IB Math SL IA – Is Tapering Effective?

Name: Jacob House
IB Candidate Number: 001187 0016
School: Holy Heart of Mary Regional High School
Location: St. John's, Newfoundland, Canada
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Introduction

Everyone wants to do their best at something they care about. That's why we study hard, train hard and try to prepare ourselves to do well in our everyday activities. I've been involved with competitive swimming for seven years and in that time I've been away to many "higher level" meets which are often our focus for the entire year — this year for example our focus will likely be meets in London, ON, Saint John, NB, Mount Pearl, NL and Dublin, Ireland. In my main sport, competitive swimming, the way one trains for a "focus meet" and the way they train for a normal meet differ drastically.

Usually, in an effort to perform better, prior to a focus meet a swimmer will "taper". This means that the type of training done in the days or even weeks leading up to the meet changes from what it has been all year long. Often, the changes that occur are things such as decreased volume of workouts (less metres swam per practice), increased rest between sets, higher intensity bursts of work, and fine tuning technical issues such as starts (dives), turns and finishes.

I would like to base my Mathematical Exploration around the concept of tapering so that I, as a competitive swimmer, can know first hand if what I do to train for a focus meet is actually effective in improving my times. I want to know if this difference in training that leads up to a higher level meet actually has any noticeable correlation with swimmers, on average, performing better in their different events.

Background Information

Tapering

Many factors, such as swim suit design, goggle design, shaving down and warming-up, have an impact on a swimmer's performance. However, a swimmer's training is the most important factor; specifically, the taper period which occurs between seven and twenty-one days before a competition or meet.[1]

Tapering is a recovery technique that is used prior to a meet to reverse the fatigue caused by intense training and to allow the athlete to achieve peak performance in competition.[2] Tapering affects three areas of a swimmer's preparation: the frequency of practices, the intensity of each

1 Tapering and Performance. (n.d.)
2 Hooper, et al. (1998)

session and the duration of the taper.[3]

If done correctly, an effective taper has been shown in previous studies to yield up to a three percent improvement over non-tapered results.[4] These results were likely gained using higher performance swimmers, with more experience and who likely had more means, such as pool-time, at their disposal than the swim teams I worked with for this study.

STUDY

To determine if, in the real world, tapering is an effective training tool to improve swimmers time in a meet, I have gathered approximately twenty swimmers' results from various meets, including some of my own. These results have already been recorded at official swim meets governed by Swimming / Natation Canada and were available on their web-site, www.swimming.ca. To access a swimmer's data I simply need to know the individual's name and birthdate.[5] The swimmers chosen for this study were male and female, between the ages of thirteen and eighteen years old and came from two local swim clubs. The participants have been swimming competitively anywhere from 2 - 11 years. All of the swimmers who agreed to participate in this study are friends of mine and I will be returning the findings of the study to them afterwards so that they are able to adjust their training to perform better in competition.

The data in the table in the following page (Figure 2.1) has been determined through finding the mean (Figure 1) of each swimmer's change in event time from previous best time for tapered and non-tapered swim meet results. Each swimmer had at least fifteen times for both non-tapered and tapered events for a total of 395 and 337 swims[6], respectively.

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

Where: x_i = race$_i$ time in seconds
n = total number of races

Figure 1: The Mean of a Set of Data

3 Tapering and Performance. (n.d.)
4 Tapering and Performance. (n.d.).
5 See Appendix A for Media Release Consent Waivers from each participant
6 See Appendix B for raw data tables

