endorsed by US Swimming is designed to indicate an equal quality swim as swimmers age up, that is grow taller. For example, a 500 point swim as a 10 year old has the same quality as a 500 point swim as a 14 year old. The time is faster and the swimmer is taller, but the quality of the swim is the same. This point system essentially predicts the plateau. In this report, we will see how well SP correlates with the Hy-Tek system.

Time is Not on Your Side

As a performance indicator, swimming times do not indicate who the better swimmer is. For example, two swimmers swim the same time, one swimmer is 5 feet tall and the other is 6 feet tall. If we use times as a performance indicator we conclude the two swimmers equal, however, clearly the smaller swimmer here would be the better swimmer. Times indicate speed, not proficiency.

Swimming Proficiency (SP) is Born

The best swimmers may not be the fastest swimmers. It is speculated that the best athletes and therefore the best swimmers probably do not come from the tallest 5 percent of the population. More probable is that the best swimmers are among the other 95 percent. Who are they? How do we measure? How do we level the playing field?

The best way to level the playing field in swimming is to devise an unbiased performance metric that neutralizes the height factor. Let's look at the typical swimming race. Who is the better swimmer, the 6 foot female swimming a 50 second 100 free or a 5 foot 6 inch female swimming a 54 second 100 free? Note that the 6 foot swimmer swims 50 body lengths in this 100 yard event versus the 5 foot 6 inch swimmer swimming 54.5 body lengths or 4.5 more body lengths. The idea that the race has disproportional body length distances seems unfair. What if we use the number of body lengths as a devisor into time and calculate the average time per body length? This ratio will allow us to compare swimmers and find out who swims their own body length (BL) the fastest. The person who swims their own BL faster is the better swimmer only if this ratio is a fair measure for all swimmers.

Using the previous example, it was noted that the 6 foot swimmer swims her body length 50 times versus the 5 foot 6 inch swimmer who has to swim her body length 54.5 times or 4.5 more body lengths. Using the number of body lengths (BL) a swimmer swims in a given event is the approach taken to factor out height. A fair race is to have each swimmer swim the same number of body lengths. This is the central idea behind the new swimming proficiency (SP) performance metric. By taking a swimmer's time and dividing it by the number of BL's you will get the average time per body length, which by definition is the swimmers swimming proficiency (SP). SP is simple to calculate given time and height inputs.

So in our example, who is the better swimmer? The SP for the 6 foot swimmer is 1.00 sec/BL and for the 5 foot 6 inch swimmer it is 0.99 sec/BL. Answer: the 5 foot 6 inch swimmer is better because she is more proficient. The 6 foot swimmer would have to swim a 49.5 to be as good as the 5 foot 6 inch swimmer.

Consider these examples of whose better:

- Any event: Either gender, same time, 5' 3" VS 6' 0"
- 100 SCY Fly: 5' 8" male goes 48.2 sec VS 6' 4" male who goes 45.00 sec
- 100 SCY Free: 5' 3" female goes 55.2 sec VS 5' 8" female who goes 51.5 sec
- 50 SCY Free: 5' 4" female goes 24.8 sec VS 5' 10" female who goes 23.0 sec

Because swimming times are significantly influenced by the height of the swimmer, it is certain we cannot determine who the best swimmers are by times. Taller swimmers have a speed advantage, but as this validation report proves, not a proficiency advantage.

Definition:
Swimming Proficiency (SP) is defined as the average speed you swim your own body length (BL). Simple to calculate, first calculate the number of your body lengths in a given event.

SP = Your Event Time / Your # of Event BL's

Inch for Inch
How much time does each inch in height save? Consider the trade factors below for 50 and 100 freestyle.

Trade Factors - Based on Average Height with All American Swimming Proficiency[2]

	50 Free	100 Free
MEN	0.33 sec per inch	0.72 sec per inch
WOMEN	0.40 sec per inch	0.87 sec per inch

[2] See Original Sports Research website, swimmingpotential.com for SP Standards. The All American SP standard is one of seven SP standards developed for every event. Reaching this standard means the quality of the swim is equal to or better than those swimming All America times.

Trade factors vary as a function of SP and height, but the majority of swimmers can follow these general rules.

General Trade Factors

	50 Free	100 Free
MEN	0.35 sec per inch	0.75 sec per inch
WOMEN	0.42 sec per inch	0.90 sec per inch

The tables above are an example of how significant an inch in height is. Think of it this way: For every inch you grow, your 100 Freestyle will drop by 0.9 seconds if you are female or 0.75 seconds if you are male. Or, for every inch taller you are over your competition, you have this trade factor advantage. A three inch height advantage for example is the same as a 2.2 to 2.7 second head-start, respectively for men and women.

Proportionality

At this point it is important to note that although taller swimmers have a speed advantage, they, along with all swimmers, may also have many speed disadvantages. From APPENDIX A, view the uncontrollable and ungoverned performance factors. Through attributes surveys the list was paretoized listing the factors from most important to least important. Clearly, the most significant factor was height. Height is not the only uncontrollable and ungoverned factor effecting speed, but it is deemed the most significant. Because people grow proportionally, taller people also tend to have bigger hands, feet, arms, legs, and longer reaches. Of course not all people have the same proportions and there can be significant variations in proportions. Some people have abnormally large hands or long reaches for their size. In other words, some people have abnormal proportions. This being said, abnormally large hands and long arms for example ranked near the bottom of importance. There is no evidence that the fastest swimmers have abnormally large hands or abnormally long reaches. Even the speculation about Michael Phleps having an abnormally long wingspan is not true. Michael is above average but quite normal. Michael is 76 inches tall with a wingspan of 79.13 inches, a wingspan to height ratio of 1.041. The average ratio is 1.022 with a standard deviation of 0.024, which means 84% of the population has a ratio less than 1.046. Michael has a wingspan to height ratio that is larger that 79% of the population, above average yes, abnormal no.

Reach, Height, and Body Length

Reach is an advantage in swimming. From toe tip to fingertip, the longer the better. Reach is different than wing-span, but both have a relationship to height. Height is a very good indicator of both reach and wingspan due to proportionality. As a practical matter, height is easily and often measured, unlike reach, and so is the factor used in the SP equation as the equivalent to the term body length.

Turnover Myth

Contrary to popular belief, shorter swimmers may not have faster turnover than taller swimmers. Limited data from a collegiate study actually supports the opposite – that faster/taller swimmers have higher turnover. Why? As this study is in progress, the following speculation is offered.

- The more motivated faster/taller swimmers train better, smarter, and harder and as a result improve their turnover whereas the less motivated slower/shorter swimmers do not.
- Although the distance the hand travels in one stroke increases with taller swimmers, it is the length of the power phase that most slows down the turnover rate. Increasing the momentum of your swim makes it easier to pull, thus increasing hand speed. The speedier hand-speed compensates for the longer distance resulting is the same turnover rate (strokes per minute).
- Proportionality suggests that larger arms/hands have proportionally larger shoulders/muscles and therefore power. All strokes except breaststroke require a 360 degree shoulder movement. The stroke is a circular muscle movement at the shoulder, all else follows. All else equal as you grow, turnover remains the same.
- Relative to machinery, the upper end of turnover speeds by humans is extremely slow. Variation at these slow rates is insignificant.

Regardless of whether there is a turnover difference between tall and short swimmers, it is certain that this factor has not changed the fact that taller groups are faster.

Fairness

Regarding all the uncontrollable and ungoverned performance factors in APPENDIX A, one could argue it unfair to have high VO2 compete against low VO2 or fast twitch against slow twitch or small hands against large hands. Since there is no practical way to level the playing field for all these factors, this much will remain unfair as is so for all of sport and competition. Perhaps more important is the notion that competition need not be fair. David versus Goliath although unfair, has a place in competition as does the Yankees best money can buy versus all the rest.

Performance Ratios

Like many performance metrics, ratios are often the best. Stocks are not evaluated for their price but for their Price/Earnings ratio. The best jumpers are not the highest jumpers. Man jumps higher than fleas but can barely jump his own height, while fleas can jump 30 times their height. Baseball uses many ratios to compare performance, like batting averages and on base percentages. How else do you compare a batter who has 1000 at bats versus a batter that has only 100? Other examples are weight loss competitions measuring pounds lost per body weight. A 500 pound person losing 10 pounds is not the same thing as a 180 pound person losing 10 pounds. Formula 1 racing by definition sets a formula to keep the competition fair. Sailing is full of classes defined by ratios to keep the boats the same. It is common to use ratios as a way to level the playing field.

Outlook

Competitive swimming has falsely evolved using time standards as a way of determining who the best swimmers are. In fact today's leaders of the sport are culling out the fastest swimmers across all age groups and beyond in a way that results in discouraging the best swimmers and alienating all but the very fastest. There is little to no education or even curiosity among the sports publicity agents and boards that sees the opportunity to grow the sport simply by recognizing the simple truth that in swimming, the fastest are not the best and that the best swimmers have yet to be recognized.

This truth will be recognized either willfully or with regret. The more a sport deviates from true athletic competition, the less respected it becomes. Eventually, a very tall swimmer with average skill will dominate swimming and become a spectacle. Imagine a seven foot swimmer, eight inches taller than the average world class swimmer, easily smashing world records. This would be news indeed, but in the end it would be a spectacle that would scatter doubt over the credibility of swimming as a sport.

The population trend according to USA Swimming data[3] starts with approximately 30 thousand 8 and unders we will call the Class of 2008. Between the ages of 8 and 9 the class loses about 8 thousand class-mates. Between 9 and 11, the class gains back about 5 thousand class-mates. From 11 onto graduation, a steady 17 thousand are lost and never graduate. The class of 2008 started at 30 thousand and ends up with only 10 thousand in the senior class. Could we retain more swimmers if we recognized more swimmers?

In everyday commentary and articles, the notion is repeated over and over again that the fastest and the best are the same thing. Truly troubling is that when in search of the best we only seek out the fastest we are disrespecting the majority of swimmers. Would more people appreciate and respect swimming if we recognized not only the fastest swimmers but also the best swimmers? As a voice for the sport, give SP a chance and the sport will grow. The use of SP provides the opportunity to explore who the best swimmers are.

Advice

Let's recognize more swimmers for the right reasons. Comparing swimmers by their SP will create more competition, more recognition, more motivation, and ultimately more swimmers as the sport will become more popular.

Stop taking credit for unearned time improvements due to getting taller. Start using SP to determine earned improvement. Start using the SP Standards to see where you stand.

Stop comparing swimmers by their times. Times are not an indicator of who the better swimmers are. Start using SP to determine who the best are. Learn from the best. Recognize the best. Motivate the best.

Go to swimmingpotential.com or swimmingproficiency.com and use the SP Calculator. Find out your SP and where you stand among the SP standards. Find out how fast you need to go to become All-State, All-American, National Team, Olympic Team, or World Record Class proficient. Very cool!

Finally, a level playing field for competitive swimming. Inch for inch, how good are you?

[3] USA Swimming website. www.usaswimming.org, USA Swimming Tools/Times&Time Standards/Stats

Validation Approach:

The speed you swim your own body length (BL) is a simple calculation called Swimming Proficiency (SP). The issue is whether this calculation can be used as a performance metric to compare swimming proficiency. In order to qualify as a performance metric it must be proven to be fair, unbiased and neutral. It cannot favor smaller or taller swimmers.

How do we prove SP a fair performance metric? The best way is to vary height and hold all other performance factors equal and constant. Under these conditions we would collect data over time from thousands of swimmers. If individual swimmer SP does not change as they grow, then you would conclude SP is not influenced by height.

The problem is holding all other performance factors equal and constant. If not impossible, it is certainly not practical. APPENDIX A lists all the performance factors. Of these, only sex can be held equal and constant: All of the others (nutrition, rest, recovery, experience, level of effort, conditioning, technique, appendage sizes/shapes, body fat, VO2 Max, fast twitch muscle fiber, testosterone level, etc) cannot be held equal and constant. We can however attempt to minimize the variation.

The validation approach is to collect data from existing data sources and reduce the data in such a way as to minimize the variation in other performance factors. In order to minimize variation in the data we can address the sources of obvious variation. Growth spurts, testosterone effect, high and low experience, over and under training, high achievers and low achievers.

Variation Issues:

Sex – Male and female data will remain separated. There is a significant performance difference between men and women of the same height especially in the older age groups. The testosterone effect with men clearly separates men from women. Among men the testosterone effect adds another variable. Not all men get this boost at the same time or at the same level.

Age - Growth spurts create a data issue, although captured for individuals, normal growth data does not apply to groups effected by growth spurts, namely the top 100 and other fast groups. Data shows that the top 100 age group swimmers in the 10 & Under and 12 & Under groups are on average experiencing growth spurts. These swimmers are exceptionally tall for their age, well above the 99 percentile. For both girls and boys, 10 year olds above 5ft 1 in and 12 year olds above 5ft 6inches are above the 99 percentile. Therefore, only age groups 13 & Over will be used.

Training - Holding training constant means to have seasonal training that does not vary in terms of the workout or the swimmers level of effort. Swimmers closest to this criteria are in the top 3 tracks of the motivational time standards. The fastest/tallest groups do not meet these criteria as they receive the most attention from coaches and the most recognition which is highly motivational and results in continuous improvement. The slower/smaller swimmers tend to be on the other extreme, lacking in any kind of routine and or dedication. Therefore, the fastest or top 1% and the slowest or track 4 groups were factored out of the data.

Experience – Competitive swimmers with 3 or more years experience of winter and summer swimming tend to acquire this experience before the age of 12. Inexperienced swimmers (beginners) can significantly impact age group average times. Therefore, only age groups 13 & Over will be used.

Data Reduction:

All time data will be:

- Championship season times.
- Event – 100 SCY Free

Variables:

- Height

Speed Factors to be Isolated:

- Sex – male, female
- Age Groups -13-14, 15-16, 17-18 years of age.
- 55th to 98th speed percentiles (top 3 tracks) per USA Swimming Percentile Based Motivational Time Standards[4].

Speed Factors Not Isolated:

- No effort was made to isolate all other physical attributes such as body types, foot size, hand size, reach. All are proportional to some extent to height. Variations in proportionality are not isolated.

- No effort was made to isolate physical performance attributes such as testosterone levels, VO2 max, fast/slow twitch muscle mass.

- No effort was made to isolate nutrition, rest/recovery, mental, equipment, facility or officiating factors.

[4] 2005-2008 National Age Group Motivational Times – Percentile Based

Data Sources:

NCAA Division I time databases and NCAA team bios with height data were combined and analyzed to study the time versus height and SP versus height relationships.

USA Swimming databases were used to access historical times, names of swimmers, ages, dates, and swimmer biographies with height and age data. Additionally, USA Swimming endorsed age group motivational time standards and the Hy-Tek Point System databases were accessed.

The US National Center for Health Statistics growth rate databases were used to define normal growth rates for US children ages 8 through 20 years.

The approach to understanding normal swimming proficiency (SP) patterns was to combine normal time and age based databases with normal growth rate data.

Original data sampled swimmers from all ages and performance groups in order to understand the statistical height data for each performance group. The performance groups are defined by USA Swimming's percentage based age group motivational time standards.

The Hy-Tek Point System database, endorsed by USA Swimming, was used for comparison and correlation to the SP system. This database predicts swimming times for swimmers who do not improve their swimming quality as they age and grow. Hy-Tek refers to this as a "quality" point system. A given point value, say 500 points, has equal quality regardless of age. For example a 12 yr old girl swimming 61.93 in 100 SCY free earns 508 points. At age 14, 508 points equals a 58.60 sec swim. The times are faster as the swimmer ages-up, however, these time improvements are "unearned". Unearned factors like growing taller and physically maturing explains the time improvement. Therefore, by plotting all the age group times for a given point value, Hy-Tek establishes a baseline from which "earned" improvement can be measured. Essentially, the Hy-Tek Point System uses "unearned" time improvements to establish base time lines. Unearned time improvements are attributed to unearned performance factors like height and other naturally occurring physical factors. For males, maturing means increased levels of testosterone, which is performance enhancing. Earned time improvements are attributed to earned performance factors like conditioning and technique.

The SP performance metric focuses only on the effect height has on times. Like Hy-Tek, SP can be used to establish base time lines. Again, SP isolates only the height effect whereas Hy-Tek isolates all naturally occurring physical performance factors. Given the very similar approaches of Hy-Tek and SP to factor out unearned performance factors, a comparative study was performed. Correlation by regression analysis was one approach. The second approach was an optimization study.

NCAA Division I Data and Analysis – SP Validation

<u>NCAA Div I Population</u>

The sport of swimming culls out the competition by time standards. The swimmers who survive this process and become NCAA Div I swimmers are shown in the following charts. Clearly height is a significant factor in swimming survival. Figure 1 below shows a significant population shift to taller swimmers. The average male at 5 feet 9 inches (69 inches) becomes the shortest 9% of the NCAA population. By contrast the tallest 5% at 6 feet 2 inches (74 inches) joins the tallest 24% of the NCAA population. In Figure 2, the same population shift to taller swimmers is true for the women.

Analyzing height groups as they relate to SP and times, the population sizes of each height group must be equal in order for the comparison to be valid. Each height group must have an equal chance to perform. Statistically, we know that larger populations will have larger variation. As variation increases, so does the chance of finding an extreme athlete. Simply put, there is a better chance that larger populations will produce the best athletes. This understanding is critical as we analyze "unequal size" height groups resulting from the culling of swimmers by times.

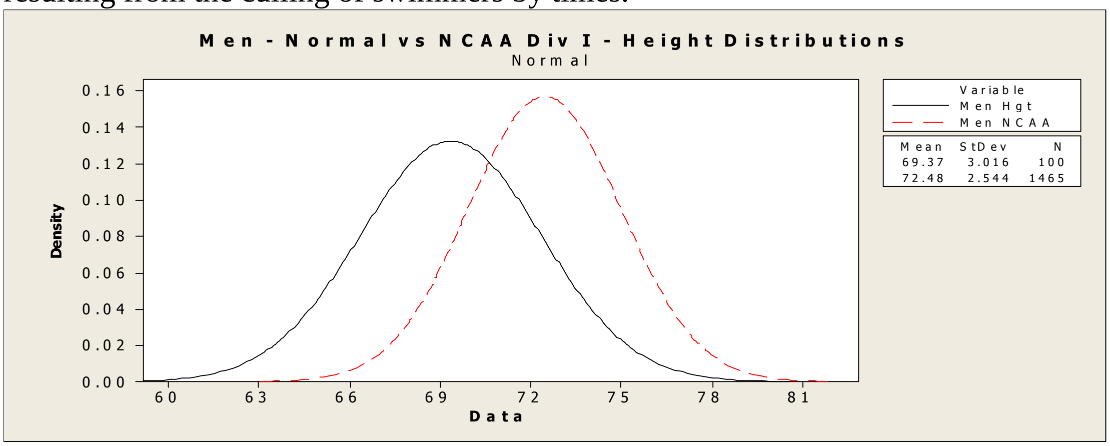


FIGURE 1 – MEN – NORMAL VS NCAA DIV I – HEIGHT DISTRIBUTIONS

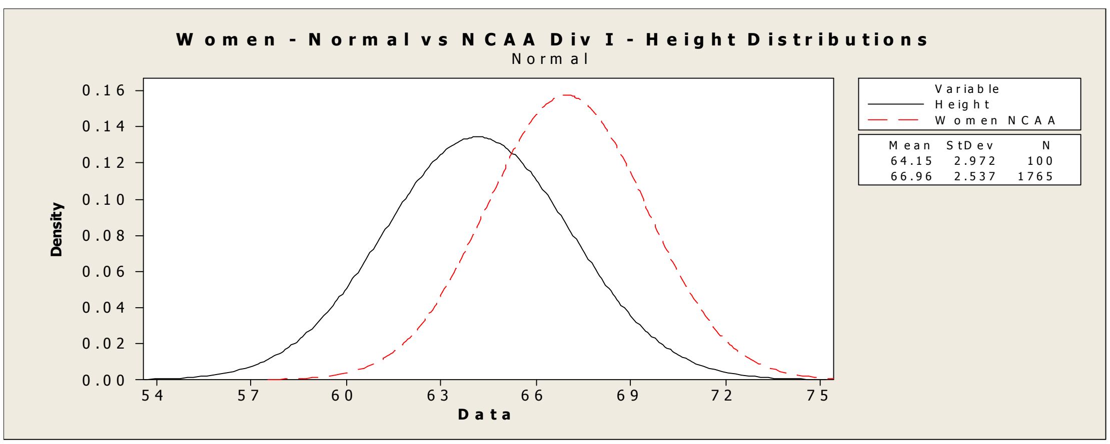


FIGURE 2 – WOMEN – NORMAL VS NCAA DIV I – HEIGHT DISTRIBUTIONS

In FIGURE 3 below the population size shift from the normal population into the NCAA Div I is shown. The normal distribution is broken into quartiles, so each height group (1Q, 2Q, 3Q, 4Q) starts out at the same size, namely 25% of the total population. The first observation is that the population size shift for men and women is nearly identical. Second, the taller the height group the less swimmers are lost to the culling process. For example, 65% of NCAA Div I male swimmers come from the tallest 25% (4Q) of the overall population. The 3Q is 22%, the 2Q is 10%, and the 1Q is only 3%. Third, the tallest 65% are 71.53 inches (5 feet 11.5 inches) or taller.

Group by group the NCAA statistics are compromised by the culling effect. The 1Q survivors are few and are the very fastest of this group. Statistically, these 1Q survivors represent the far left tail of this group's time distribution. The non-survivors need consideration in any height group analysis of times and SP. As we move towards the taller 2Q, 3Q, and 4Q groups, more and more swimmers survive, less and less non-survivors need statistical consideration.

Men - 20 Yrs Old

Normal %		25%		50%		75%		99%	100%	**Total**
Normal Hgt (Inches)		67.76		69.65		71.53		76.15		
Pop Name	1Q		2Q		3Q		4Q			
Pop Size	25%		25%		25%		24%		1%	100%
NCAA Div I %	⇩	3%	⇩	13%	⇩	35%	⇩	93%	⇩	
NCAA Div I Pop Size	3%		10%		22%		58%		7%	100%
								65%		

Women - 20 Yrs Old

Normal %		25%		50%		75%		99%	100%	**Total**
Normal Hgt (Inches)		62.54		64.29		66.04		70.32		
Pop Name	1Q		2Q		3Q		4Q			
Pop Size	25%		25%		25%		24%		1%	100%
NCAA Div I %	⇩	4%	⇩	15%	⇩	36%	⇩	91%	⇩	
NCAA Div I Pop Size	4%		11%		21%		55%		9%	100%
								64%		

FIGURE 3 – MEN & WOMEN – POPULATION SIZE SHIFT

The data in FIGURE 4 below (blue diamonds) represents best times from those who swam the 100 Free in the 2010 championship season. Adding back times from the remaining population is illustrated by the red bars. On an average basis, times get faster as swimmers get taller. Only the fastest compete so the data tends to be on the bottom side of what would be the average. Times for a given height group are influenced by the population size, and height. Larger populations have a greater chance of producing an extreme athlete. So there are very few competitors in shorter height groups but they are the best of what was a large group and are very fast. On the opposite side there are also very few competitors in the taller height groups however they tend to be the average of a very small group because small groups tend to have small variation about the center.