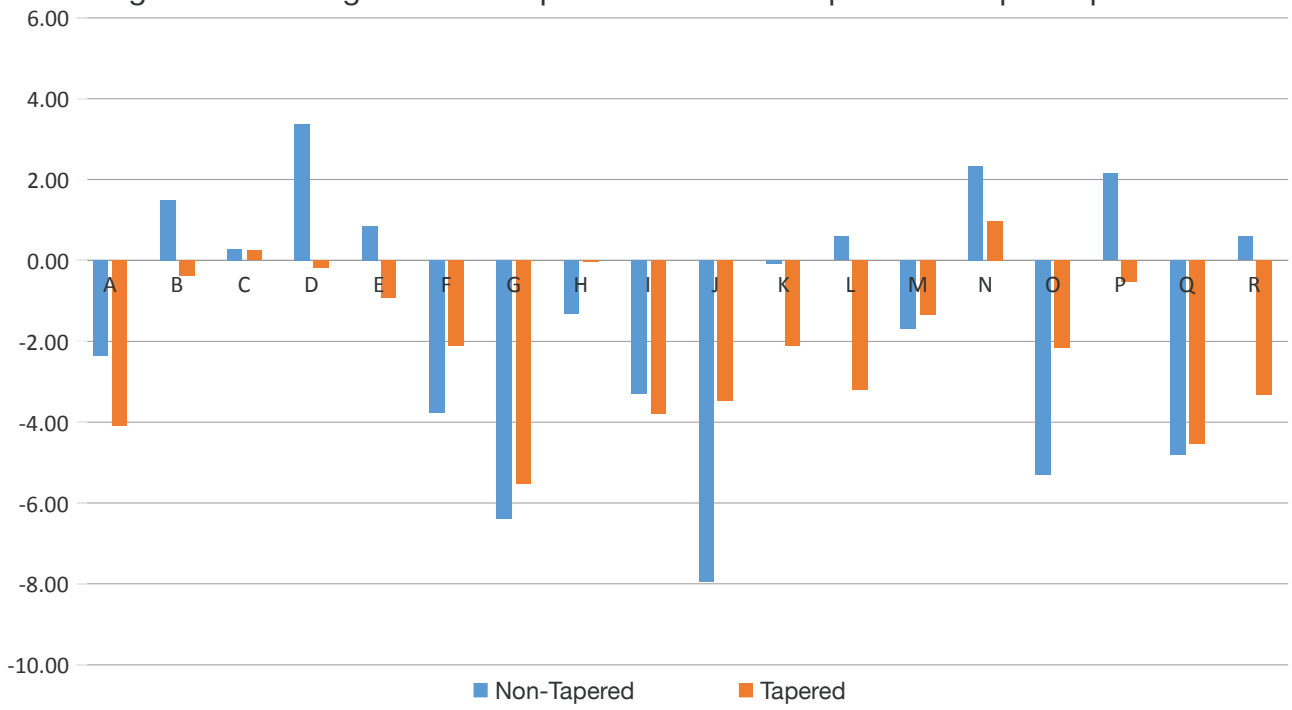
Note that a negative percentage is good. A swimmer wants to go faster, taking time off their previous personal best and this is represented by a negative number. Positive values indicate that a swimmer added time which means they swam slower than their previous personal best time. This is not an improvement in performance.

Figure 2.1: Average Percent Improvement – Non-Tapered vs. Tapered per Swimmer

Swimmer	Non-Tapered (NT)	Tapered (T)	Difference (T - NT)
A	-2.36	-4.10	-1.74
B	1.50	-0.39	-1.89
C	0.28	0.25	-0.03
D	3.37	-0.19	-3.56
E	0.85	-0.93	-1.78
F	-3.77	-2.10	1.67
G	-6.40	-5.53	0.87
H	-1.32	-0.04	1.28
I	-3.29	-3.78	-0.49
J	-7.95	-3.47	4.48
K	-0.09	-2.10	-2.01
L	0.59	-3.19	-3.78
M	-1.69	-1.35	0.34
N	2.33	0.97	-1.36
O	-5.30	-2.16	3.14
P	2.15	-0.54	-2.69
Q	-4.82	-4.54	0.28
R	0.59	-3.32	-3.91
Overall Average	**-1.41**	**-2.03**	**-0.62**

Below, Figure 2.2 demonstrates this data in a bar graph format.

Figure 2.2: Average Percent Improvement – Non-Tapered vs. Tapered per Swimmer



The values in the table (Figure 2.1) show that on average, each swimmer bettered their previous personal best time by 1.41% in each race without tapering. With tapering however, this number increased to a 2.03% decrease in time – a 0.62% difference.

The table below (Figure 3) represents the total number of races and how many of this total had any decrease in time – no matter how small or large the difference may be. The percentage of swims that were best times from each non-tapered and tapered race is included in the far right column.

Figure 3: Time Improvement – Non-Tapered vs. Tapered per Race

	Number of Races	Time Improvement (count / percentage)	
Non-Tapered	395	216	54.86
Tapered	337	249	73.89

Figure 3 shows that without tapering approximately 55% of races were personal best times while approximately 74% were personal bests with tapering. This 19% increase is indicative that tapering increases the probability of swimming a personal best time.

Figure 4: Time Improvement – Non-Tapered vs. Tapered per Swimmer

	Number of Swimmers	Time Improvement (count / percentage)	
Non-Tapered	18	10	55.56
Tapered	18	16	88.89

Figure 4, shown above, is similar to Figure 3 except it displays the swimmers' average improvements rather than the number of races. Once again, this data shows a noticeable increase in the amount of swimmers who improved with tapering.

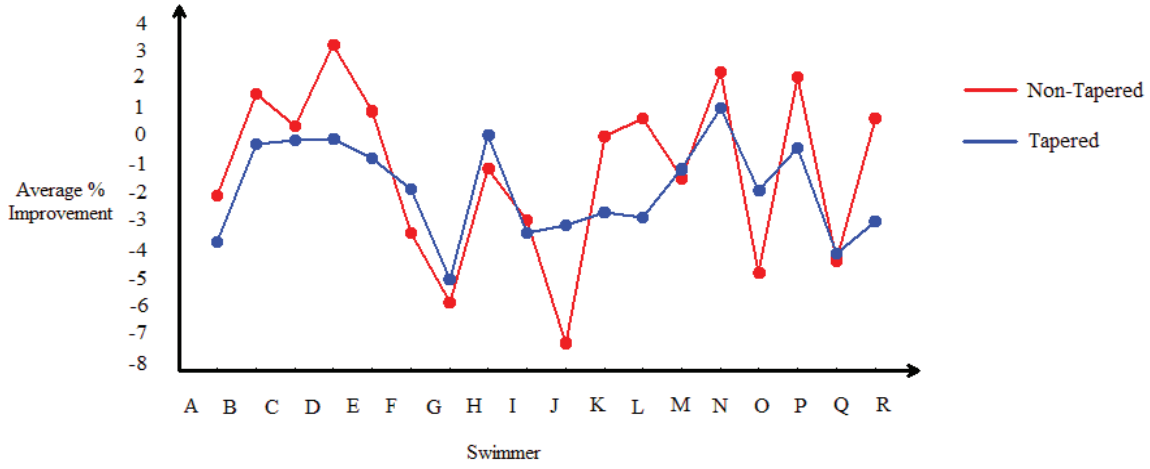
Data Analysis

Studies on the effectiveness of tapering prior to a swimming competition have been conducted and it has been shown that there is a consistent performance improvement of approximately three percent in competitive swimmers. This level of improvement is visible only after an optimal taper which is specific to each swimmer.

My results show an increase in performance of approximately 2.06%. While this is slightly short of the reported three percent it is close enough to show that tapering has a positive effect on a swimmer's performance. The data shown above is raw data with minimal processing. Due to this, some factors that may have contributed to a slightly lower improvement may include things such as stale times – a swimmer racing in an event which they haven't raced in over twelve months. The exaggerated amount of improvement in a situation like this would be mostly due to the swimmer's growth and general training, not the taper. This is shown in Figure 2.2 as well as on the next page in Figure 5 – participant J took approximately a minute off in a single event that was not tapered. This is solely due to the fact that he or she had not swam the event in a very long time. Nevertheless, as the graph illustrates, this drastically threw off this swimmer's average. Another factor that may influence the data is if a swimmer doesn't improve at all, with or without tapering. Swimmers C and N were removed from the data pool as they showed no significant improvement. One last factor

which was noticed to skew the data above is swimmers who are not as competitive as they used to be. After calculating the results shown above, I spoke with a select couple of swimmers whose results varied from the trend set by the majority of swimmers. Each of the people I spoke to admitted that they are not as serious about competition as they previously were or as other swimmers currently are. Swimmers B and P were dropped from the data pool for this reason. This contributed to the extremely small range between non-tapered and tapered for several of the athletes represented in Figures 2.1, 2.2 and 5.

Figure 5: Graphical Representation of Data from Figure 2.1



IMPROVEMENT

To account for this, after determining both non-representative swimmers and individual races, I removed these numbers from the data pool[7] and recalculated the percent improvement using this filtered data. These new results are included below.