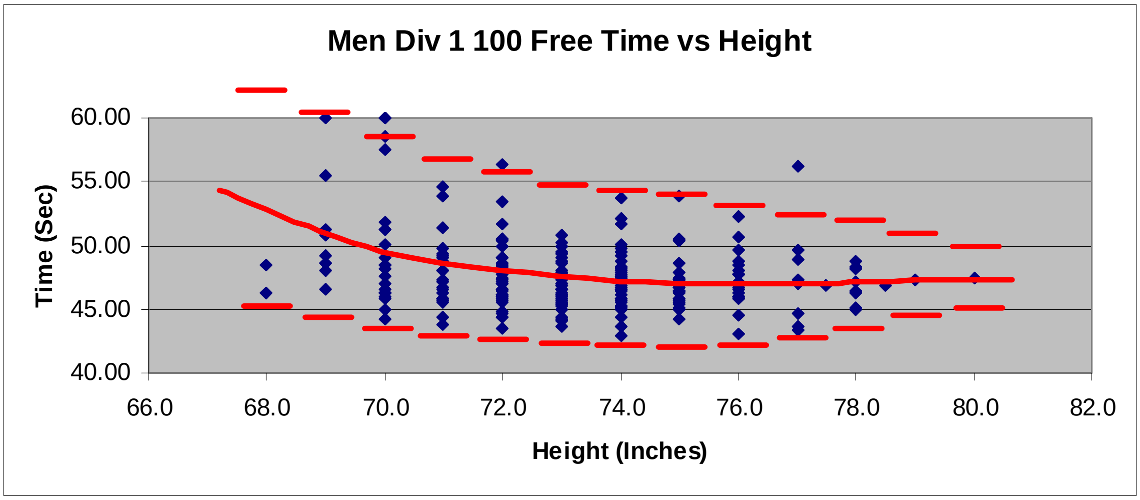


FIGURE 4 – MEN DIV I – 100 FREE – TIME VS HEIGHT

The data in FIGURE 5 below represent the swimming proficiency (SP) for the swimmers in FIGURE 4. Note the arrow-head pattern of the data. Variation around the average for each height group gets narrower as the group population gets smaller. The taller groups draw from ever smaller populations. The actual data is the best of the group, so for large groups it tends toward the bottom well below the average because no one else in that group can compete. For taller groups with small populations SP tends toward the average. The larger populations will tend to produce more extreme athletes. Thus you would expect the NCAA height groups starting at 69.65 inches to have the best single SP as represented by the minimum values. As it turns out for this sample, the very best SP values are in the height groups 71, 70, 72, and 68. These groups draw from more swimmers than do the taller groups to the right. The higher population height groups have a higher probability of producing extremes and so population size must be considered in any analysis that compares height differences.

Most important is the average for all height groups assuming everyone got to compete in the championship season in the same events. If we were to add to the data set, the missing swimmers, the arrow-head pattern below would further evolve. The top side of the average would tend to mirror the bottom side. The flat average for all height groups indicates SP parity.

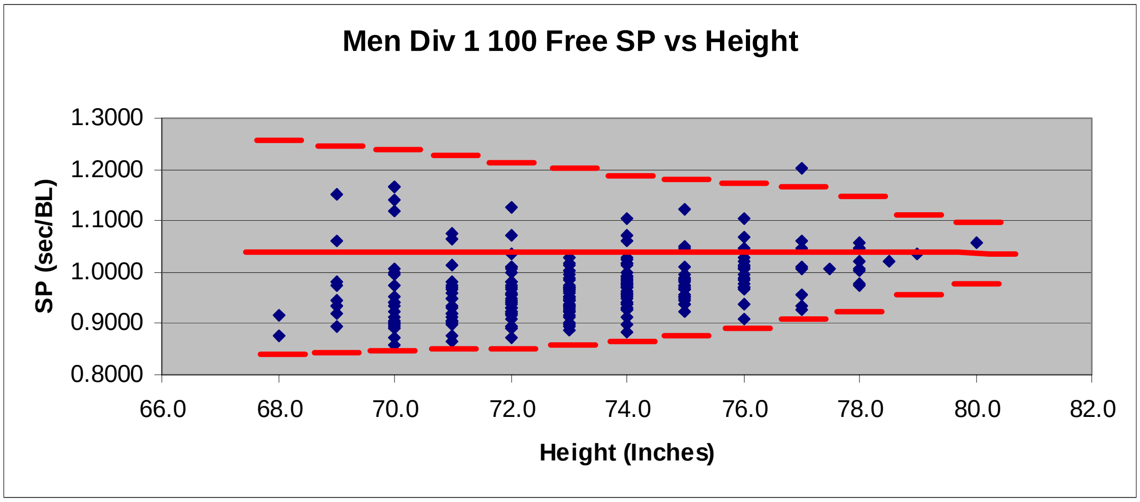


FIGURE 5 – MEN DIV I – 100 FREE – SP VS HEIGHT

The data in FIGURE 6 and 7 below is the Time vs. Height and SP vs. Height data for women. The pattern is the same is for the men in Figures 4 and 5. Times improve as swimmers get taller up to the point where the population size of the very tall height groups are too small to produce extreme athletes. SP parity is very evident in Figure 7 again up to the points where the population sizes are too small to support extreme athletes.

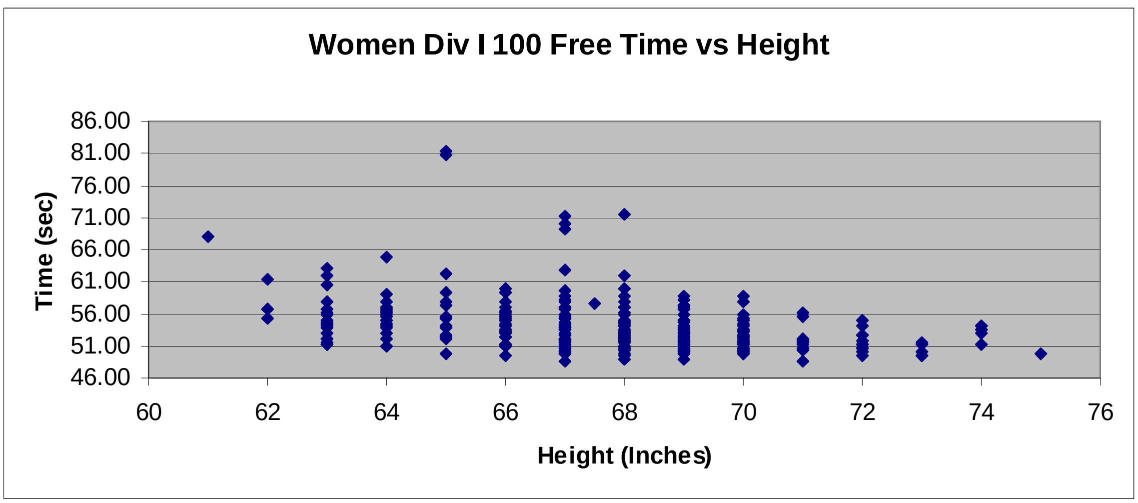


FIGURE 6 – WOMEN DIV I – 100 FREE – TIME VS HEIGHT

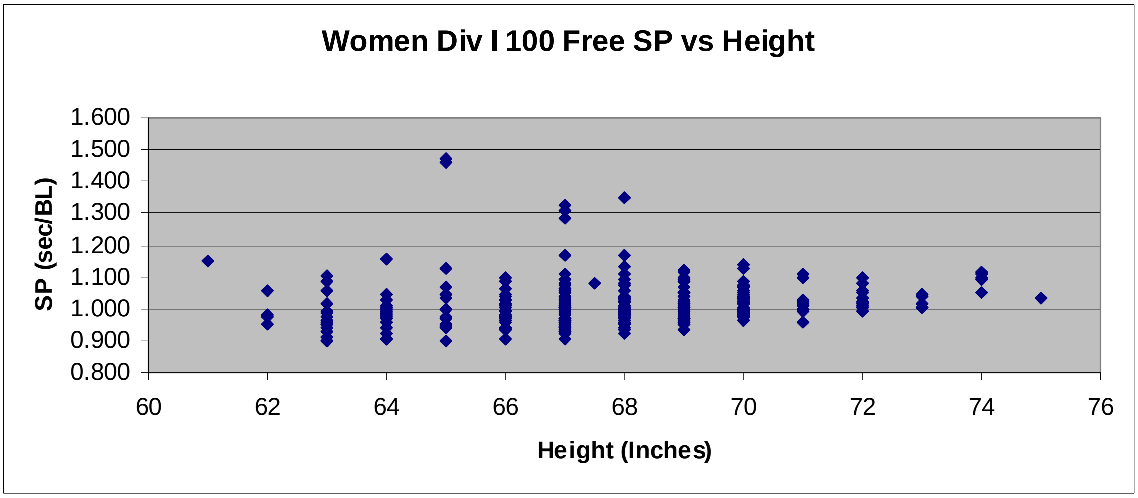


FIGURE 7 – WOMEN DIV I – 100 FREE – SP VS HEIGHT

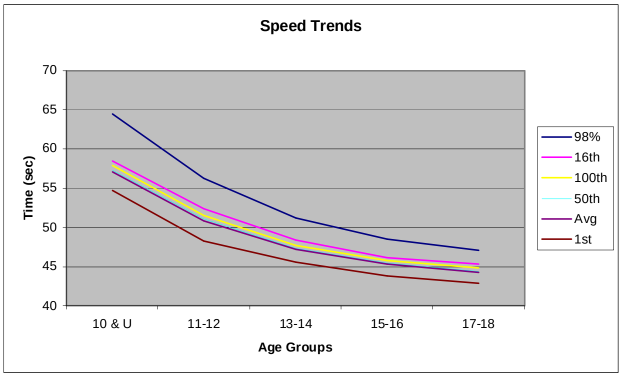
USA Swimming Data and Analysis – Swimming Proficiency (SP) Trends:
<u>Time Data</u>

The normal progression of swimming times in the US is best understood by first looking at the top 100 times over the last 40 plus years for every age group. **Figure 1** below shows the trend in swimming times versus age group for the 1st, average, 50th, 100th positions in the Boys and Girls 100 yard (SCY) freestyle. These actual times indicate the extent to which swimming times have improved for the fastest US swimmers as they age. They represent the normal time progression for the fastest swimmers.

Also in Figure 1 is the 2008 16th of top16 and the 98th percentile from US Swimming's Age Group Motivational Time Standards. The key point here is that the motivation standard is the same pattern as the historical actual times.

2008 Seed Times - 16th of Top 16
All Time Top 100 - 1st, 50th, 100th
Motivational Time Std - 98%
100 SCY Free Boys

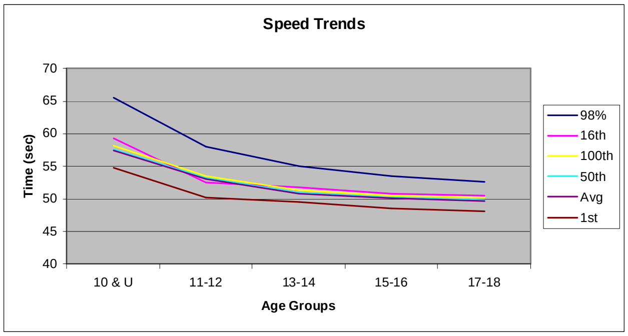
	Age Groups				
	10 & U	**11-12**	**13-14**	**15-16**	**17-18**
98%	64.49	56.19	51.19	48.49	47.09
16th	58.43	52.34	48.33	46.12	45.25
100th	57.85	51.50	47.67	45.75	44.81
50th	57.27	51.02	47.28	45.48	44.39
Avg	57.08	50.77	47.16	45.34	44.25
1st	54.74	48.25	45.49	43.83	42.85



BOYS

2008 Seed Times - 16th of Top 16
All Time Top 100 - 1st, 50th, 100th
Motivational Time Std - 98%
100 SCY Free Girls

	Age Groups				
	10 & U	**11-12**	**13-14**	**15-16**	**17-18**
98%	65.49	57.99	55.09	53.49	52.69
16th	59.25	52.53	51.82	50.87	50.59
100th	58.23	53.56	51.44	50.56	50.29
50th	57.63	53.21	50.91	50.21	49.75
Avg	57.44	53.03	50.82	50.08	49.67
1st	54.75	50.27	49.53	48.52	48.06



GIRLS

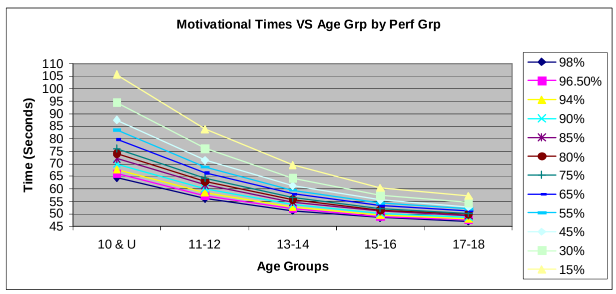
FIGURE 1 – Speed Trends of Top 100 Over the Last 40 Years – Boys & Girls

Figure 2A shows all the performance group percentiles in the Age Group Motivational Time Standards. The trend clearly shows the times getting faster for every performance group as the swimmers age-up.

Note the motivational time standards from Figure 2A follow the same pattern as the actual time improvements from Figure 1. What this means is that the motivational time standard progressions are also "normal" progressions. For example, a normal swimmer at the 85th percentile as a 12 year old will stay at the 85th percentile as he ages, essentially following the "normal" progression. The designers of the motivational time standards know that a swimmer has to "earn" moving up in category. If simply by turning 13 a swimmer moved up from the 85th percentile to the 90th percentile, the motivational time standards would be worthless. A swimmer needs to work harder than the norm in order to move up in category. This is, in fact, the essence of the motivational time standards, motivate to work harder than the norm. The norm of course is defined by the data based motivational time standards. It can be concluded that the motivational time standards progress similarly to the actual times of the fastest 100 historically. These time standards are therefore normal predictions of speed as swimmers age-up.

2005-2008 National Age Group Motivational Times (Seconds) - Percentile Based
100 SCY Free Boys

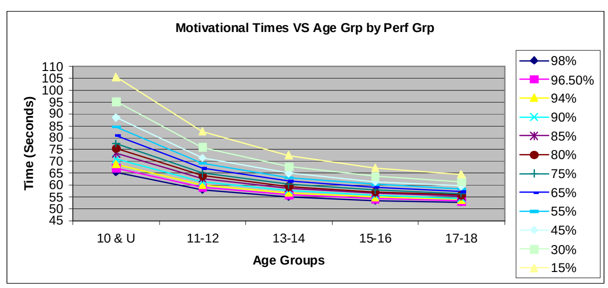
		Age Groups				
Track	Percentile	**10 & U**	**11-12**	**13-14**	**15-16**	**17-18**
1	**98%**	64.49	56.19	51.19	48.49	47.09
	96.50%	65.99	57.29	51.99	48.99	47.59
	94%	67.69	58.59	52.79	49.59	48.09
2	**90%**	69.89	60.09	53.79	50.29	48.69
	85%	72.09	61.59	54.79	50.99	49.29
	80%	74.19	62.99	55.69	51.59	49.89
3	**75%**	76.09	64.19	56.49	52.19	50.29
	65%	79.79	66.39	57.99	53.29	51.19
	55%	83.59	68.69	59.49	54.29	51.99
4	**45%**	87.49	71.39	61.19	55.49	52.89
	30%	94.59	76.19	64.29	57.39	54.49
	15%	105.59	83.79	69.49	60.39	57.19



BOYS

2005-2008 National Age Group Motivational Times (Seconds) - Percentile Based
100 SCY Free Girls

		Age Groups				
Track	Percentile	**10 & U**	**11-12**	**13-14**	**15-16**	**17-18**
1	**98%**	65.49	57.99	55.09	53.49	52.69
	96.50%	67.09	58.99	55.89	54.19	53.19
	94%	68.89	60.09	56.79	54.89	53.79
2	**90%**	71.09	61.39	57.69	55.69	54.49
	85%	73.39	62.69	58.69	56.49	55.19
	80%	75.49	63.89	59.49	57.19	55.89
3	**75%**	77.49	64.99	60.29	57.89	56.39
	65%	80.99	67.09	61.69	59.09	57.39
	55%	84.69	69.19	63.19	60.19	58.49
4	**45%**	88.49	71.49	64.89	61.39	59.59
	30%	95.19	75.89	67.79	63.59	61.49
	15%	105.59	82.69	72.49	67.09	64.49



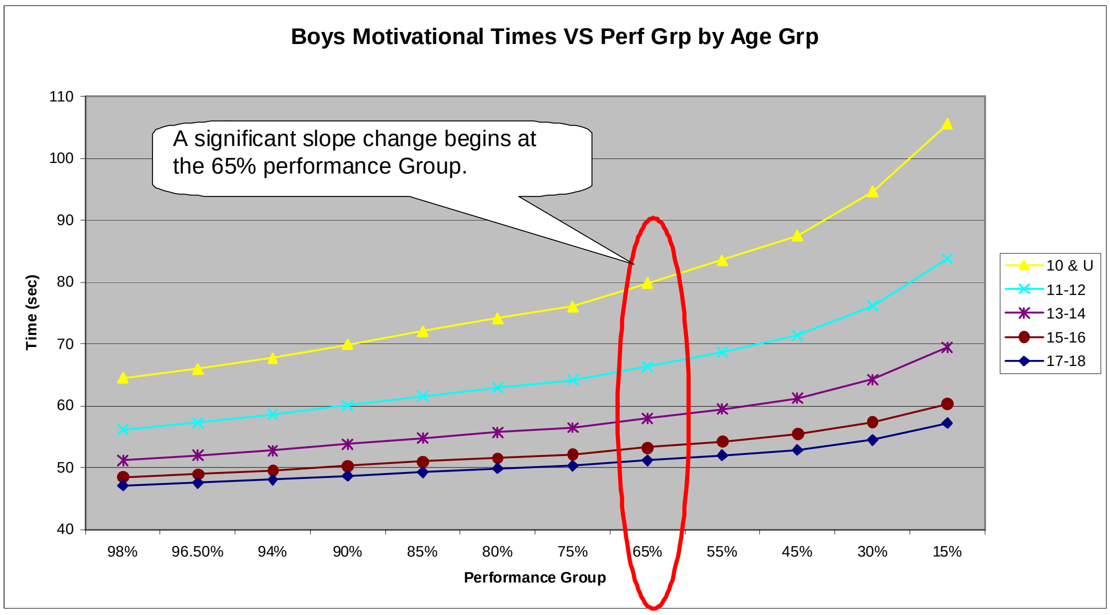
GIRLS

FIGURE 2A – Motivational Time Standards – Boys & Girls

What about the abnormal swimmer? Swimmers who are shorter than the norm for their performance group typically go down in performance percentile as they age up. Why? The standard is tracking to a taller norm. The unearned time improvements built into the taller norm exceed the unearned improvements the smaller swimmer actually gets. In this case the smaller swimmer has to "earn" more improvement than is normal simply to stay even with the curve. The opposite is true for swimmers who are taller than the norm for their performance group. Whether intended or not, height is a factor in the usefulness of these time standards.

Figure 2B shows all the age groups in the Age Group Motivational Time Standards. The trend clearly shows the times getting slower for every age group as the swimmers move down in performance group.

Note that a significant slope change occurs for both boys and girls at the 65% performance group. This suggests that this group and those to the right are not homogeneous with those groups to the left. In other words, there are likely two populations for each age group with the split at the 65% performance group.



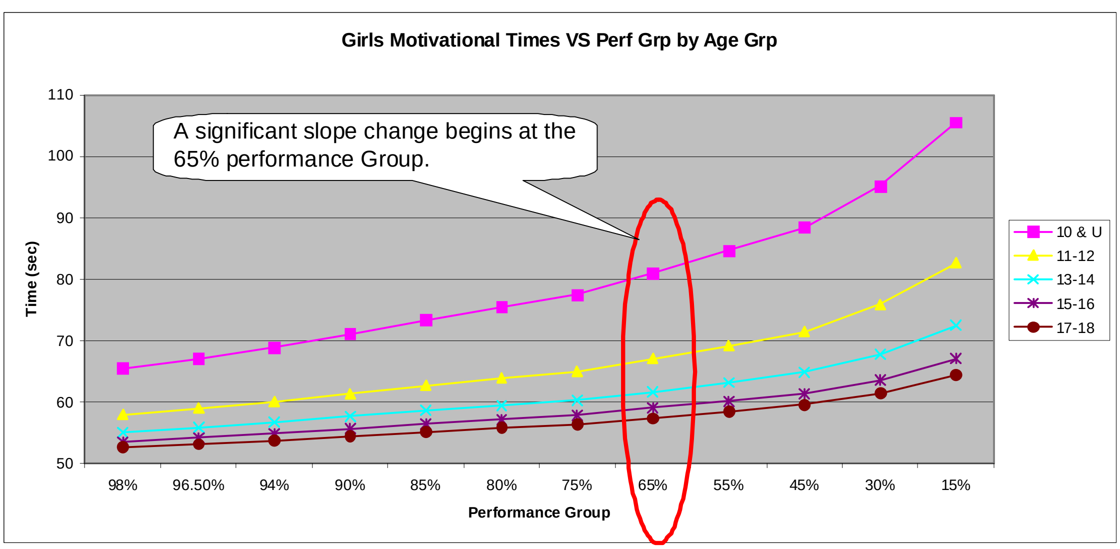


FIGURE 2B – Motivational Time Standards – Boys & Girls

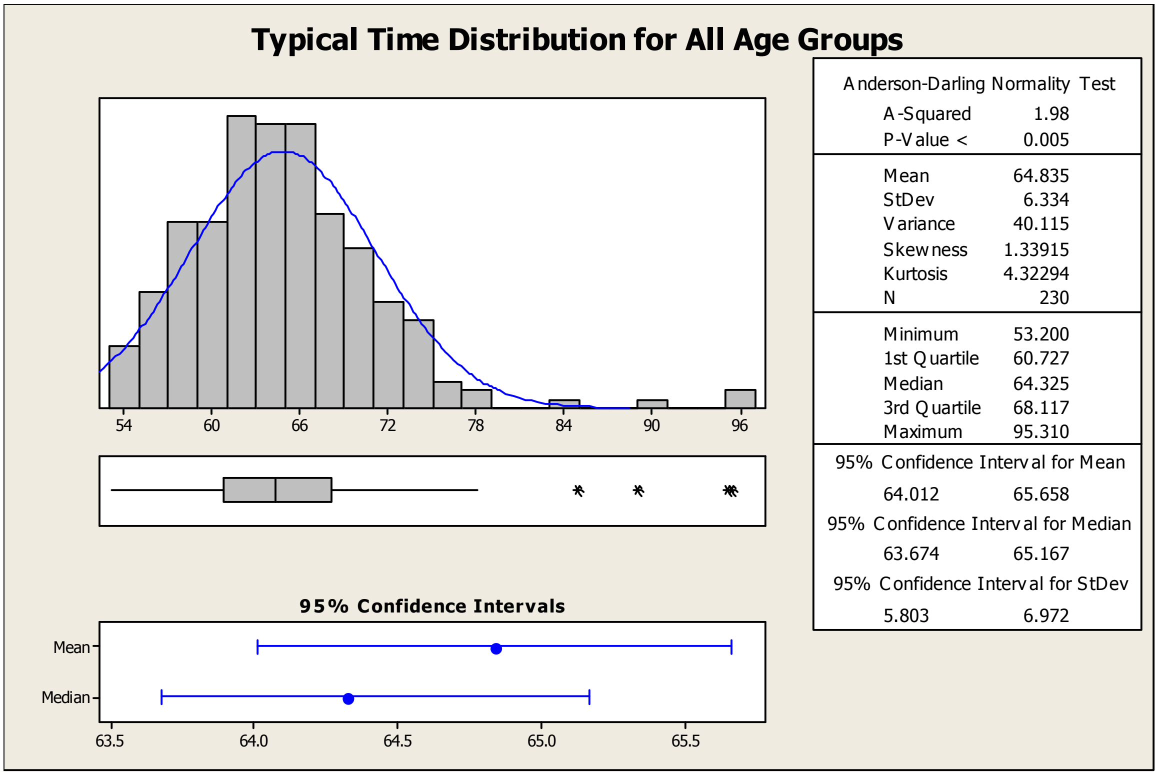
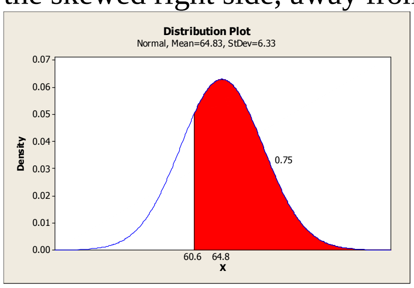


FIGURE 2C – Typical Time Distribution for All Age Groups

The **Figure 2C** time distribution above is typical of all age groups. Time distributions are all peaked (ref positive Kurtosis) and skewed to the right (ref positive Skewness). All distributions are asymmetrical. As expected this means swimming faster has predictable limits where swimming slower has no limits. Note that the mean value will move toward the skewed right side, away from the median.



The performance percentile designations in Figure 2A and 2B come from normal distributions like that in 2C. From the example above, the 75% performance group standard is 60.6 seconds because 75% of the distribution is slower than 60.6 seconds. The population size of each performance group comes from the distribution's Y axis. The largest group populations are always centered about the mean and get smaller as the groups move away from the mean.

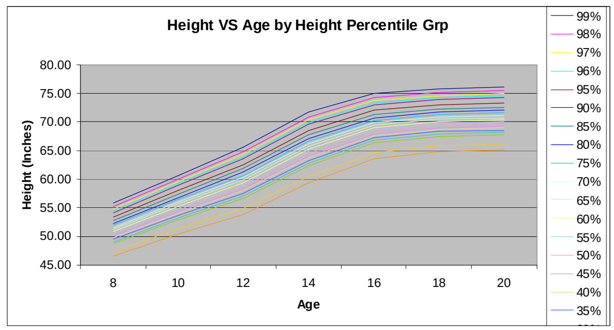
Summary: There are 3 distinct populations within each age group. The very fastest/tallest, highly trained/motivated (~1%); the slowest/smallest, low training/motivation, and the "normal" group.

Height Data

To test SP as a performance metric, we must apply height data and show the relationship between SP and height. **Table 1** represents height percentiles from the National Center for Health Statistics (11/21/2000)[5]. These are normal growth rates, that is, averages for US children ages 8 through 20. Individuals may vary from a growth percentile, such as having a growth spurt; however, most grow according to the percentile. If you are at the 60th percentile at the age of 8 for example, the norm is to grow along the 60% growth line. The growth spurt years for boys is 10 – 14. For girls 10 – 13.

Men

	Stature for Age (Inches)				MEN		
	SOURCE: National Center for Health Statistics (11/21/2000)						
	8	10	12	14	16	18	20
99%	55.76	60.66	65.63	71.71	74.97	75.83	76.15
98%	55.12	59.95	64.81	70.86	74.19	75.07	75.39
97%	54.71	59.50	64.30	70.33	73.69	74.59	74.91
96%	54.41	59.16	63.91	69.92	73.32	74.23	74.54
95%	54.16	58.88	63.59	69.59	73.02	73.94	74.25
90%	53.31	57.94	62.50	68.47	71.98	72.93	73.23
85%	52.74	57.30	61.77	67.71	71.28	72.25	72.55
80%	52.28	56.80	61.18	67.10	70.72	71.71	72.00
75%	51.89	56.36	60.68	66.58	70.24	71.24	71.53
70%	51.54	55.97	60.23	66.12	69.81	70.83	71.11
65%	51.22	55.61	59.81	65.68	69.41	70.44	70.72
60%	50.91	55.26	59.42	65.27	69.03	70.07	70.35
55%	50.61	54.94	59.04	64.88	68.67	69.72	70.00
50%	50.31	54.61	58.66	64.49	68.31	69.37	69.65
45%	50.02	54.28	58.28	64.09	67.94	69.02	69.29
40%	49.72	53.95	57.90	63.70	67.58	68.67	68.94
35%	49.41	53.60	57.51	63.29	67.20	68.30	68.57
30%	49.09	53.24	57.09	62.86	66.80	67.91	68.18
25%	48.74	52.85	56.64	62.39	66.37	67.50	67.76
10%	47.32	51.27	54.82	60.51	64.64	65.81	66.06
5%	46.47	50.33	53.73	59.38	63.60	64.80	65.04



Women

	Stature for Age (Inches)				WOMEN		
	SOURCE: National Center for Health Statistics (11/21/2000)						
	8	10	12	14	16	18	20
99%	55.82	60.64	66.18	69.18	69.88	70.20	70.32
98%	55.16	59.90	65.40	68.47	69.20	69.50	69.61
97%	54.74	59.43	64.91	68.02	68.76	69.05	69.16
96%	54.43	59.08	64.54	67.69	68.44	68.71	68.83
95%	54.17	58.79	64.24	67.41	68.17	68.44	68.55
90%	53.29	57.81	63.21	66.47	67.26	67.49	67.61
85%	52.70	57.14	62.51	65.84	66.65	66.86	66.98
80%	52.23	56.61	61.96	65.33	66.16	66.35	66.47
75%	51.83	56.16	61.49	64.90	65.74	65.92	66.04
70%	51.47	55.75	61.06	64.51	65.37	65.53	65.65
65%	51.13	55.37	60.66	64.15	65.02	65.17	65.29
60%	50.81	55.02	60.29	63.81	64.69	64.83	64.95
55%	50.50	54.67	59.93	63.48	64.37	64.50	64.62
50%	50.20	54.33	59.57	63.15	64.05	64.17	64.29
45%	49.89	53.99	59.21	62.82	63.74	63.84	63.96
40%	49.59	53.64	58.85	62.49	63.42	63.52	63.64
35%	49.27	53.29	58.47	62.15	63.09	63.18	63.29
30%	48.93	52.91	58.07	61.79	62.74	62.81	62.93
25%	48.57	52.50	57.65	61.40	62.37	62.42	62.54
10%	47.10	50.86	55.92	59.83	60.85	60.85	60.97
5%	46.22	49.87	54.89	58.89	59.94	59.91	60.03

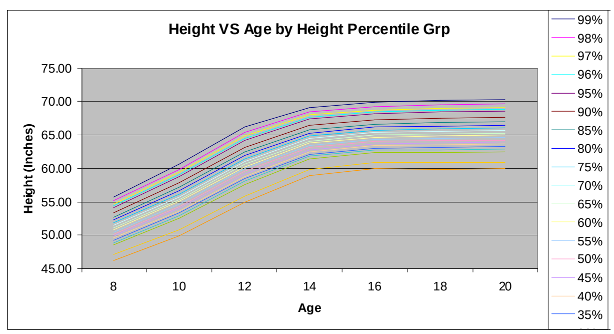


TABLE 1 – STATURE MEN & WOMEN – 8 TO 20 YEARS

Table 2 shows the predicted average height percentiles for each performance group across all age groups. For example, the 98% performance group (row 1, column 2) has a "flat" 99% percentile average height for each age group. The average heights for each age group are stated in inches.

[5] National Center for Health Statistics, November 2000, US Children 8 to 20 Years

Men

	Height vs Perf % - Flat Height Pct for each Perf Pct					
	100	SCY	Free	Boys		
Hgt %	Perf %	Age Groups				
		10 & U	11-12	13-14	15-16	17-18
99%	98%	60.66	65.63	71.71	74.97	75.83
98%	96.50%	59.95	64.81	70.86	74.19	75.07
95%	94%	58.88	63.59	69.59	73.02	73.94
90%	90%	57.94	62.50	68.47	71.98	72.93
80%	85%	56.80	61.18	67.10	70.72	71.71
70%	80%	55.97	60.23	66.12	69.81	70.83
60%	75%	55.26	59.42	65.27	69.03	70.07
50%	65%	54.61	58.66	64.49	68.31	69.37
45%	55%	54.28	58.28	64.09	67.94	69.02
40%	45%	53.95	57.90	63.70	67.58	68.67
25%	30%	52.85	56.64	62.39	66.37	67.50
25%	15%	52.85	56.64	62.39	66.37	67.50

Women

	Height vs Perf % - Flat Height Pct for each Perf Pct					
	100	SCY	Free	Girls		
Hgt %	Perf %	Age Groups				
		10 & U	11-12	13-14	15-16	17-18
99%	98%	60.64	66.18	69.18	69.88	70.20
98%	96.50%	59.90	65.40	68.47	69.20	69.50
95%	94%	58.79	64.24	67.41	68.17	68.44
90%	90%	57.81	63.21	66.47	67.26	67.49
80%	85%	56.61	61.96	65.33	66.16	66.35
70%	80%	55.75	61.06	64.51	65.37	65.53
60%	75%	55.02	60.29	63.81	64.69	64.83
50%	65%	54.33	59.57	63.15	64.05	64.17
45%	55%	53.99	59.21	62.82	63.74	63.84
40%	45%	53.64	58.85	62.49	63.42	63.52
25%	30%	52.50	57.65	61.40	62.37	62.42
25%	15%	52.50	57.65	61.40	62.37	62.42

TABLE 2 – PREDICTED AVERAGE HEIGHTS PER PERFORMANCE GROUP

NOTE: For any given performance group, the average height for each age group actually varies. The 75% performance group indicates an average “flat” height percentile of 60% for each age group. However, the height percentiles across the age groups actually vary from 59% to 62%. The averages get proportionally larger as groups get older and shorter. Why? Less successful swimmers leave the sport at a steady rate as they age-up. Call it the swimming exodus. These less successful swimmers are predominantly shorter, therefore, the group height averages go up as groups get older and shorter. **For purposes of simplicity, this report uses the flat averages stated in Table 2.**

Swimming Proficiency Data

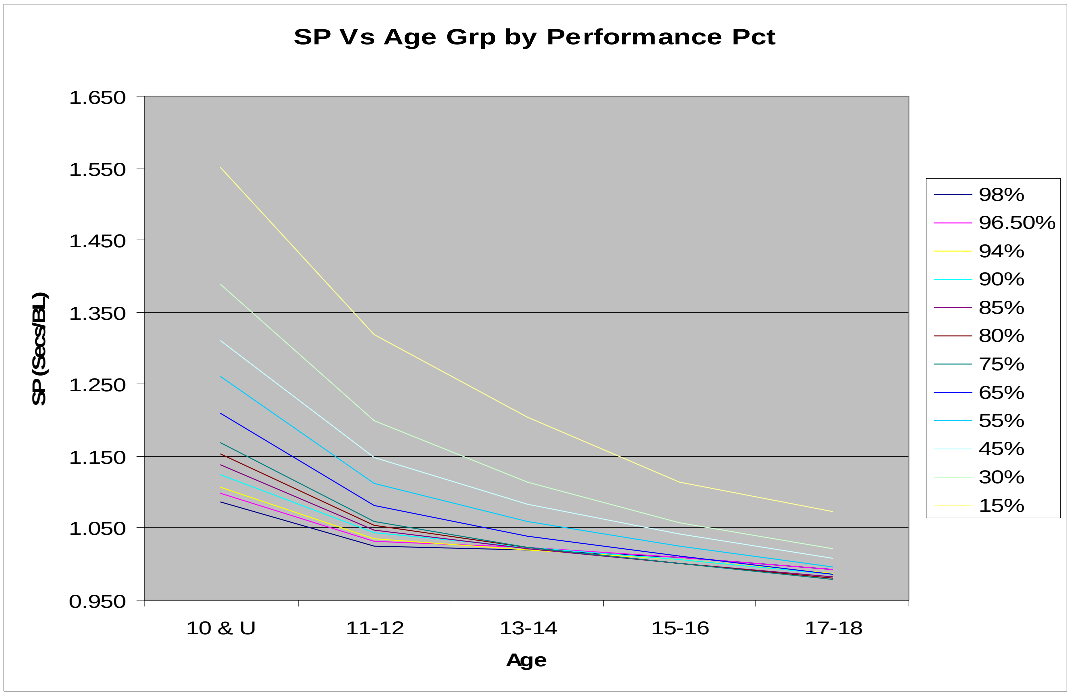
Table 3 combines Figure 2A Age Group Motivational Time Standards with Table 2 Average Heights per Performance Group 2 to calculate SP by age group and performance group. Essentially we are applying normal growth curves to each performance group to understand the SP trend for that group. The SP trends for each age group assume normal progress per the age group motivational time standards and normal growth.

	Swimming Proficiency (Seconds/Body Length)					
	100	**SCY**	**Free**	**Boys**		
Hgt %	**Perf %**	**Age Groups**				
		10 & U	**11-12**	**13-14**	**15-16**	**17-18**
99%	**98%**	1.087	1.024	1.020	1.010	0.992
98%	**96.50%**	1.099	1.031	1.023	1.010	0.992
95%	**94%**	1.107	1.035	1.021	1.006	0.988
90%	**90%**	1.125	1.043	1.023	1.006	0.986
80%	**85%**	1.137	1.047	1.021	1.002	0.982
70%	**80%**	1.153	1.054	1.023	1.000	0.982
60%	**75%**	1.168	1.059	1.024	1.001	0.979
50%	**65%**	1.210	1.082	1.039	1.011	0.986
45%	**55%**	1.260	1.112	1.059	1.025	0.997
40%	**45%**	1.311	1.148	1.083	1.042	1.009
25%	**30%**	1.389	1.199	1.114	1.058	1.022
25%	**15%**	1.550	1.318	1.204	1.113	1.072

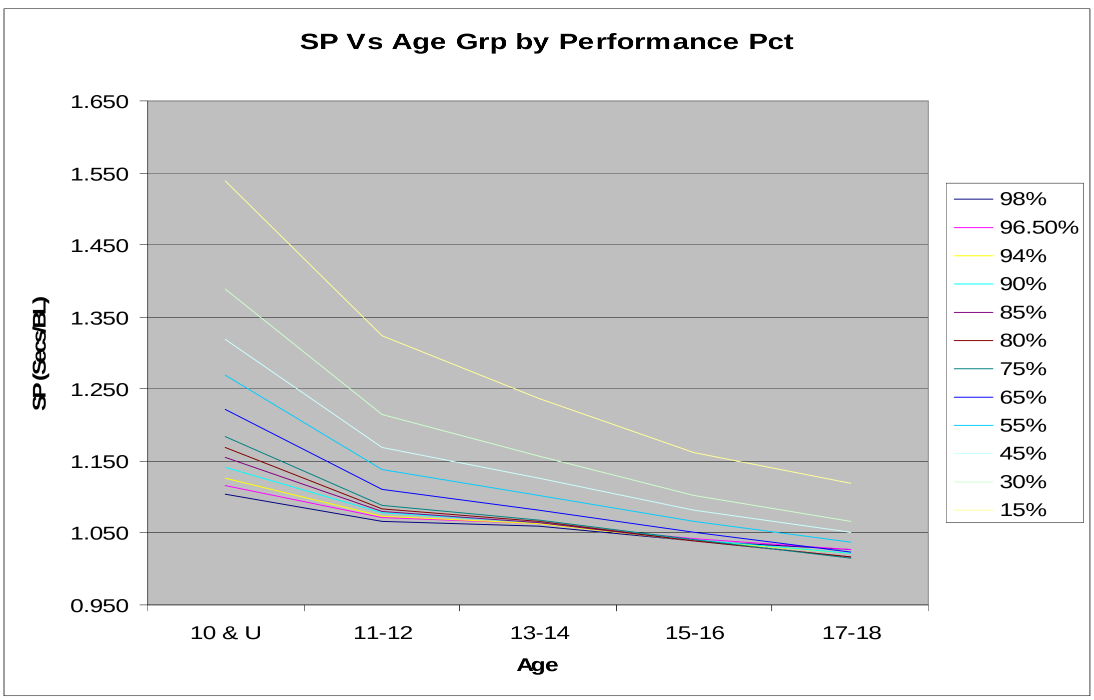
	Swimming Proficiency (Seconds/Body Length)					
	100	**SCY**	**Free**	**Girls**		
Hgt %	**Perf %**	**Age Groups**				
		10 & U	**11-12**	**13-14**	**15-16**	**17-18**
99%	**98%**	1.103	1.066	1.059	1.038	1.027
98%	**96.50%**	1.116	1.072	1.063	1.042	1.027
95%	**94%**	1.125	1.072	1.063	1.039	1.023
90%	**90%**	1.142	1.078	1.065	1.041	1.022
80%	**85%**	1.154	1.079	1.065	1.038	1.017
70%	**80%**	1.169	1.084	1.066	1.038	1.017
60%	**75%**	1.184	1.088	1.069	1.040	1.015
50%	**65%**	1.222	1.110	1.082	1.051	1.023
45%	**55%**	1.270	1.138	1.103	1.066	1.037
40%	**45%**	1.319	1.169	1.126	1.082	1.051
25%	**30%**	1.388	1.215	1.156	1.102	1.066
25%	**15%**	1.540	1.324	1.236	1.162	1.118

TABLE 3 – SP FOR AGE & PERFORMANCE GROUPS

Figure 3 plots the data from Table 3 and shows the relationship between SP and age for each performance group. We see that SP improves for all performance groups as kids age-up.



BOYS

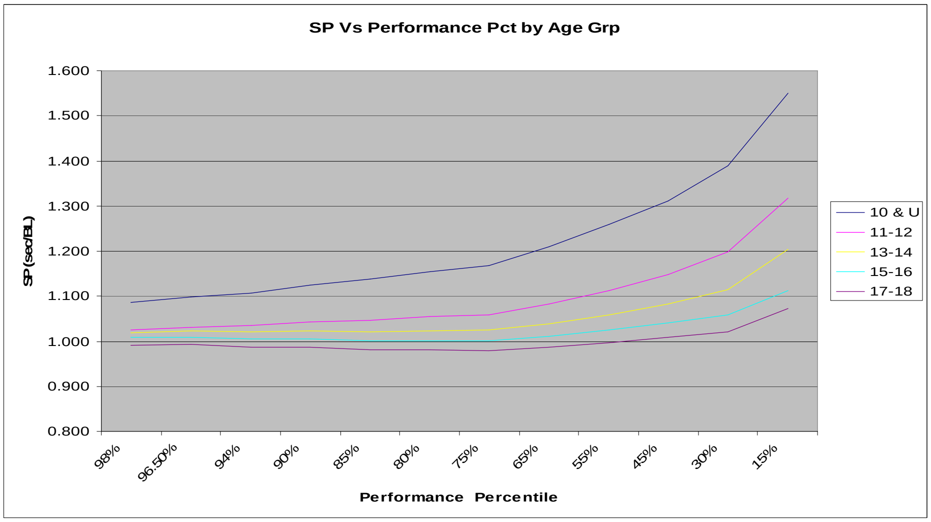


GIRLS

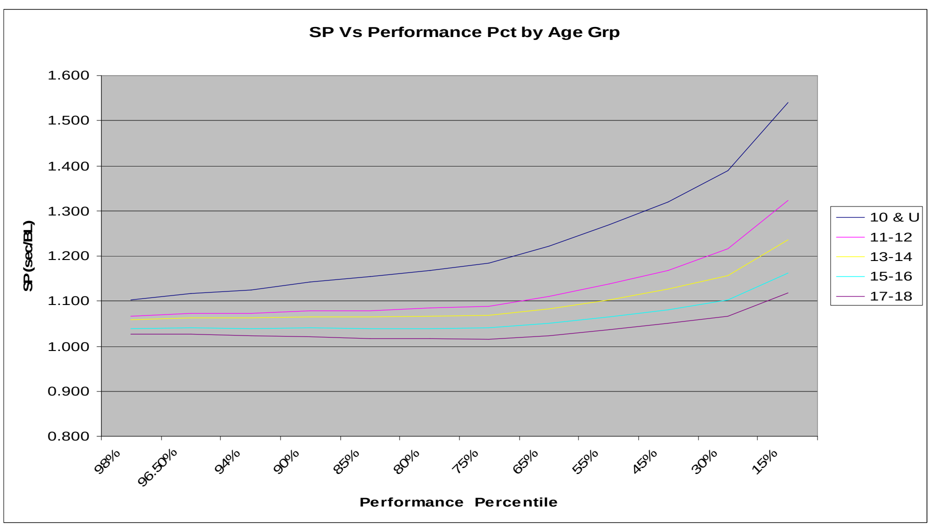
FIGURE 3 – SP Vs AGE GROUPS BY PERFORMACE GROUPS

Figure 4 plots the data from Table 3 and shows the relationship between SP and performance groups for each age group.

Each age group has a slightly different trend from the 98% to 75% performance groups. The two younger age groups see a rise in SP. The next two age groups are relatively flat. And the oldest age group shows SP slightly decreasing. From 65% and below, all age groups see SP rapidly increase, that is SP gets worse. NOTE: The smaller the SP number, the more proficient. Adjusting the average heights estimated for each performance group does not change the result.



BOYS



GIRLS

FIGURE 4 – SP Vs PERFORMANCE GROUPS BY AGE GROUPS

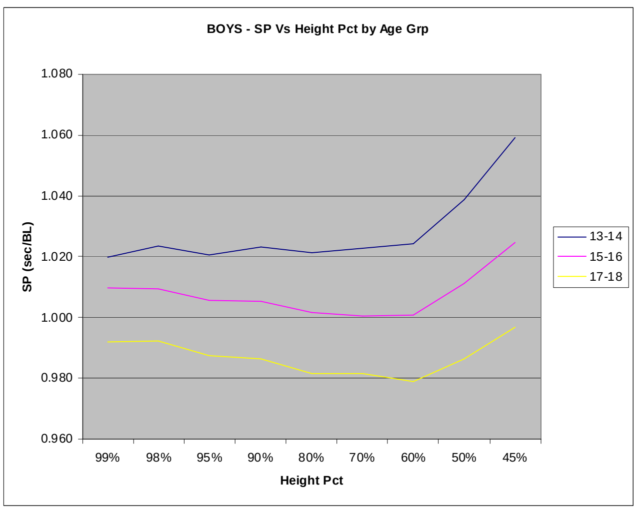
Figure 5 reduces the data from Table 3. Following our data reduction rules and avoiding factors that cause skewed results, the more telling trends will be found in the 13 and over age groups and between the 98% and 55% performance groups. Data in these groups reflects more consistent training and experience and less influence from growth spurts. The performance group labels were replaced with their respective average height percentiles. For these height groups as a whole, SP is relatively flat (+/- 0.005 seconds) until the dramatic upturn at the 50% height 65% performance group. Adjusting the average heights estimated for each performance group does not change these trends.

Why the upturn in SP at the 50% Height (65% performance) group?

As noted in Figure 2B, the age group motivational times have a significant slope change at the 65% performance group. This performance group and those to the right are likely non-homogenous. Perhaps due to less training, experience, motivation, and natural ability these groups have significantly inferior SP.

Why the slight improvements in SP from 98% to 60% height?