Figure 6.1, shown on the next page, is similar to Figure 2.1 except it uses the filtered data rather than raw data. Swimmers and individual races that were deemed non-representative were removed from the data pool.

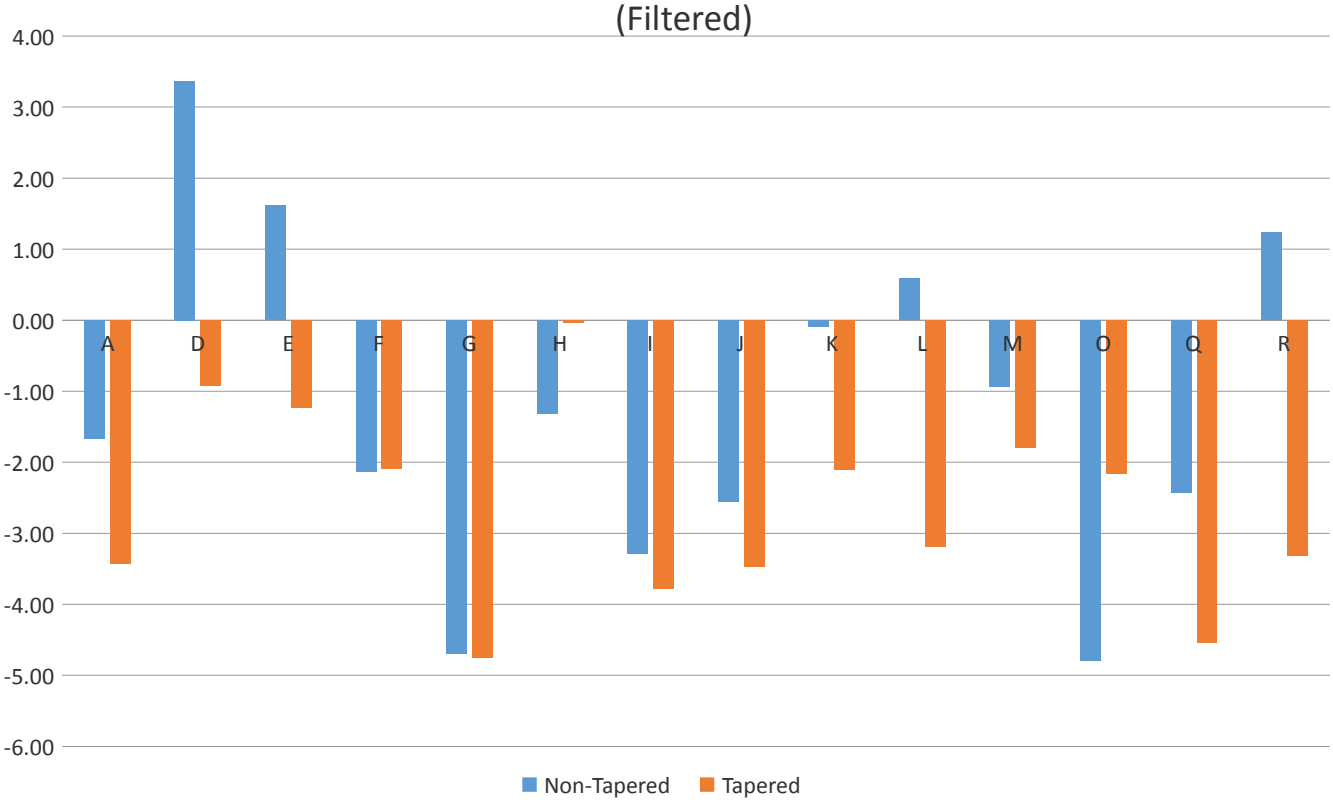
7 See Appendix C for data tables containing filtered data

Figure 6.1: Average Percent Improvement – Non-Tapered vs. Tapered per Swimmer (Filtered)

Swimmer	Non-Tapered (NT)	Tapered (T)	Difference (T - NT)
A	-1.67	-3.43	-1.76
D	3.37	-0.92	-4.29
E	1.62	-1.24	-2.85
F	-2.13	-2.10	0.03
G	-4.70	-4.75	-0.05
H	-1.32	-0.04	1.27
I	-3.29	-3.78	-0.49
J	-2.55	-3.47	-0.92
K	-0.09	-2.10	-2.01
L	0.59	-3.19	-3.78
M	-0.94	-1.79	-0.85
O	-4.80	-2.16	2.64
Q	-2.43	-4.54	-2.11
R	1.23	-3.32	-4.55
Overall Average	**-1.22**	**-2.63**	**-1.41**

On the next page, Figure 6.2 demonstrates this data in a bar graph format.