As noted in Table 2, these trends are based on "flat" average height percentiles across all age groups when in fact, due to the swimming exodus, the average height percentiles increase slightly as performance groups get shorter and older. The trends below get flatter when we use the "actual" height percentiles as opposed to the "flat" height percentiles. Regardless, the trends below indicate SP parity within plus or minus 0.005 seconds.



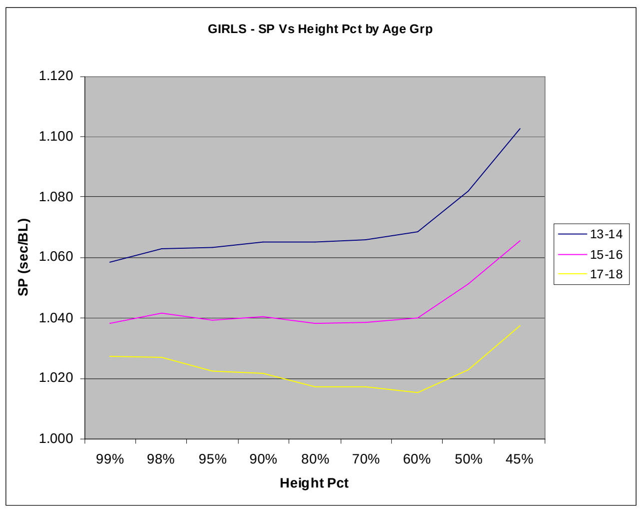


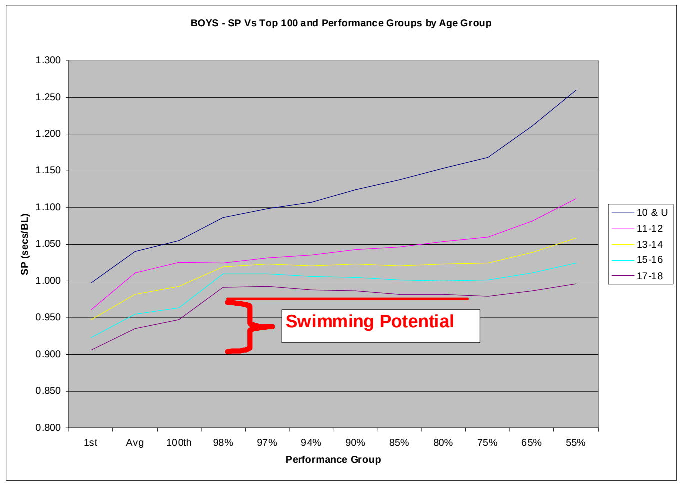
FIGURE 5 – SP Vs HEIGHT GROUPS BY AGE GROUPS

Figure 6 combines the SP data from the top 100 over the last 40 years and the motivational time standard performance groups. Here we can see the fastest group (top 100) is also the tallest group with the best group SP. Top 100 SP indicates the potential SP for everyone else. If a smaller slower swimmer is as talented as the taller faster swimmer, then there is no reason why the smaller swimmer cannot achieve the same SP. Given equal motivation and training opportunity, many swimmers from the slower performance groups can improve their SP to equal the top 100. After all, the top 100 come from the tallest 5% of the population. Surely the other 95% of the population can produce equal or better SP. The fastest swimmers have no other advantages in SP other than being more motivated and better trained. Maximizing swimming potential can be estimated using SP.

Swimming Proficiency (Seconds/Body Length)
100 SCY Free Boys

Hgt %	Perf %	10 & U	11-12	13-14	15-16	17-18
	1st	0.998	0.961	0.947	0.923	0.906
	Avg	1.041	1.011	0.982	0.955	0.936
	100th	1.055	1.026	0.993	0.964	0.948
99%	98%	1.087	1.024	1.020	1.010	0.992
98%	97%	1.099	1.031	1.023	1.010	0.992
95%	94%	1.107	1.035	1.021	1.006	0.988
90%	90%	1.125	1.043	1.023	1.006	0.986
80%	85%	1.137	1.047	1.021	1.002	0.982
70%	80%	1.153	1.054	1.023	1.000	0.982
60%	75%	1.168	1.059	1.024	1.001	0.979
50%	65%	1.210	1.082	1.039	1.011	0.986
45%	55%	1.260	1.112	1.059	1.025	0.997

(Age Groups: 10 & U, 11-12, 13-14, 15-16, 17-18)



Swimming Proficiency (Seconds/Body Length)
100 SCY Free Girls

Hgt %	Perf %	10 & U	11-12	13-14	15-16	17-18
	1st	1.006	0.966	0.961	0.946	0.939
	Avg	1.056	1.019	0.986	0.977	0.970
	100th	1.070	1.029	0.998	0.986	0.982
99%	98%	1.103	1.066	1.059	1.038	1.027
98%	97%	1.116	1.072	1.063	1.042	1.027
95%	94%	1.125	1.072	1.063	1.039	1.023
90%	90%	1.142	1.078	1.065	1.041	1.022
80%	85%	1.154	1.079	1.065	1.038	1.017
70%	80%	1.169	1.084	1.066	1.038	1.017
60%	75%	1.184	1.088	1.069	1.040	1.015
50%	65%	1.222	1.110	1.082	1.051	1.023
45%	55%	1.270	1.138	1.103	1.066	1.037

(Age Groups: 10 & U, 11-12, 13-14, 15-16, 17-18)

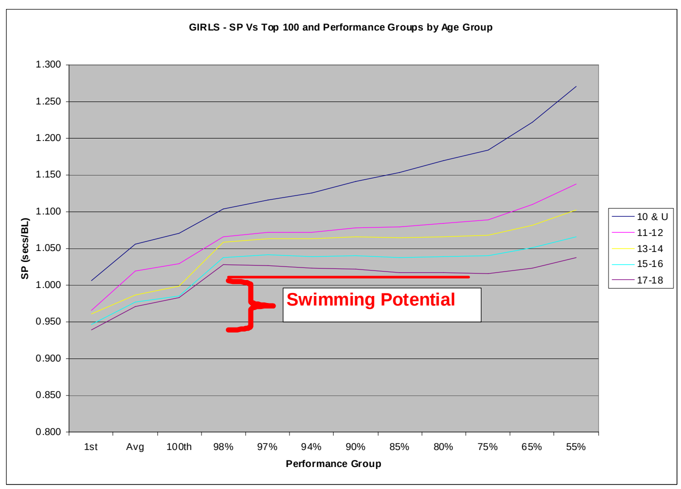


FIGURE 6 – SP Vs TOP 100 & PERFORMANCE GROUPS BY AGE

SP Trend Conclusions:
There are three distinct populations of swimmers. The fastest, the slowest, and all the rest. The fastest are taller, more motivated, harder working, and better trained. The slowest are smaller, less motivated, less willing to work, and less trained. The remaining group or middle group make up the large majority of competitive swimmers and are the focus group for this trend study.

For the middle population:

- SP improves for all performance groups as kids age-up. Ref Figure 3.
- SP is equal (within 0.005 seconds) for all age groups as kids get slower and shorter. Ref Figure 5.

For the slowest population:

- SP significantly declines at the 65% performance group and below.

For the fastest population:

- The most significant finding in this trend study is how much better the top 100 SP is than all the rest. See Figure 6. The only reasonable explanation for this superior SP is superior motivation and training. This world class SP represents the full swimming potential for everyone else. It sets the standard by which everyone else can be measured.

It is not difficult to find SP parity throughout the age group motivational time standards. There are swimmers across the height spectrum in different performance groups with equal SP.

Hy-Tek Power Point System Correlation – SP Validation:
Purpose: The purpose of this study is to validate or invalidate Swimming Proficiency (SP) as a neutral and therefore fair performance indicator for swimmers of all heights.

Summary: Competitive swimming favors taller swimmers. Swimming groups categorized by height and time proves that height is an advantage and that comparing swimmers by times is an unfair comparison. The better comparison uses a ratio called swimming proficiency (SP) that neutralizes the height advantage allowing for a more fair comparison of swimming competitiveness.

Through regression analysis comparing SP times with Hy-Tek Point System times, P values of 0.000 and R values greater than 99% are statistically significant and do not reject the hypothesis that SP times equal Hy-Tek times. This result validates the SP equation. It does not favor either tall or short swimmers; it is neutral and therefore a fair performance indicator.

Validation Approach:
Perform a regression analysis that indicates how well SP times correlate with Hy-Tek point system times.

The Hy-Tek Point System endorsed by US Swimming is designed to indicate an equal quality swim as swimmers age up, that is grow taller. For example, a 500 point swim as a 10 year old has the same quality as a 500 point swim as a 14 year old. The time is faster and the swimmer is taller, but the quality of the swim is the same. Each performance line represents constant quality "times". Constant quality implies holding constant all controllable factors effecting speed such as conditioning, technique, and level of effort. These controllable factors can produce "earned" time improvements. Uncontrollable natural factors like height are allowed to vary. These uncontrollable factors produce "unearned" time improvements. Thus Hy-Tek time lines represent "unearned" speed improvements. Height of course is the most obvious of the "unearned" time improvements. Said differently, the Hy-Tek time lines represent the baseline times from which "earned" improvements can be measured. Having successfully accomplished this, the Hy-Tek system is considered a neutral, unbiased performance indicator for all swimmers of all heights. These time lines are precisely the same time lines that SP predicts when SP is held constant.

Thus to validate the SP equation as a fair performance indicator for all swimmers regardless of their height, SP must be shown to correlate with the already endorsed Hy-Tek Point System.

Nine USA Swimming motivational time standard performance groups 55% to 98% were used to determine equivalent Hy-Tek points, which ranged from 490 to 726 points for the boys and 461 to 725 points for the girls. Additionally the 800 point level was chosen. Estimated average heights were used for each point level/performance group, from which SP was calculated and held constant. Given the SP, normal growth rates were assumed and the next year's time was calculated. Holding SP constant year to year achieves the same result as Hy-Tek's constant quality time lines.

Hypothesis:

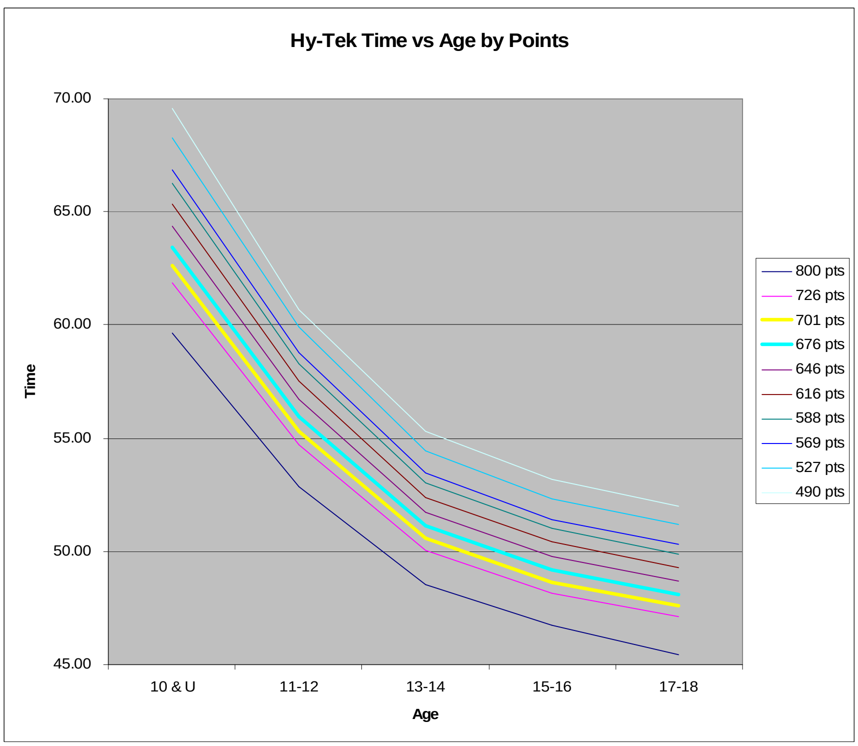
1) SP = Hy-Tek. SP times are equal to Hy-Tek Point System Times.

Discussion:

Figure A shows the Hy-Tek point times for each age and performance group. Each line represents constant quality performance or the "zero quality improvement" time line. Note that the times do improve as the swimmers age up. Constant quality implies holding constant all controllable factors effecting speed such as conditioning, technique, and level of effort. Uncontrollable factors like height are allowed to vary. Thus the curves below represent speed improvements only as a function of natural physical "unearned" factors.

Boys
Hy-Tek Points vs Time
100 SCY Free

Perf Pct	Pts	10 & U	11-12	13-14	15-16	17-18
		Age Groups				
n/a	**800 pts**	59.65	52.89	48.55	46.71	45.43
98%	**726 pts**	61.87	54.70	50.07	48.16	47.09
96.50%	**701 pts**	62.64	55.33	50.58	48.66	47.59
94%	**676 pts**	63.42	55.96	51.12	49.17	48.09
90%	**646 pts**	64.37	56.73	51.75	49.79	48.69
85%	**616 pts**	65.33	57.51	52.40	50.42	49.29
80%	**588 pts**	66.25	58.26	53.02	51.01	49.89
75%	**569 pts**	66.87	58.77	53.45	51.42	50.29
65%	**527 pts**	68.29	59.92	54.42	52.34	51.19
55%	**490 pts**	69.59	60.65	55.28	53.18	51.99



Girls
Hy-Tek Points vs Time
100 SCY Free

Perf Pct	**Pts**	**Age Groups 10 & U**	**11-12**	**13-14**	**15-16**	**17-18**
n/a	**800 pts**	60.11	54.61	52.28	51.23	51.23
98%	**725 pts**	62.21	56.36	53.80	52.72	52.69
96.50%	**700 pts**	62.93	56.96	54.32	53.23	53.19
94%	**671 pts**	63.77	57.67	54.93	53.83	53.79
90%	**638 pts**	64.75	58.48	55.64	54.53	54.49
85%	**605 pts**	65.76	59.32	56.37	55.24	55.19
80%	**574 pts**	66.72	60.12	57.06	55.92	55.89
75%	**551 pts**	67.44	60.72	57.59	56.43	56.39
65%	**508 pts**	68.83	61.93	58.60	57.42	57.39
55%	**461 pts**	70.40	63.18	59.73	58.53	58.49

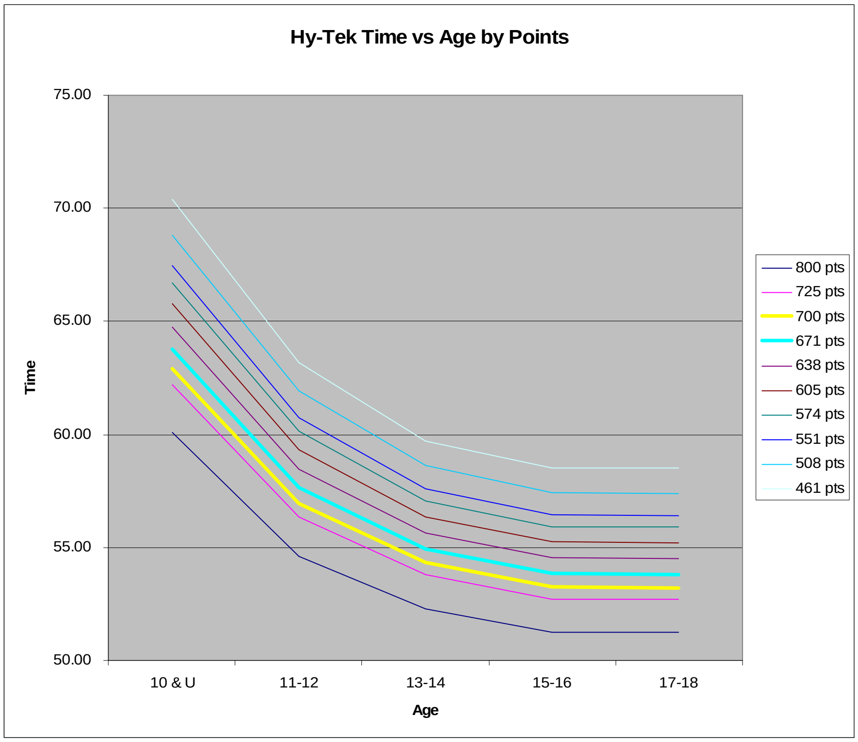
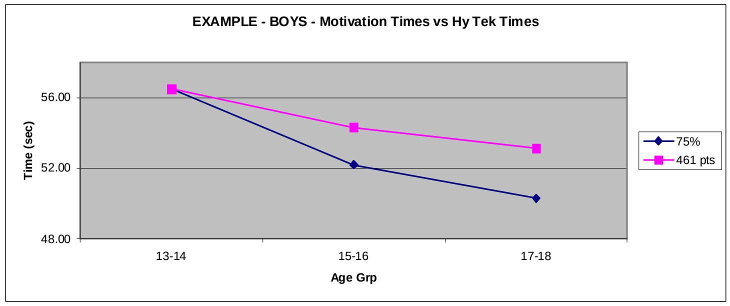


FIGURE A – Hy-Tek Point Curves Associated with Performance Groups

Figure B below demonstrates the zero quality improvement time line versus the motivational or normal progress time line. The 13-14 age group and 75% performance group times were selected. These times equals 461 points for the boys and 440 points for the girls. Note the significant difference as the motivational times end up nearly 3 seconds faster than the Hy-Tek times.

BOYS
EXAMPLE Hy-Tek VS Motivational Times

	13-14	**15-16**	**17-18**
75%	56.49	52.19	50.29
461 pts	56.49	54.30	53.13



GIRLS
EXAMPLE Hy-Tek VS Motivational Times

	13-14	**15-16**	**17-18**
75%	60.29	57.89	56.39
440 pts	60.29	59.35	59.00

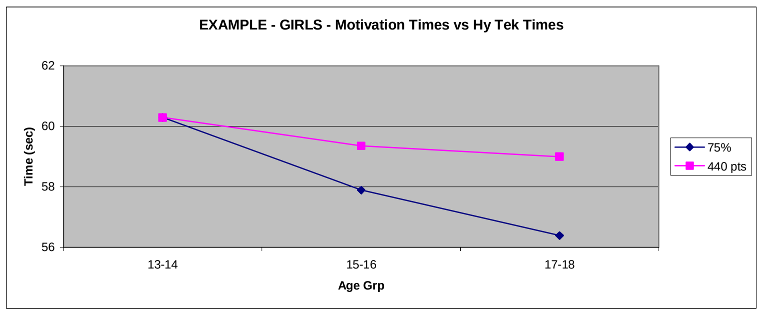


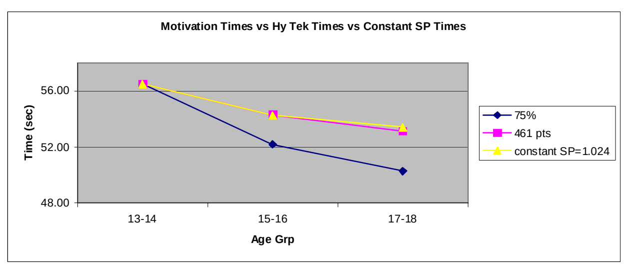
FIGURE B – Hy-Tek Point Time Lines VS Motivational Time Lines

Next in **Figure C** we add in the times calculated by SP. Note that the times predicted by SP based on normal growth curves closely lines up with the Hy-Tek times. This is simply an illustration that both SP and Hy-Tek times are nearly the same.

Boys Time Comparison
Hy-Tek Points vs Motivational Time vs Constant SP
100 SCY Free
Age Groups

	13-14	**15-16**	**17-18**
75%	56.49	52.19	50.29
461 pts	56.49	54.30	53.13
constant SP=1.024	56.49	54.26	53.41

45% Hgt



Girls Time Comparison
Hy-Tek Points vs Motivational Time vs Constant SP
100 SCY Free
Age Groups

	13-14	**15-16**	**17-18**
75%	60.29	57.89	56.39
440 pts	60.29	59.35	59.00
constant SP=1.069	60.29	59.39	59.25

62% Hgt

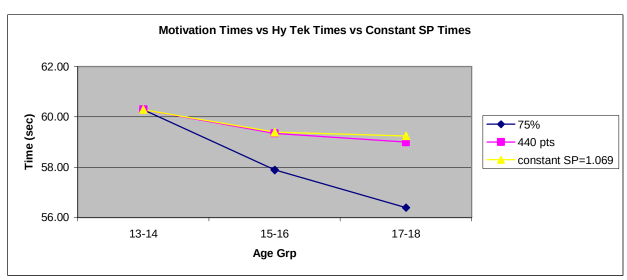


FIGURE C – Hy-Tek Point Time Lines, SP Time Lines VS Motivational Time Lines

Regression Analysis - Boys:

To determine how well SP predicts Hy-Tek we perform the following regression analysis.

Boys
Regression Analysis - SP Time Prediction of Hy-Tek Times
100 SCY Free

Age	Ref	Hy-Tek Pt	SP	Hy-Tek	Delta
13 to 14	1	800	48.38	48.55	-0.17
13 to 14	2	726	49.89	50.07	-0.18
13 to 14	3	701	50.38	50.58	-0.20
13 to 14	4	676	50.83	51.12	-0.29
13 to 14	5	646	51.48	51.75	-0.27
13 to 14	6	616	52.08	52.40	-0.32
13 to 14	7	588	52.66	53.02	-0.36
13 to 14	8	569	53.06	53.45	-0.39
13 to 14	9	527	53.97	54.42	-0.45
13 to 14	10	490	54.83	55.28	-0.45
14 to 15	11	800	47.15	47.72	-0.57
14 to 15	12	726	48.62	49.20	-0.58
14 to 15	13	701	49.08	49.71	-0.63
14 to 15	14	676	49.54	50.23	-0.69
14 to 15	15	646	50.09	50.87	-0.78
14 to 15	16	616	50.64	51.51	-0.87
14 to 15	17	588	51.18	52.12	-0.94
14 to 15	18	569	51.55	52.53	-0.98
14 to 15	19	527	52.44	53.48	-1.04
14 to 15	20	490	53.24	54.33	-1.09
15 to 16	21	800	47.00	46.71	0.29
15 to 16	22	726	48.46	48.16	0.30
15 to 16	23	701	48.94	48.66	0.28
15 to 16	24	676	49.41	49.17	0.24
15 to 16	25	646	49.99	49.79	0.20
15 to 16	26	616	50.57	50.42	0.15
15 to 16	27	588	51.13	51.01	0.12
15 to 16	28	569	51.50	51.42	0.08
15 to 16	29	527	52.40	52.34	0.06
15 to 16	30	490	53.22	53.18	0.04
16 to 17	31	800	46.35	46.10	0.25
16 to 17	32	726	47.79	47.53	0.26
16 to 17	33	701	48.27	48.03	0.24
16 to 17	34	676	48.76	48.53	0.23
16 to 17	35	646	49.35	49.14	0.21
16 to 17	36	616	49.95	49.76	0.19
16 to 17	37	588	50.52	50.35	0.17
16 to 17	38	569	50.91	50.75	0.16
16 to 17	39	527	51.80	51.66	0.14
16 to 17	40	490	52.63	52.48	0.15
17 to 18	41	800	45.93	45.43	0.50
17 to 18	42	726	47.36	47.09	0.27
17 to 18	43	701	47.85	47.59	0.26
17 to 18	44	676	48.33	48.09	0.24
17 to 18	45	646	48.93	48.69	0.24
17 to 18	46	616	49.53	49.29	0.24
17 to 18	47	588	50.11	49.89	0.22
17 to 18	48	569	50.50	50.29	0.21
17 to 18	49	527	51.40	51.19	0.21
17 to 18	50	490	52.21	51.99	0.22

TABLE A – Boys Data for Regression Analysis

BOYS Regression Analysis - SP Predictions of Hy-Tek

The following series of regression analyses uses SP predicted times for swimmers as they age up and Hy-Tek Point System predicted times as swimmers age-up. The regression analysis indicates how well SP correlates with Hy-Tek.

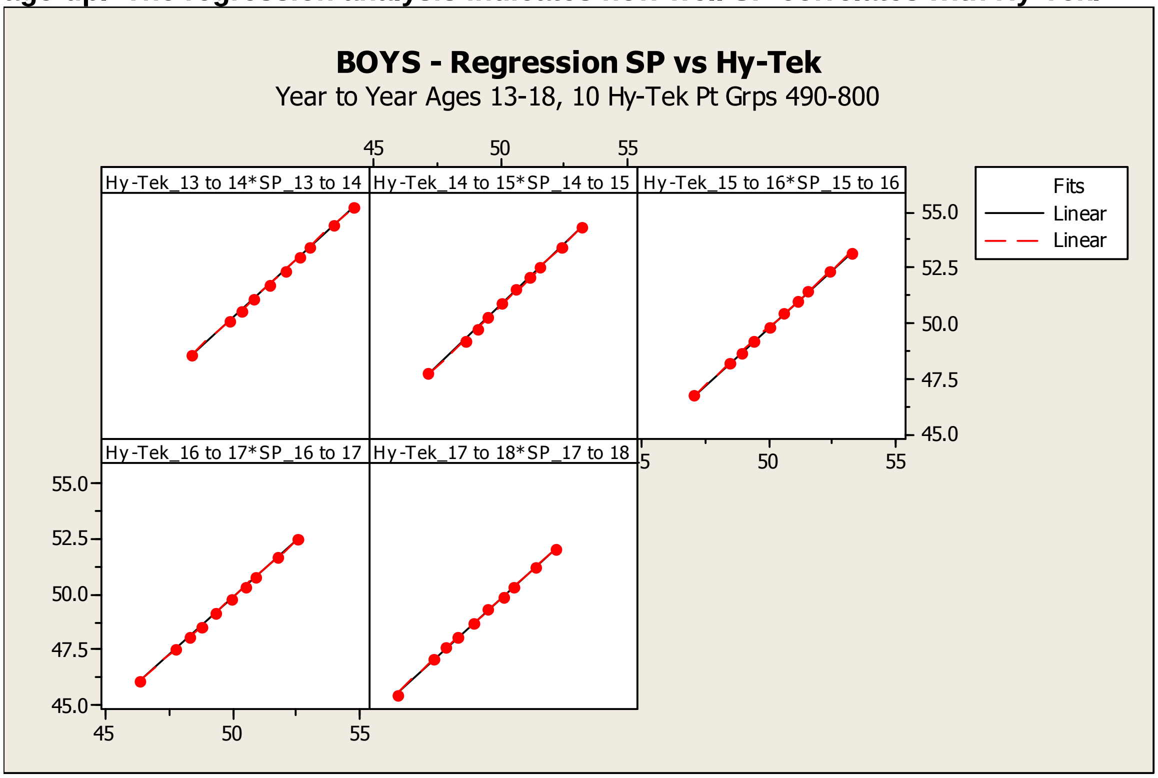


FIGURE D – Boys Year to Year Regression – SP vs. Hy-Tek

Summary - Year to Year Across All Hy-Tek Groups 490-800
Based on Average Height for Each Performance Group & Normal Growth Rates

	13 to 14	14 to 15	15 to 16	16 to 17	17 to 18
P value	.000	.000	.000	.000	.006
R-Sq	100.0%	99.9%	100.0%	100.0%	99.9%

These results indicate a very good correlation. P-values less than 0.01 supports not rejecting that SP and Hy-Tek variation is equal. The R-Sq values indicate the proportion of variation explained by the regression equation, which is 99.9% of it.

Based on this regression analysis the hypothesis that SP Times = Hy-Tek Times cannot be rejected.

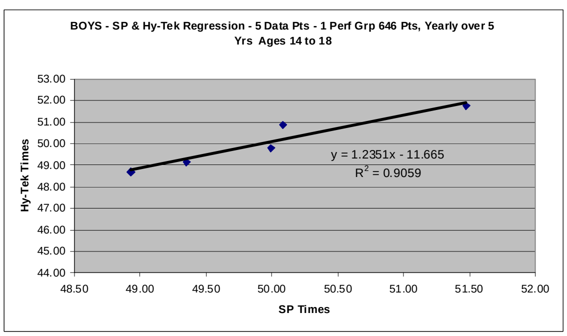
Although the regression was favorable, the actual variations in Table A are still significant, especially in the 14 to 15 age group.

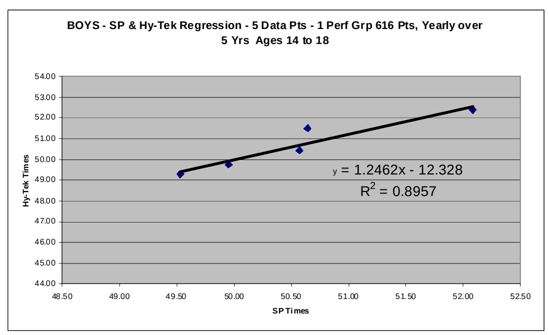
BOYS
Summary - Performance Groups 800-490 Over 5 Years (13 to 18 years)
Based on Average Height for Each Performance Group & Normal Growth Rates

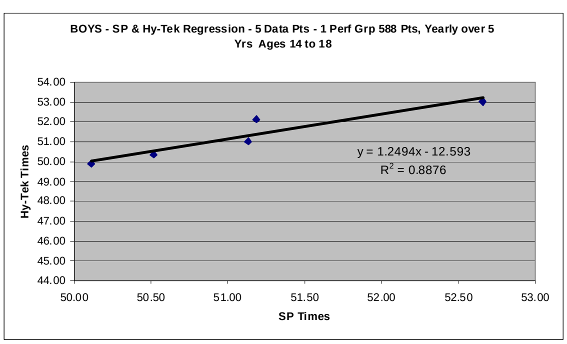
The heights used in the correlation were not the optimum. The Hy-Tek optimum heights are listed below, which if used in the correlation study would significantly improve the correlation. But still there is significant unexplained variation.

The age 14 to 15 predictions from Table A have the highest variation, and shows in the regression analysis as an outlier. Interesting is that this is not true for the girls. A likely explanation for this variance is that Hy-Tek allows for testosterone effect in maturing boys while SP does not.

AVG Hgt %	Pts	Perf Grp	R- Sq	Hy-Tek Optimum Hgt %	SP	SP Standard	R- Sq
99%	800 pts	>98%	93%				
99%	726 pts	98%	93%				
98%	701 pts	96.50%	92%				
95%	676 pts	94%	93%				
90%	646 pts	90%	91%	60%	0.9549	All American	98%
80%	616 pts	85%	90%				
70%	588 pts	80%	89%				
60%	569 pts	75%	88%	65%	0.9885	All Region	98%
50%	527 pts	65%	88%				
45%	490 pts	55%	87%	10%	0.9549	All American	98%







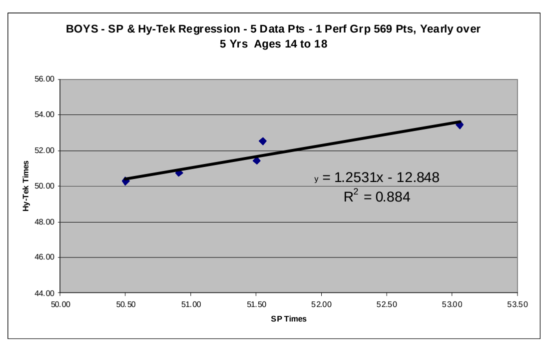


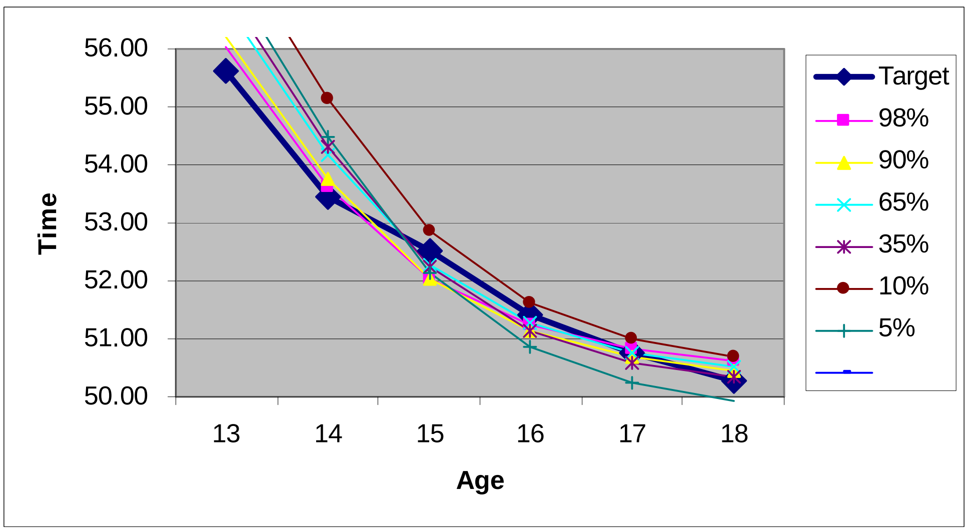
FIGURE E – BOYS - REGRESSION EXAMPLES

Figure F is typical of optimization data for the full Hy-Tek point range. Considerable variation is shown in Figure F due to the slope change of the Hy-Tek time line (Target) at age 14 to 15. This discrepancy is consistent with the regression analysis. Clearly, the 14 to 15 year old portion of the Hy-Tek time lines, significantly differ from the SP time lines. Otherwise, Hy-Tek and SP time lines agree.

569 Pt Optimization

Time Matrix - Optimum Hgt % VS Age @ Range of SP All-Town to World Class

			13	14	15	16	17	18
SP Standards		Target	55.61	53.45	52.53	51.42	50.75	50.29
All-Town	1.0558	98%	56.02	53.64	52.04	51.23	50.82	50.63
All-State	1.0222	90%	56.22	53.75	52.02	51.13	50.68	50.46
All-Region	0.9885	65%	56.77	54.18	52.28	51.27	50.77	50.52
All-American	0.9549	35%	57.00	54.31	52.26	51.15	50.60	50.33
National Team	0.9266	10%	57.98	55.13	52.85	51.61	50.99	50.69
Olympic Team	0.8985	5%	57.34	54.47	52.14	50.86	50.23	49.91
World Record Class	0.8726							



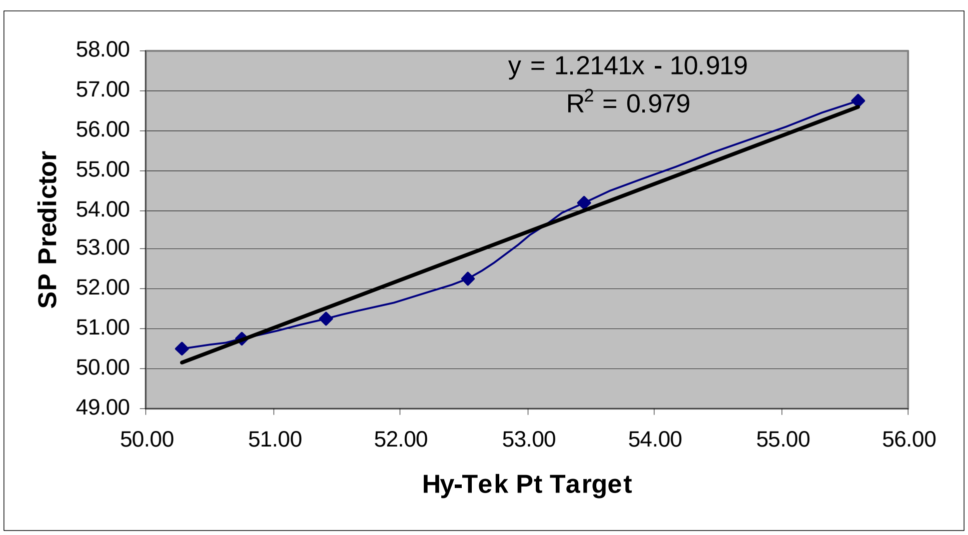


FIGURE F – BOYS - OPTIMIZATION EXAMPLE

Regression Analysis - Girls:

To determine how well SP predicts Hy-Tek we perform the following regression analysis.

Girls
Regression Analysis - SP Time Prediction of Hy-Tek Times
100 SCY Free

Age	Ref	Hy-Tek Pt	SP	Hy-Tek	Delta
13 to 14	1	800	52.63	52.28	0.35
13 to 14	2	725	54.16	53.80	0.36
13 to 14	3	700	54.63	54.32	0.31
13 to 14	4	671	55.16	54.93	0.23
13 to 14	5	638	55.79	55.64	0.15
13 to 14	6	605	56.42	56.37	0.05
13 to 14	7	574	57.05	57.06	-0.01
13 to 14	8	551	57.51	57.59	-0.08
13 to 14	9	508	58.45	58.60	-0.15
13 to 14	10	461	59.55	59.73	-0.18
14 to 15	11	800	51.91	51.60	0.31
14 to 15	12	725	53.42	53.10	0.32
14 to 15	13	700	53.93	53.61	0.32
14 to 15	14	671	54.51	54.22	0.29
14 to 15	15	638	55.20	54.92	0.28
14 to 15	16	605	55.90	55.64	0.26
14 to 15	17	574	56.56	56.32	0.24
14 to 15	18	551	57.07	56.84	0.23
14 to 15	19	508	58.06	57.84	0.22
14 to 15	20	461	59.17	58.96	0.21
15 to 16	21	800	51.44	51.23	0.21
15 to 16	22	725	52.94	52.72	0.22
15 to 16	23	700	53.44	53.23	0.21
15 to 16	24	671	54.03	53.83	0.20
15 to 16	25	638	54.71	54.53	0.18
15 to 16	26	605	55.41	55.24	0.17
15 to 16	27	574	56.07	55.92	0.15
15 to 16	28	551	56.57	56.43	0.14
15 to 16	29	508	57.56	57.42	0.14
15 to 16	30	461	58.66	58.53	0.13
16 to 17	31	800	51.08	51.20	-0.12
16 to 17	32	725	52.56	52.69	-0.13
16 to 17	33	700	53.08	53.20	-0.12
16 to 17	34	671	53.70	53.80	-0.10
16 to 17	35	638	54.41	54.49	-0.08
16 to 17	36	605	55.14	55.20	-0.06
16 to 17	37	574	55.83	55.89	-0.06
16 to 17	38	551	56.35	56.40	-0.05
16 to 17	39	508	57.35	57.39	-0.04
16 to 17	40	461	58.46	58.50	-0.04
17 to 18	41	800	51.12	51.23	-0.11
17 to 18	42	725	52.60	52.69	-0.09
17 to 18	43	700	53.12	53.19	-0.07
17 to 18	44	671	53.73	53.79	-0.06
17 to 18	45	638	54.42	54.49	-0.07
17 to 18	46	605	55.14	55.19	-0.05
17 to 18	47	574	55.84	55.89	-0.05
17 to 18	48	551	56.36	56.39	-0.03
17 to 18	49	508	57.35	57.39	-0.04
17 to 18	50	461	58.47	58.49	-0.02

TABLE B – GIRLS Data for Regression Analysis

GIRLS Regression Analysis - SP Predictions of Hy-Tek

The following series of regression analyses uses SP predicted times for swimmers as they age up and Hy-Tek Point System predicted times as swimmers age-up. The regression analysis indicates how well SP agrees with Hy-Tek.

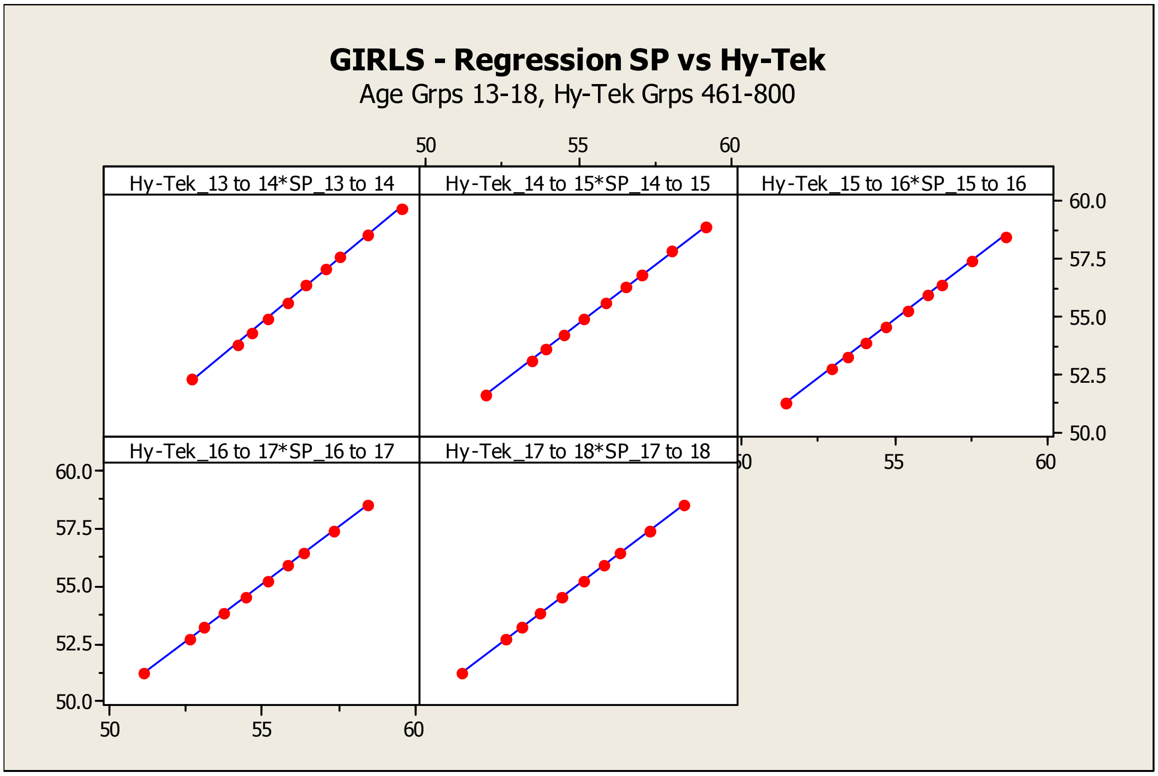


FIGURE G – Girls Year to Year Regression – SP vs. Hy-Tek

Summary - Year to Year Across All Hy-Tek Groups 461-800
Based on Average Height for Each Performance Group & Normal Growth Rates

	13 to 14	14 to 15	15 to 16	16 to 17	17 to 18
P value	**.000**	**.000**	**.000**	**.000**	**.000**
R-Sq	**99.9%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

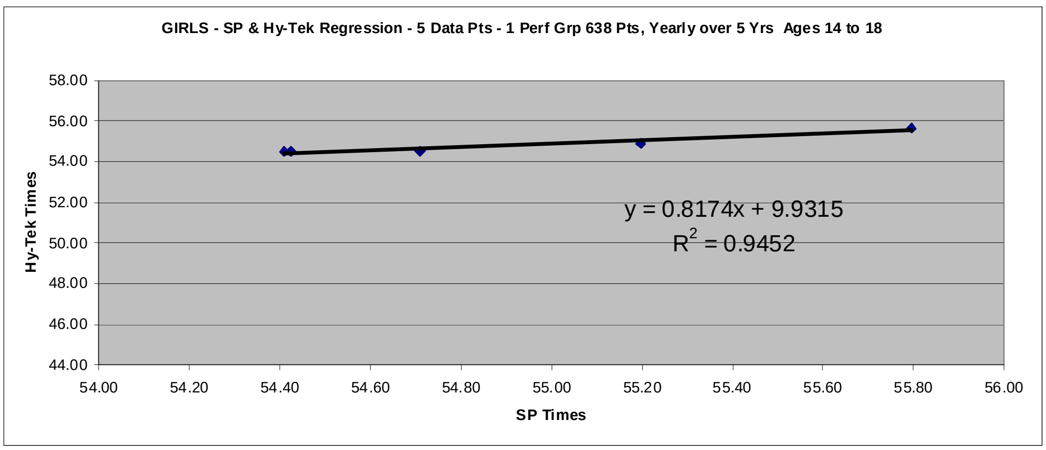
Year to year results across the Hy-Tek spectrum indicate excellent correlation. P-values less than 0.01 supports not rejecting that SP and Hy-Tek variation is equal. The R-Sq values indicate the proportion of variation explained by the regression equation, which is 99.9% of it.

Based on this regression analysis the hypothesis that SP Times = Hy-Tek Times cannot be rejected.

Girls
Summary - Performance Groups 800-461 Over 5 Years (13 to 18 years)
Based on Average Height for Each Performance Group & Normal Growth Rates

Regression by performance groups across 5 years (13-18) had the following result. R-Sq values ranged from 92% to 95%. The heights and SP values used in the correlation were not the optimum for Hy-Tek. For example, the 638 pt time line used an average height of 90% and an SP of 1.02 while the optimum turned out to be 40% with an SP of 0.9626. The Hy-Tek optimum heights and SP values are listed below with their resultant R-Sq values above 98%.

AVG Hgt %	Pts	Perf Grp	R-Sq	Hy-Tek Optimum Hgt %	SP	SP Standard	R-Sq
99%	800 pts	>98%	94%	80%	0.9472	Olympic Team	99%
99%	725 pts	98%	95%				
98%	700 pts	96.50%	95%	65%	0.9626	National Team	99%
95%	671 pts	94%	95%				
90%	638 pts	90%	95%	40%	0.9626	National Team	99%
80%	605 pts	85%	94%				
70%	574 pts	80%	94%				
60%	551 pts	75%	93%	30%	0.9831	All American	99%
50%	508 pts	65%	92%				
45%	461 pts	55%	92%	75%	1.0708	All Town	99%



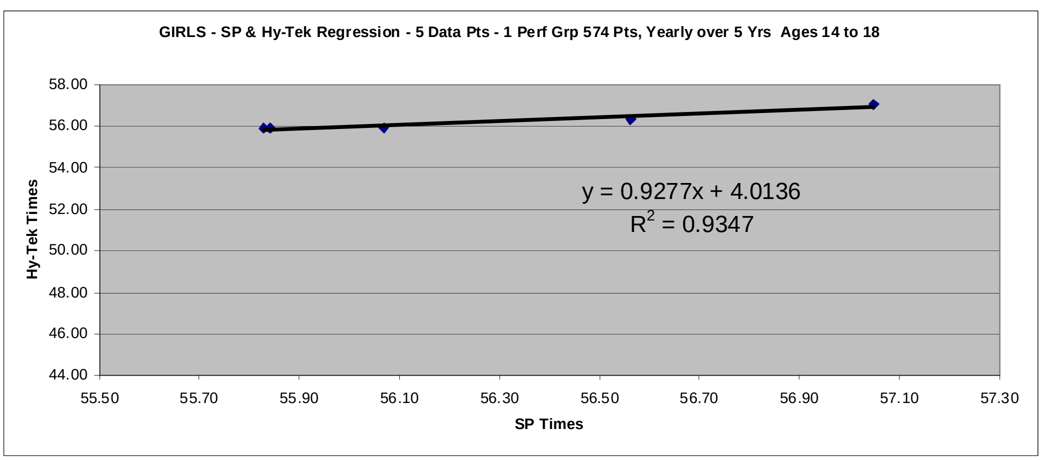


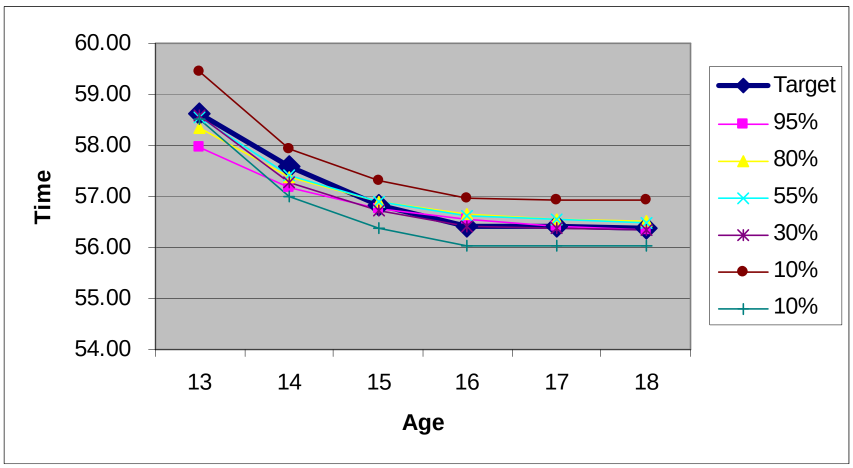
FIGURE H – GIRLS REGRESSION EXAMPLE

Figure I is typical of optimization data for the full Hy-Tek point range. It is possible that the Hy-Tek time lines are not based on normal growth curves or normal progression data. This may explain the variation not covered by the regression equations.

551 Pt Optimization

Time Matrix - Optimum Hgt % VS Age @ Range of SP All-Town to World Class

			13	**14**	**15**	**16**	**17**	**18**
SP Standards		Target	58.62	57.59	56.84	56.43	56.40	56.39
All-Town	1.0708	95%	57.96	57.18	56.75	56.55	56.41	56.33
All-State	1.0415	80%	58.35	57.39	56.91	56.67	56.56	56.51
All-Region	1.0123	55%	58.55	57.41	56.89	56.61	56.54	56.50
All-American	0.9831	30%	58.58	57.28	56.71	56.41	56.36	56.34
National Team	0.9626	10%	59.45	57.92	57.30	56.95	56.95	56.95
Olympic Team	0.9472	10%	58.50	57.00	56.39	56.04	56.03	56.04
World Record Class	0.8402	N/A	N/A	N/A	N/A	N/A	N/A	N/A



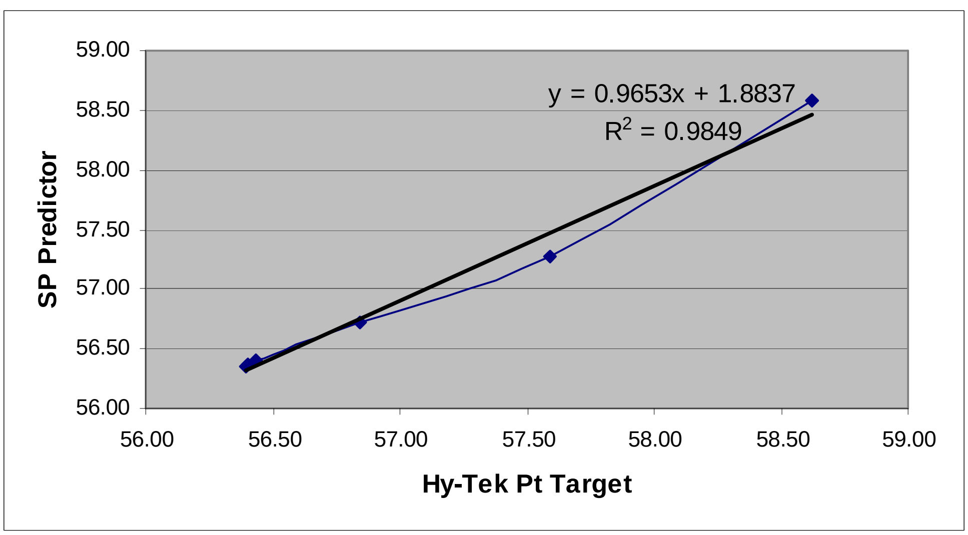


FIGURE I – GIRLS OPTIMIZATION EXAMPLE

Summary:
For the girls, year to year results across the Hy-Tek spectrum indicate excellent correlation R-Sq values above 99.9%. Regression by performance groups across 5 years (13-18) had R-Sq values above 99%.
For the boys, year to year results across the Hy-Tek spectrum indicate excellent correlation R-Sq values above 99.9%. Regression by performance groups across 5 years (13-18) had R-Sq values above 98%.

Based on this regression analysis the hypothesis that SP Times = Hy-Tek Times cannot be rejected.

The most significant difference between Hy-Tek and SP time lines was the boys 14 to 15 year old data. No explanation is offered, only speculation that Hy-Tek may consider the testosterone effect and/or Hy Tek uses different normal growth curves.

Hy-Tek Critique:
When comparing swimmers using the Hy-Tek point system, many assume higher points means better swimming. As illustrated, this may not be the case. Two swimmers both at 500 points, one is 5’4” the other 6’2” – who is the better swimmer? Clearly the shorter swimmer, but Hy-Tek points will not clarify this. Using SP, there is no mistake as to who the better swimmer is. The swimmer who swims his or her own body length the fastest is the better swimmer.

What has become crystal clear in this analysis is that any performance metric based on times alone will fail as a proficiency metric. Height is such a significant factor in unearned swimming speed, that it must be a factor in any measure of proficiency.

Swimming Proficiency Application – The SP Standards:
There are seven SP standards. All SP standards are based on time standards. Reaching a given SP standard means you are swimming at the same proficiency as swimmers who meet the equivalent time standard.

World Record Class
Olympic Class
National Team
All American
All Region
All State
All Town

The basis for each SP standard is shown below.
World Record Class – World record time and height of swimmer.
Olympic Class – US Olympic qualifying times and 20 year old 95% height percentile.
National Team – US team qualifying times and 20 year old 95% height percentile.
All American – High School All American time standard, 18 yr 95% height percentile.
All Region – Incremental
All State – Average of top 2 over last 10 years, Connecticut, 18 yr 95% hgt percentile.
All Town – 10&U 98% Motivational Time Std, 10 yr 95% height percentile.
NOTE: Ratios were used to calculate SP standards for events without time standards.

Shown below is the typical application of SP Standards. You can clearly see the seven SP standards (x.xxxx seconds per BL), your SP, your SP ranking, and your personal time standards.

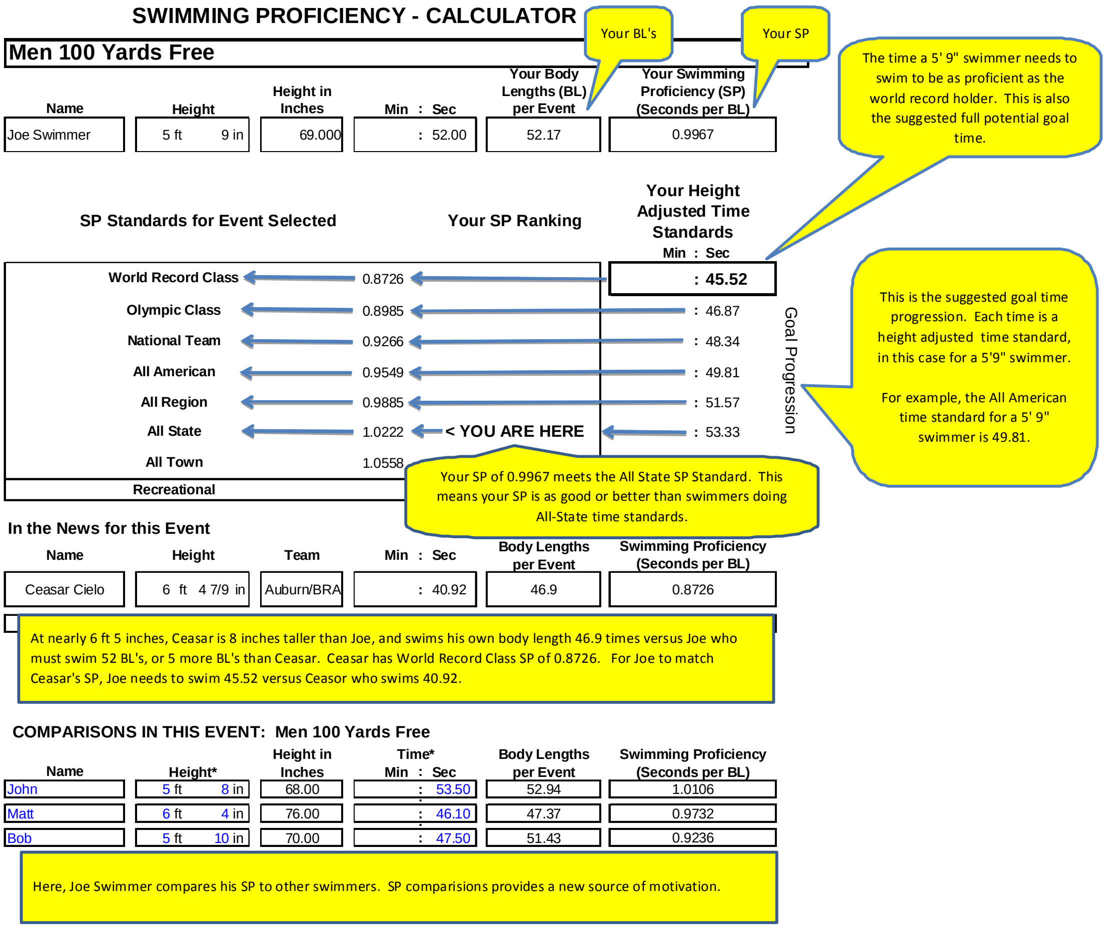
Men 100 Yards Free

Name	Height	Height in Inches	Min : Sec	Your Body Lengths (BL) per Event	Your Swimming Proficiency (SP) (Seconds per BL)
Joe Swimmer	5 ft 9 in	69.000	: 52.00	52.17	0.9967

SP Standards for Event Selected		Your SP Ranking	Your Height Adjusted Time Standards Min : Sec
World Record Class	0.8726		**: 45.52**
Olympic Class	0.8985		: 46.87
National Team	0.9266		: 48.34
All American	0.9549		: 49.81
All Region	0.9885		: 51.57
All State	1.0222	**< YOU ARE HERE**	: 53.33
All Town	1.0558		: 55.08
Recreational			

Goal Progression

Below is output from the SP Calculator with balloon notes for reference.



SWIMMING PROFICIENCY - CALCULATOR

Men 100 Yards Free

Name	Height	Height in Inches	Min : Sec	Your Body Lengths (BL) per Event	Your Swimming Proficiency (SP) (Seconds per BL)
Joe Swimmer	5 ft 9 in	69.000	: 52.00	52.17	0.9967

Your BL's

Your SP

The time a 5' 9" swimmer needs to swim to be as proficient as the world record holder. This is also the suggested full potential goal time.

SP Standards for Event Selected		Your SP Ranking	Your Height Adjusted Time Standards Min : Sec
World Record Class	0.8726		: 45.52
Olympic Class	0.8985		: 46.87
National Team	0.9266		: 48.34
All American	0.9549		: 49.81
All Region	0.9885		: 51.57
All State	1.0222	< YOU ARE HERE	: 53.33
All Town	1.0558		
Recreational			

Goal Progression

This is the suggested goal time progression. Each time is a height adjusted time standard, in this case for a 5'9" swimmer.

For example, the All American time standard for a 5' 9" swimmer is 49.81.

Your SP of 0.9967 meets the All State SP Standard. This means your SP is as good or better than swimmers doing All-State time standards.

In the News for this Event

Name	Height	Team	Min : Sec	Body Lengths per Event	Swimming Proficiency (Seconds per BL)
Ceasar Cielo	6 ft 4 7/9 in	Auburn/BRA	: 40.92	46.9	0.8726

At nearly 6 ft 5 inches, Ceasar is 8 inches taller than Joe, and swims his own body length 46.9 times versus Joe who must swim 52 BL's, or 5 more BL's than Ceasar. Ceasar has World Record Class SP of 0.8726. For Joe to match Ceasar's SP, Joe needs to swim 45.52 versus Ceasor who swims 40.92.

COMPARISONS IN THIS EVENT: Men 100 Yards Free

Name	Height*	Height in Inches	Time* Min : Sec	Body Lengths per Event	Swimming Proficiency (Seconds per BL)
John	5 ft 8 in	68.00	: 53.50	52.94	1.0106
Matt	6 ft 4 in	76.00	: 46.10	47.37	0.9732
Bob	5 ft 10 in	70.00	: 47.50	51.43	0.9236

Here, Joe Swimmer compares his SP to other swimmers. SP comparisions provides a new source of motivation.

Swimming proficiency calculators can be found in the following websites: swimmingproficiency.com, and swimmingpotential.com

APPENDIX A – PERFORMANCE FACTORS

PERFORMANCE FACTORS THAT EFFECT SWIMMING SPEED

Controllable Performance Factors - Factors Controlled by Swimmers

L1	L2	L3	
nutrition			
rest/recovery			
training			
	experience - years training/competing		
	consistency - consecutive seasons trained		
	level of effort		
	conditioning		
		aerobic	
		anaerobic	
		power - stroke/kick	
		endurance	
		turnover - strokes per second	
		distance per stroke	
		hypoxia	
		power - start/turn push off	
		workout plans	
		work/rest intervals	
		VO2	
	technique		
		feel for the water	
			stroke
			kick
			underwater kicking
			push-offs & pull-outs
			starts & turns
			streamline - swimming, starts, turns
			body position
			drag
		technique drills & execution	
		turnover - strokes per second	
		distance per stroke	

L1	L2	L3
physical		
	weight	
	body fat	
mental		
	motivation/will power	
	toughness	
	pain threshold	
	psychology	
	athletic intelligence	
	feel for the water	
drugs - performance enhancing		
equipment		
	suit - drag/buoyancy	
	goggles	
	caps	
	skin creams	
	shaving	

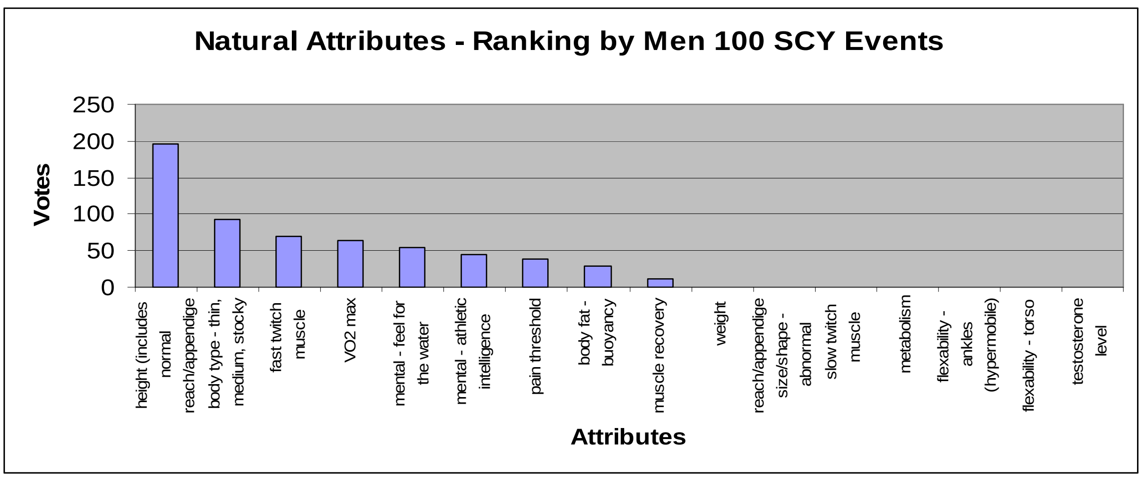
Uncontrollable Performance Factors - Factors Not Controlled by Swimmers

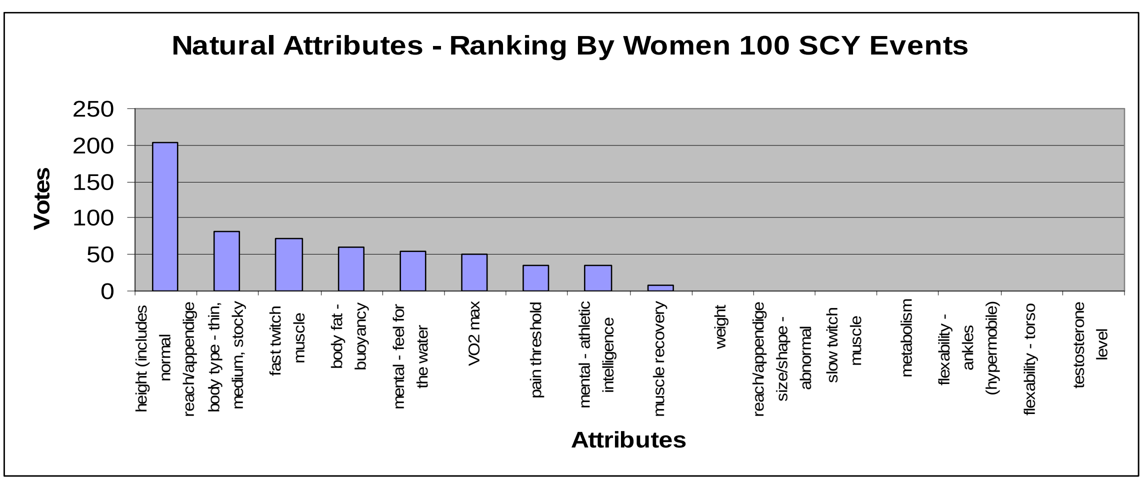
L1	L2	L3
physical		
	sex - male, female	
	age - maturity	
	body type - thin, medium, stocky	
	weight	
	body fat - buoyancy	
	height	
		horizontal reach - fingertip to toe
	appendige size/shape	
		foot size/shape
		hand size/shape
		arm size/shape
		leg size/shape
	fast twitch muscle	
	slow twitch muscle	
	VO2 max	
	pain threshold	
	metabolism	
	muscle recovery	
	flexability - ankles (hypermobile)	
	flexability - torso	
	hormones	
	illness	
	testosterone level	
	testosterone onset	

L1	L2	L3
mental		
	athletic intelligence	
	feel for the water	
	illness - depression, etc	
facility		
	lane lines	
	lane width	
	wall angle	
	wall grip	
	starting blocks	
	timing system	
	pool temperature	
	water density	
	pool depth	
officiating		
	missed calls	
	rule changes	

APPENDIX A Con't– PERFORMANCE FACTORS

Uncontrollable & Ungoverend Performance Factors - Factors Not Controlled by Swimmers and Rules						
L1	**L2**	**L3**		**L1**	**L2**	**L3**
physical				mental		
	body type - thin, medium, stocky				athletic intelligence	
	weight				feel for the water	
	body fat - buoyancy				illness - depression, etc	
	height					
		normal - horizontal reach - fingertip to toe				
		normal - appendige size/shape				
			foot size/shape			
			hand size/shape			
			arm size/shape			
			leg size/shape			
	abnormal - horizontal reach - fingertip to toe					
	abnormal - appendige size/shape					
		foot size/shape				
		hand size/shape				
		arm size/shape				
		leg size/shape				
	fast twitch muscle					
	slow twitch muscle					
	VO2 max					
	pain threshold					
	metabolism					
	muscle recovery					
	flexability - ankles (hypermobile)					
	flexability - torso					
	hormones					
	illness					
	testosterone level					
	testosterone onset					





APPENDIX B - Population Distributions – Overall vs Performance Groups
Example - Predicted Sample Sizes for Each Performance Group

Chart B.1 below is based on the Women's 18 yr old height distribution. It shows how 100 randomly picked 18 yr old women would look if lined up in order of height. The Y (vertical) axis is Height in inches. The X (horizontal) axis is the Height Percentile.

Chart B.2 is the normal distribution for the same data in chart B.1. It indicates frequency on the Y axis and the mean of 64.15 inches with a standard deviation (1 sigma) of 2.972 on the X axis.

Chart B.3 shows the height average and middle 50% for each performance group.

Chart B.4 shows the distribution in terms of frequency and height for the largest and smallest population performance groups.

Chart B.5 shows the normal distribution versus NCAA college women indicating an overall shift (~ 3 inches) towards taller women.

NOTE:

- The average height for each group descends as performance descends.
- The height range for each performance group has significant overlap into groups above and below it.
- The population size for each performance group increases as the average height for all performance groups approaches the Overall population mean. In this case 64.15 inches.

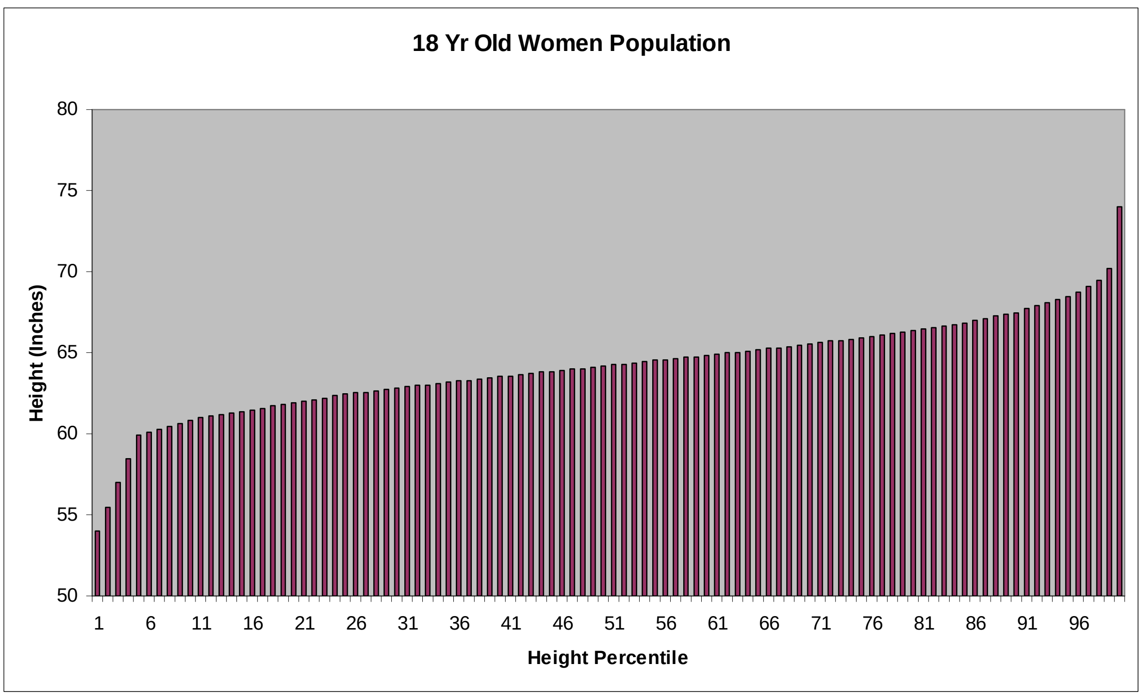


CHART B.1

APPENDIX B Con't - Population Distributions – Overall vs Performance Groups

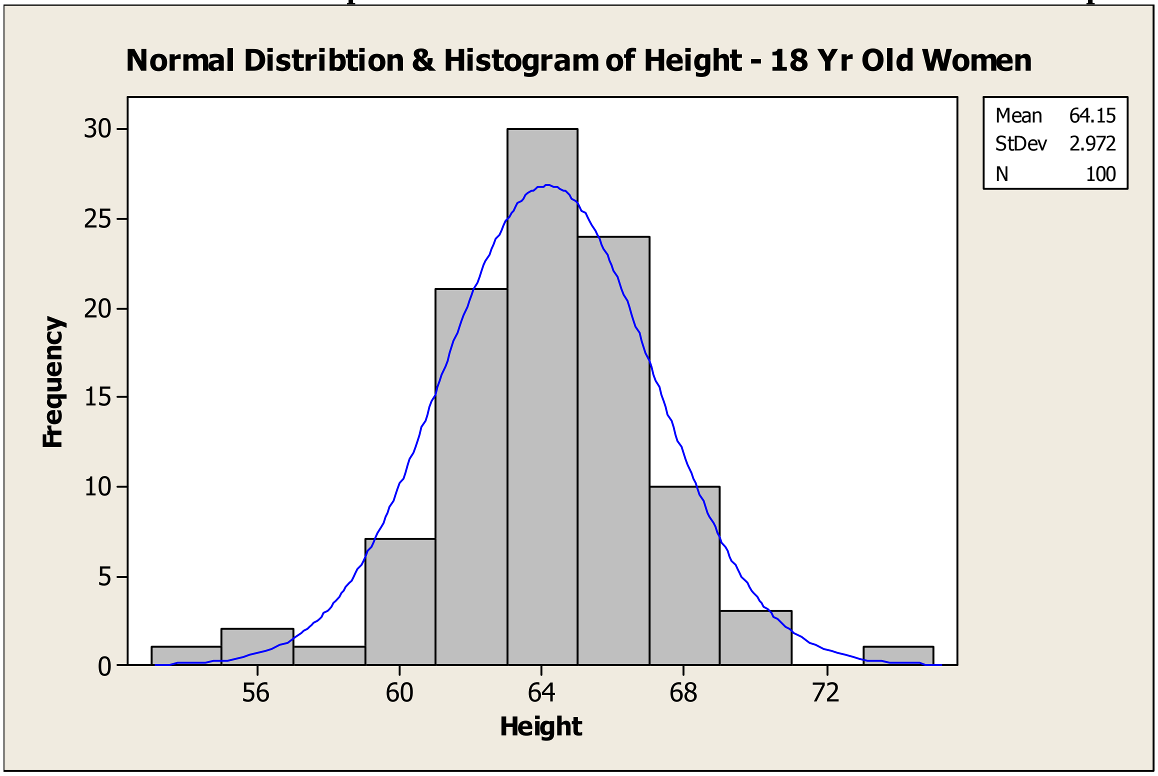


CHART B.2

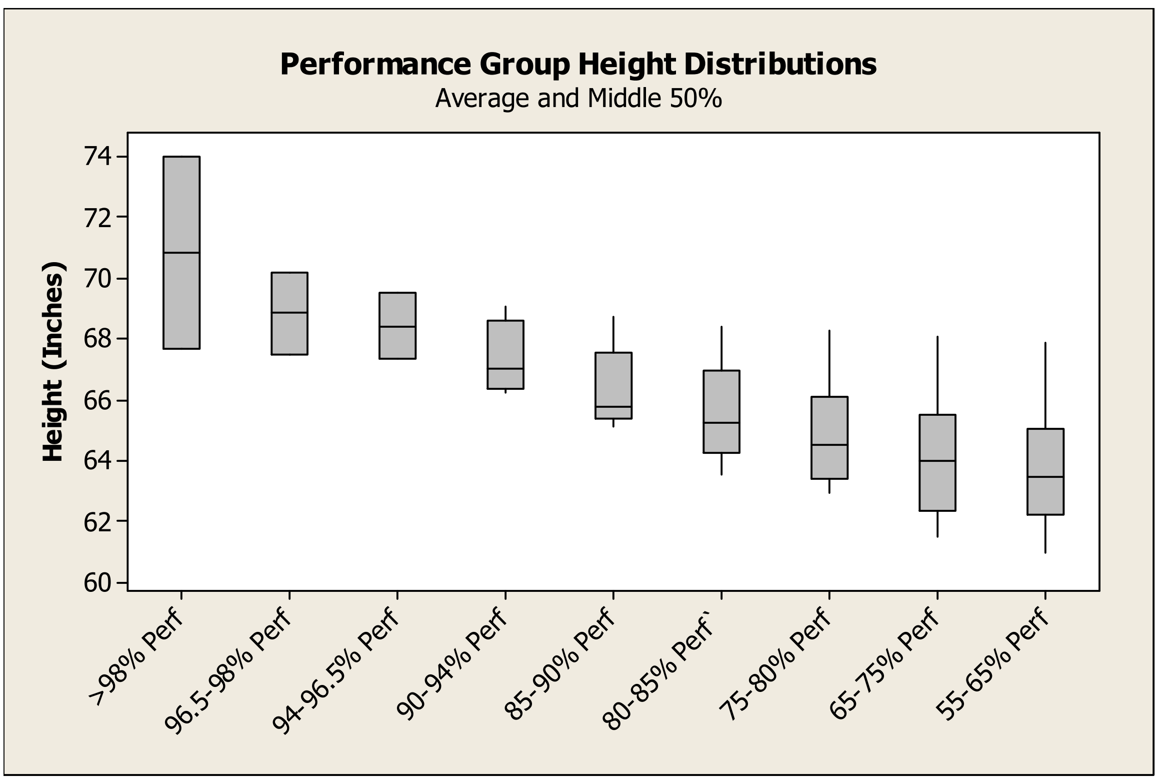


CHART B.3

APPENDIX B Con't - Population Distributions – Overall vs Performance Groups

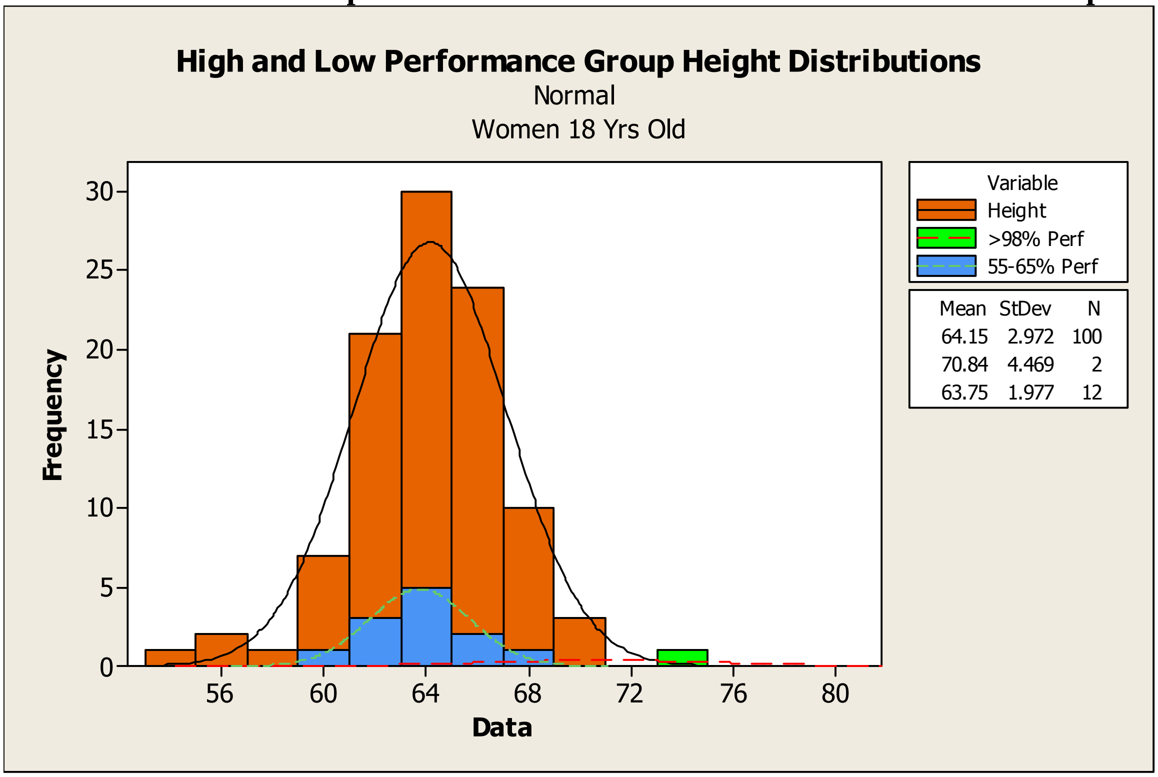


CHART B.4

APPENDIX B Con't - Population Distributions – Overall vs NCAA Div 1 Colleges

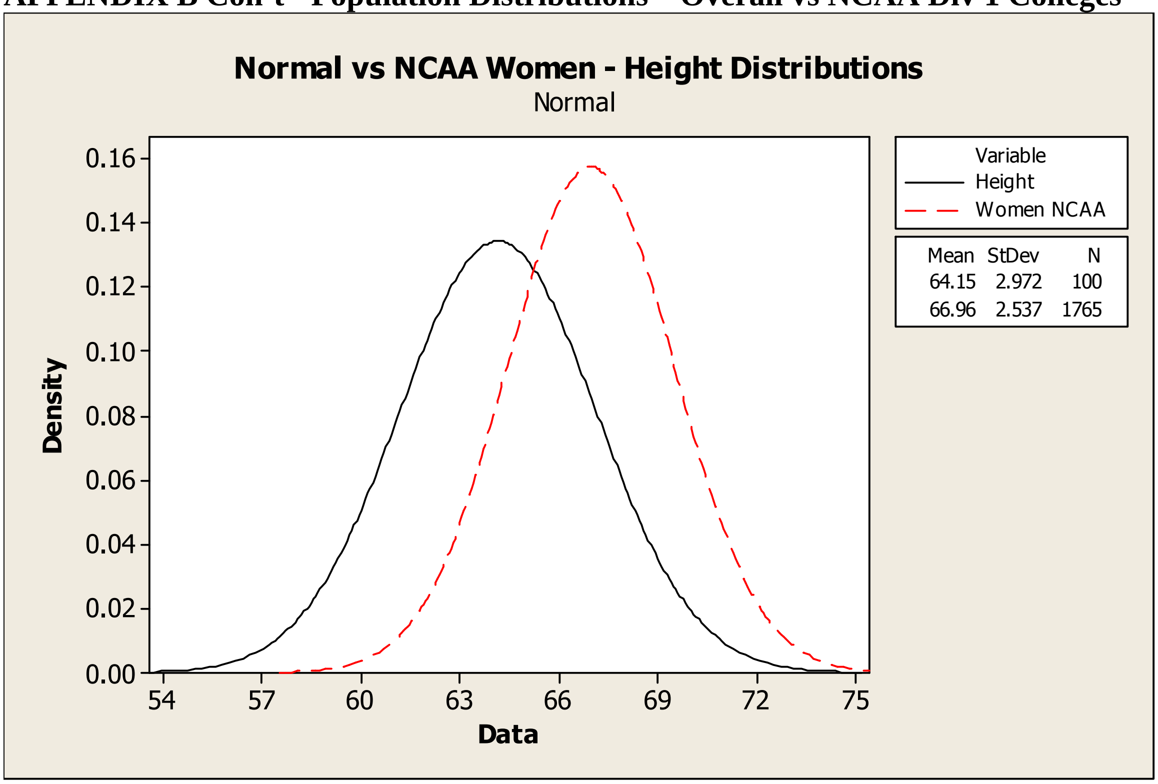
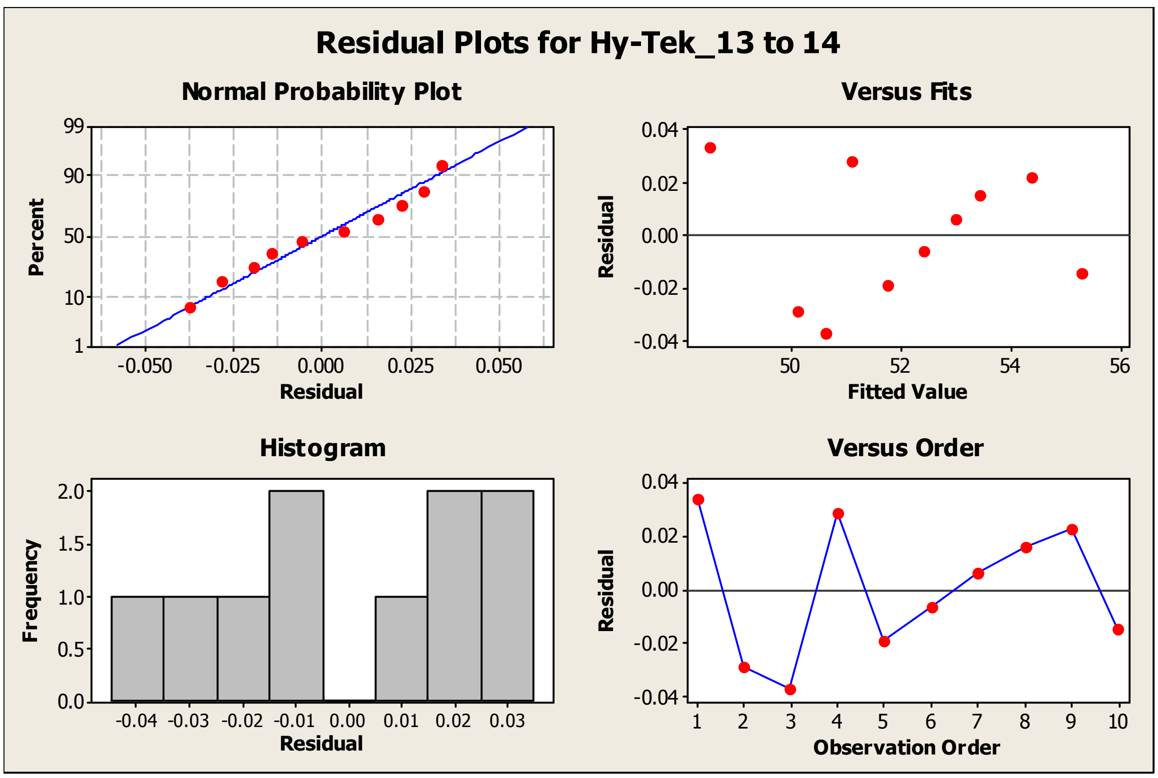


CHART B 5

APPENDIX C - BOYS YEAR TO YEAR REGRESSION ANALYSIS

Regression Analysis: Hy-Tek_13 to 14 versus SP_13 to 14

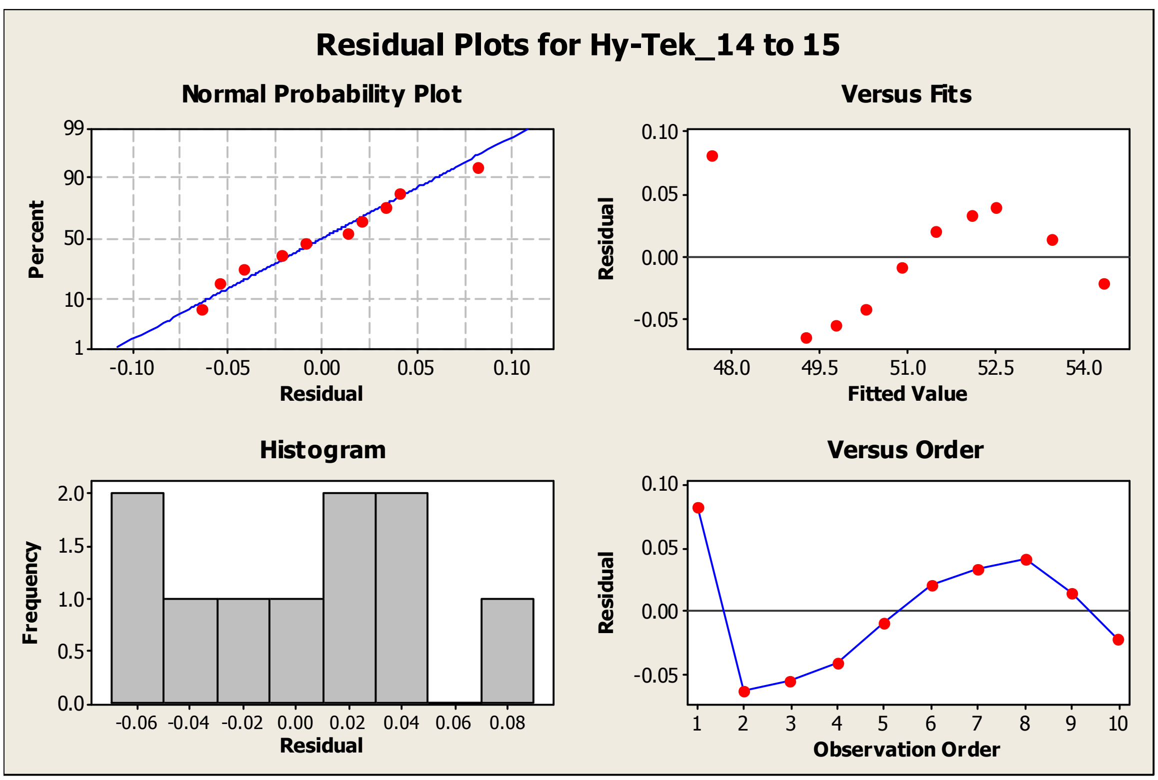
```
The regression equation is
Hy-Tek_13 to 14 = - 2.39 + 1.05 SP_13 to 14

Predictor        Coef   SE Coef       T      P    VIF
Constant      -2.3926    0.2326  -10.28  0.000
SP_13 to 14  1.05218   0.00449  234.23  0.000  1.000

S = 0.0264396   R-Sq = 100.0%   R-Sq(adj) = 100.0%

PRESS = 0.0101088   R-Sq(pred) = 99.97%

Analysis of Variance

Source          DF      SS      MS         F      P
Regression       1  38.352  38.352  54862.78  0.000
Residual Error   8   0.006   0.001
Total            9  38.357
```



APPENDIX C - BOYS YEAR TO YEAR REGRESSION ANALYSIS

Regression Analysis: Hy-Tek_14 to 15 versus SP_14 to 15

```
The regression equation is
Hy-Tek_14 to 15 = - 4.31 + 1.10 SP_14 to 15

Predictor       Coef  SE Coef       T      P    VIF
Constant     -4.3132   0.4504   -9.58  0.000
SP_14 to 15  1.10192  0.00894  123.26  0.000  1.000

S = 0.0493873   R-Sq = 99.9%   R-Sq(adj) = 99.9%

PRESS = 0.0400646   R-Sq(pred) = 99.89%

Analysis of Variance

Source          DF      SS      MS         F      P
Regression       1  37.058  37.058  15193.46  0.000
Residual Error   8   0.020   0.002
Total            9  37.078

Unusual Observations

     SP_14  Hy-Tek_14
Obs  to 15      to 15      Fit  SE Fit  Residual  St Resid
  1   47.1    47.7200  47.6374  0.0326    0.0826     2.23R

R denotes an observation with a large standardized residual.
```



APPENDIX C - BOYS YEAR TO YEAR REGRESSION ANALYSIS

Regression Analysis: Hy-Tek_15 to 16 versus SP_15 to 16

The regression equation is
Hy-Tek_15 to 16 = - 2.73 + 1.05 SP_15 to 16

Predictor	Coef	SE Coef	T	P	VIF
Constant	-2.7266	0.2476	-11.01	0.000	
SP_15 to 16	1.05072	0.00492	213.43	0.000	1.000

S = 0.0278996   R-Sq = 100.0%   R-Sq(adj) = 100.0%

PRESS = 0.0128439   R-Sq(pred) = 99.96%

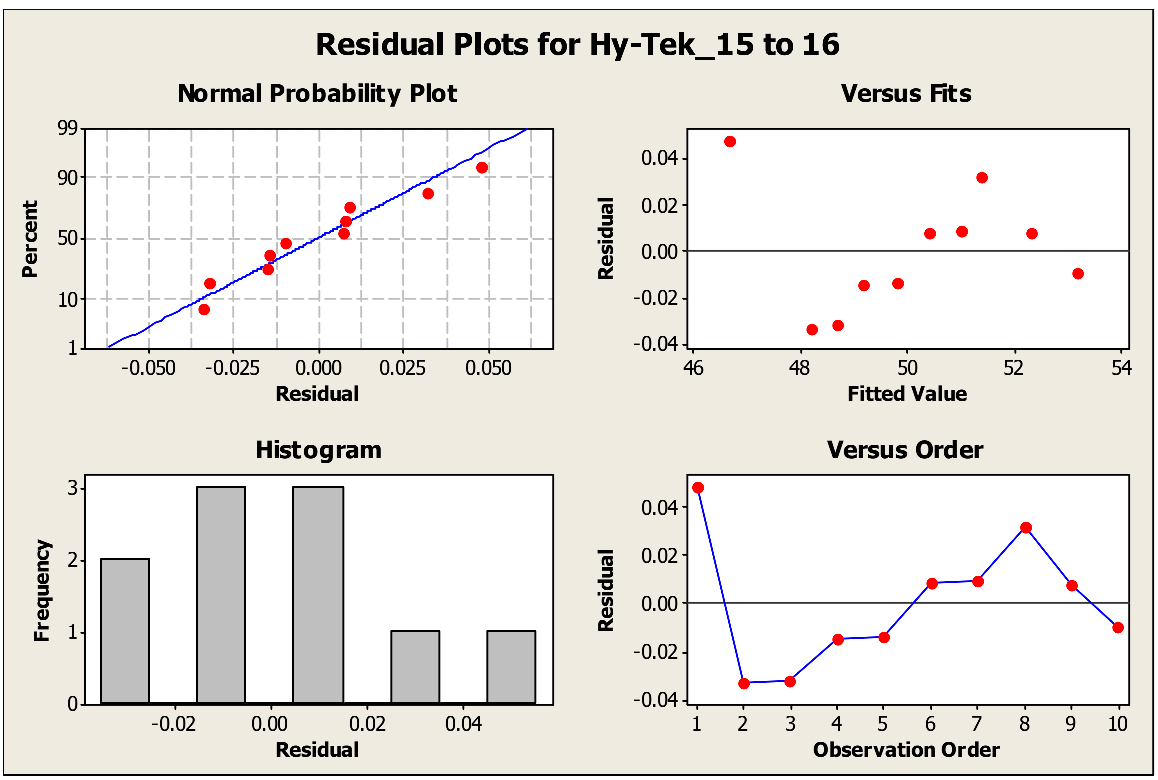
Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	35.459	35.459	45554.34	0.000
Residual Error	8	0.006	0.001		
Total	9	35.465			

Unusual Observations

Obs	SP_15 to 16	Hy-Tek_15 to 16	Fit	SE Fit	Residual	St Resid
1	47.0	46.7100	46.6619	0.0183	0.0481	2.29R

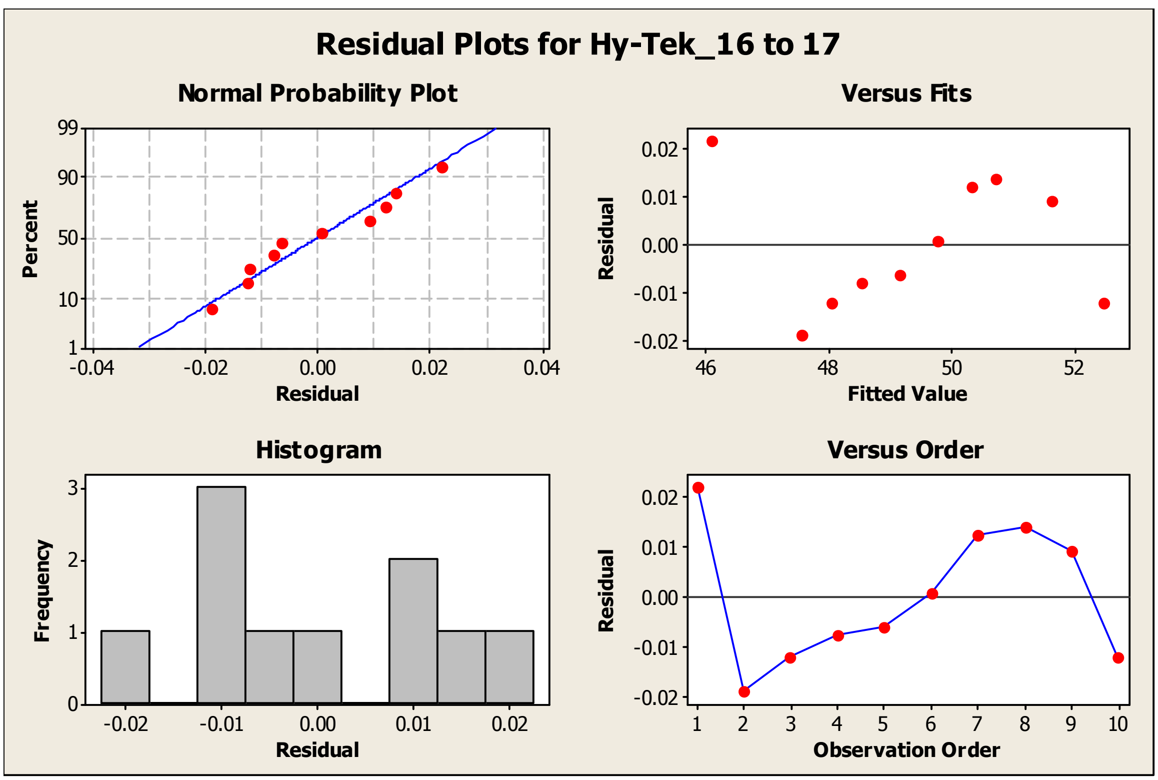
R denotes an observation with a large standardized residual.



APPENDIX C - BOYS YEAR TO YEAR REGRESSION ANALYSIS

Regression Analysis: Hy-Tek_16 to 17 versus SP_16 to 17

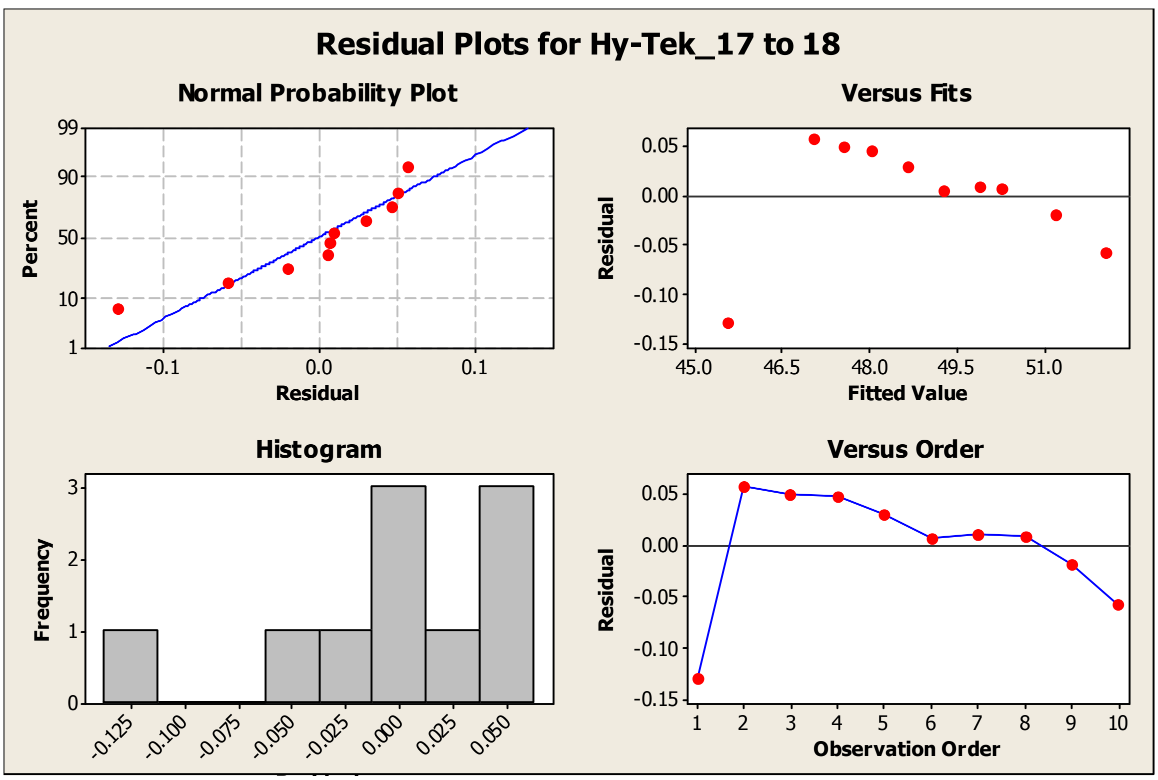
```
The regression equation is
Hy-Tek_16 to 17 = - 1.30 + 1.02 SP_16 to 17

Predictor        Coef  SE Coef       T      P    VIF
Constant      -1.3030   0.1247  -10.45  0.000
SP_16 to 17  1.02223  0.00251  407.14  0.000  1.000

S = 0.0144318   R-Sq = 100.0%   R-Sq(adj) = 100.0%

PRESS = 0.00334823   R-Sq(pred) = 99.99%

Analysis of Variance

Source          DF      SS      MS          F      P
Regression       1  34.524  34.524  165761.04  0.000
Residual Error   8   0.002   0.000
Total            9  34.526

Unusual Observations

     SP_16  Hy-Tek_16
Obs  to 17      to 17      Fit  SE Fit  Residual  St Resid
  1   46.4    46.1000  46.0781  0.0094    0.0219     2.00R

R denotes an observation with a large standardized residual.
```



APPENDIX C - BOYS YEAR TO YEAR REGRESSION ANALYSIS

Regression Analysis: Hy-Tek_17 to 18 versus SP_17 to 18

```
The regression equation is
Hy-Tek_17 to 18 = - 1.93 + 1.03 SP_17 to 18

Predictor       Coef  SE Coef      T      P    VIF
Constant     -1.9320   0.5207  -3.71  0.006
SP_17 to 18  1.03397  0.01057  97.79  0.000  1.000

S = 0.0609519   R-Sq = 99.9%   R-Sq(adj) = 99.9%

PRESS = 0.0728855   R-Sq(pred) = 99.80%

Analysis of Variance

Source          DF      SS      MS        F      P
Regression       1  35.531  35.531  9563.82  0.000
Residual Error   8   0.030   0.004
Total            9  35.561

Unusual Observations

     SP_17  Hy-Tek_17
Obs  to 18      to 18      Fit  SE Fit  Residual  St Resid
  1   45.9    45.4300  45.5594  0.0397   -0.1294     -2.80R

R denotes an observation with a large standardized residual.
```



APPENDIX D - GIRLS YEAR TO YEAR REGRESSION ANALYSIS

Regression Analysis: Hy-Tek_13 to 14 versus SP_13 to 14

The regression equation is
Hy-Tek_13 to 14 = - 5.46 + 1.10 SP_13 to 14

Predictor	Coef	SE Coef	T	P	VIF
Constant	-5.4564	0.5084	-10.73	0.000	
SP_13 to 14	1.09531	0.00905	121.03	0.000	1.000

S = 0.0567673   R-Sq = 99.9%   R-Sq(adj) = 99.9%

PRESS = 0.0513511   R-Sq(pred) = 99.89%

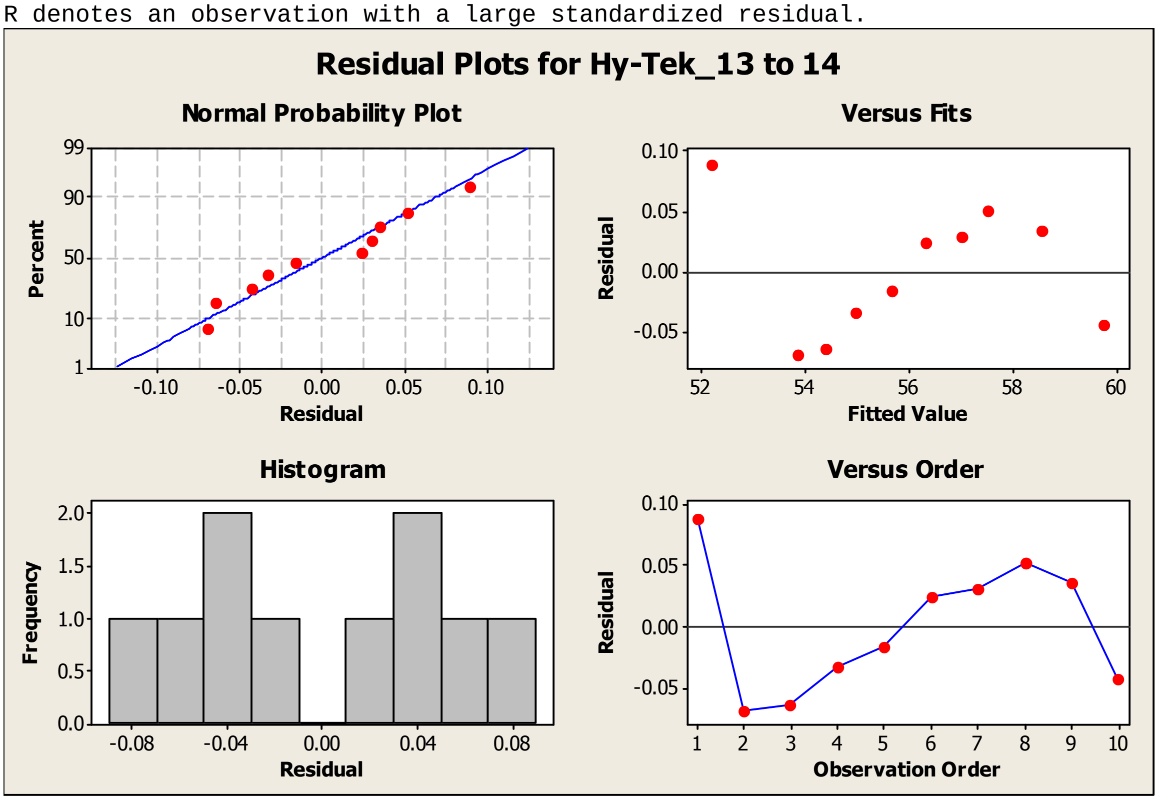
Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	47.201	47.201	14647.15	0.000
Residual Error	8	0.026	0.003		
Total	9	47.227			

Unusual Observations

Obs	SP_13 to 14	Hy-Tek_13 to 14	Fit	SE Fit	Residual	St Resid
1	52.6	52.2800	52.1910	0.0365	0.0890	2.05R

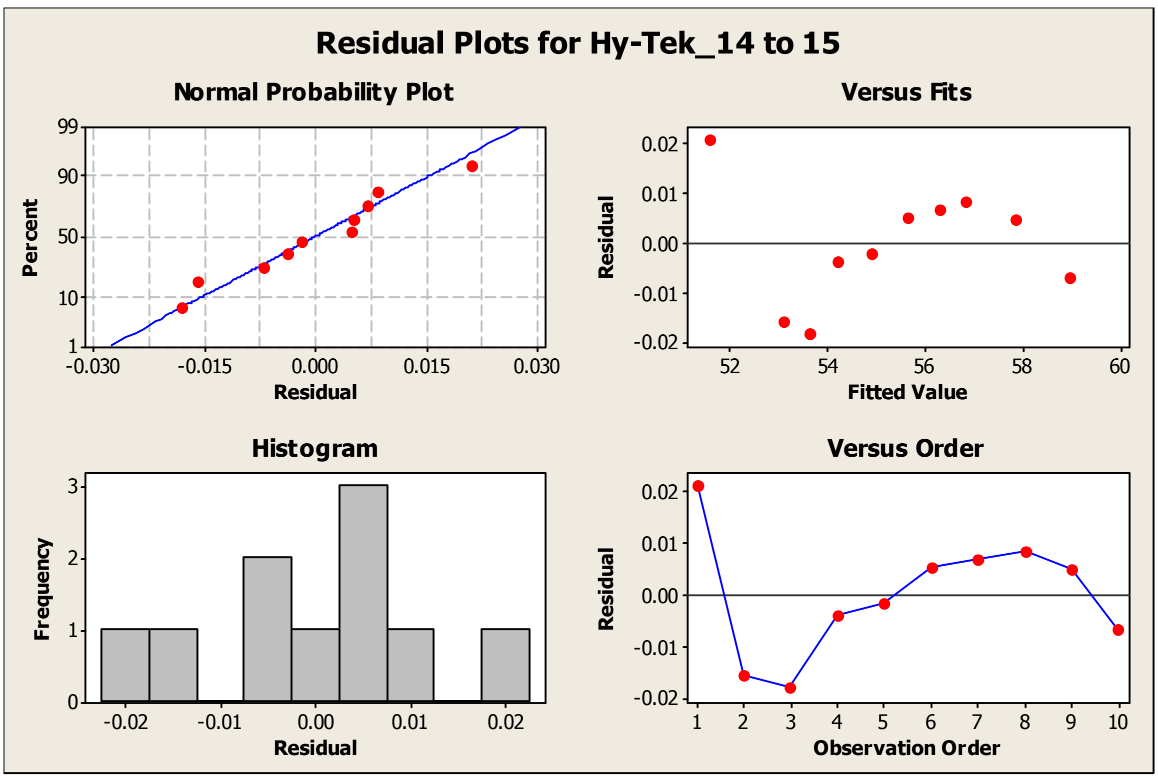
R denotes an observation with a large standardized residual.



APPENDIX D - GIRLS YEAR TO YEAR REGRESSION ANALYSIS

Regression Analysis: Hy-Tek_14 to 15 versus SP_14 to 15

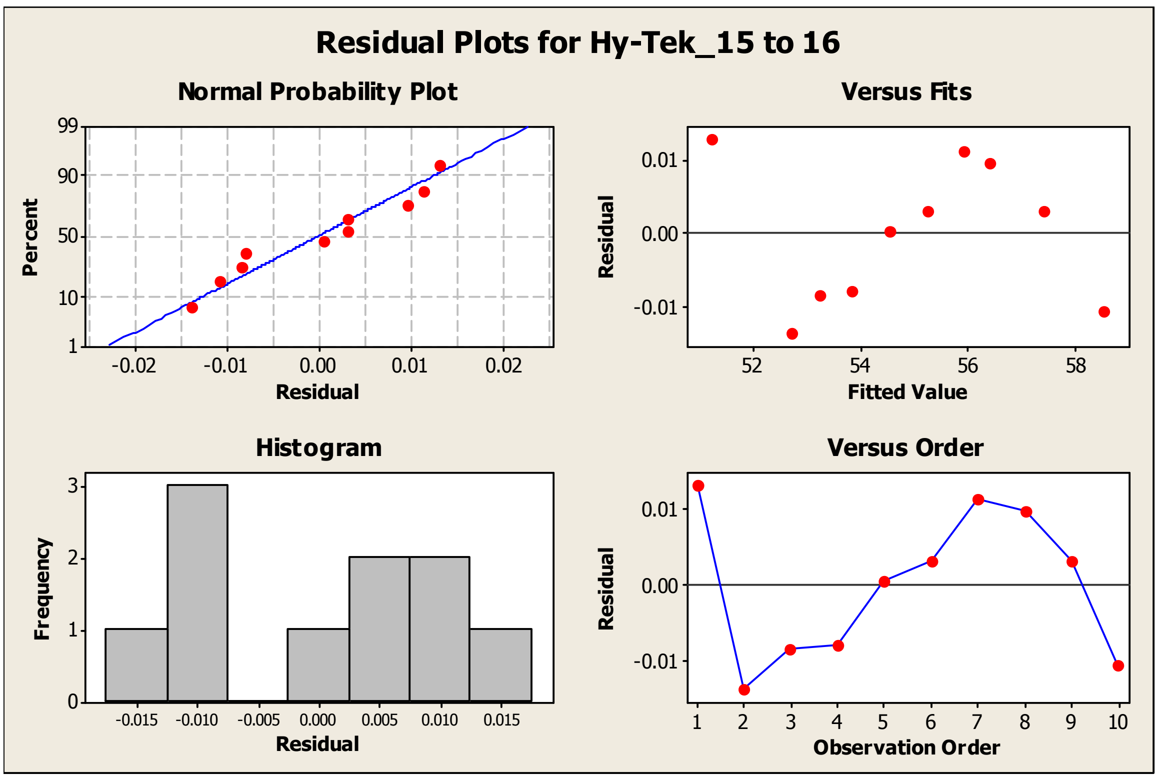
```
The regression equation is
Hy-Tek_14 to 15 = - 1.29 + 1.02 SP_14 to 15

Predictor        Coef  SE Coef       T      P    VIF
Constant      -1.2880   0.1051  -12.25  0.000
SP_14 to 15   1.01836  0.00189  538.64  0.000  1.000

S = 0.0126011   R-Sq = 100.0%   R-Sq(adj) = 100.0%

PRESS = 0.00251237   R-Sq(pred) =  99.99%

Analysis of Variance

Source          DF      SS      MS          F      P
Regression       1  46.070  46.070  290135.19  0.000
Residual Error   8   0.001   0.000
Total            9  46.071

Unusual Observations

     SP_14  Hy-Tek_14
Obs  to 15      to 15      Fit  SE Fit  Residual  St Resid
  1   51.9    51.6000  51.5788  0.0080    0.0212     2.17R

R denotes an observation with a large standardized residual.
```



APPENDIX D - GIRLS YEAR TO YEAR REGRESSION ANALYSIS

Regression Analysis: Hy-Tek_15 to 16 versus SP_15 to 16

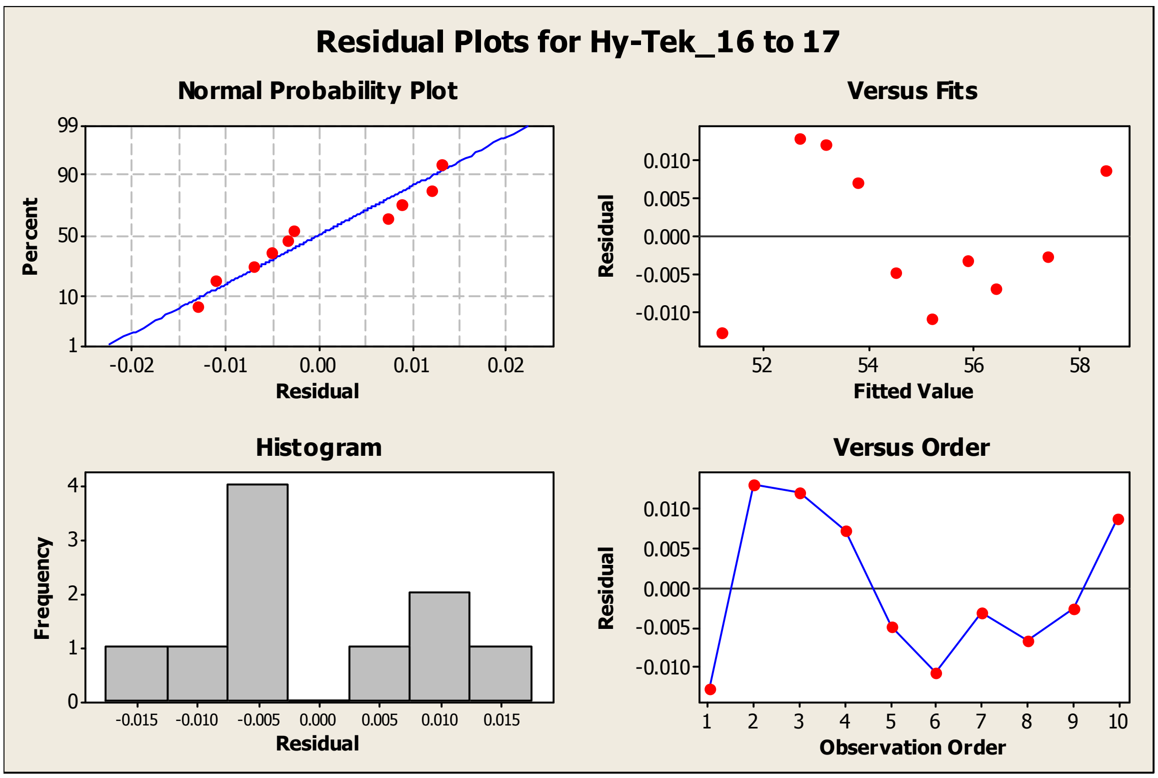
```
The regression equation is
Hy-Tek_15 to 16 = - 0.962 + 1.01 SP_15 to 16

Predictor         Coef  SE Coef       T      P    VIF
Constant      -0.96175  0.08563  -11.23  0.000
SP_15 to 16    1.01430  0.00155  652.95  0.000  1.000

S = 0.0103095   R-Sq = 100.0%   R-Sq(adj) = 100.0%

PRESS = 0.00159115   R-Sq(pred) = 100.00%

Analysis of Variance

Source          DF      SS      MS          F      P
Regression       1  45.315  45.315  426347.89  0.000
Residual Error   8   0.001   0.000
Total            9  45.316
```



APPENDIX D - GIRLS YEAR TO YEAR REGRESSION ANALYSIS

Regression Analysis: Hy-Tek_16 to 17 versus SP_16 to 17

```
The regression equation is
Hy-Tek_16 to 17 = 0.874 + 0.986 SP_16 to 17

Predictor         Coef   SE Coef       T      P    VIF
Constant       0.87395   0.08150   10.72  0.000
SP_16 to 17  0.985512  0.001486  663.12  0.000  1.000

S = 0.0101516   R-Sq = 100.0%   R-Sq(adj) = 100.0%

PRESS = 0.00148586   R-Sq(pred) = 100.00%

Analysis of Variance

Source          DF      SS      MS          F      P
Regression       1  45.316  45.316  439725.59  0.000
Residual Error   8   0.001   0.000
Total            9  45.317
```



APPENDIX D - GIRLS YEAR TO YEAR REGRESSION ANALYSIS

Regression Analysis: Hy-Tek_17 to 18 versus SP_17 to 18

```
The regression equation is
Hy-Tek_17 to 18 = 0.713 + 0.988 SP_17 to 18

Predictor         Coef   SE Coef       T      P    VIF
Constant       0.71285   0.06519   10.94  0.000
SP_17 to 18   0.988066  0.001188  831.46  0.000  1.000

S = 0.00807176   R-Sq = 100.0%   R-Sq(adj) = 100.0%

PRESS = 0.000982323   R-Sq(pred) = 100.00%

Analysis of Variance

Source          DF      SS      MS          F      P
Regression       1  45.043  45.043  691330.92  0.000
Residual Error   8   0.001   0.000
Total            9  45.043
```