Figure 6.2: Average Percent Improvement – Non-Tapered vs. Tapered per Swimmer (Filtered)



With the data filtered, the average improvement is 2.63%, a 0.60% increase over the raw data. While this number is still slightly less than 3%, it's much closer than 2.03%. Notice how, using the example from above, swimmer J's difference changed from 4.48% in Figure 2.1 to -0.92% in Figure 6. These results begin to show how outliers can affect an entire data set, thus giving seemingly inaccurate results. To see this effect even more clearly, please refer to Figures 7 and 8, located below, for the filtered-data-revision of Figures 3 and 4.

Figure 7: Time Improvement – Non-Tapered vs. Tapered per Race (Filtered)

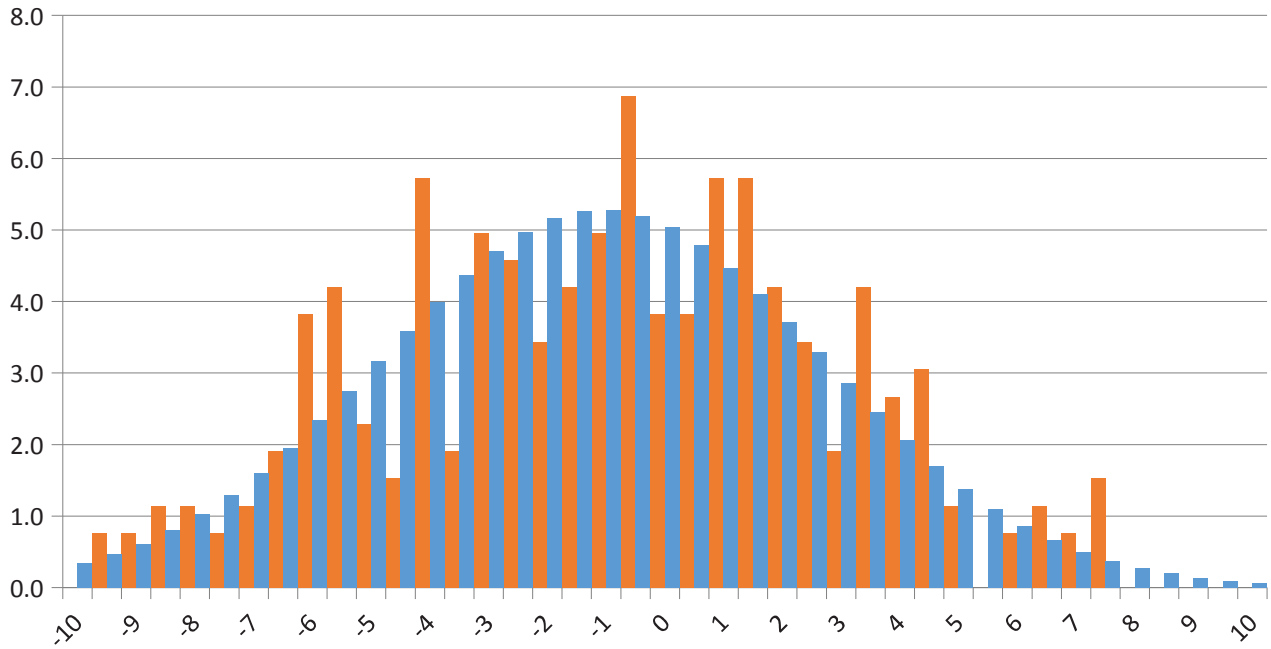
	Number of Races	Time Improvement (count / percentage)	
Non-Tapered	263	158	60.08
Tapered	254	203	82.86

Figure 8: Time Improvement – Non-Tapered vs. Tapered per Swimmer (Filtered)

	Number of Swimmers	Time Improvement (count / percentage)	
Non-Tapered	14	10	71.43
Tapered	14	14	100.00

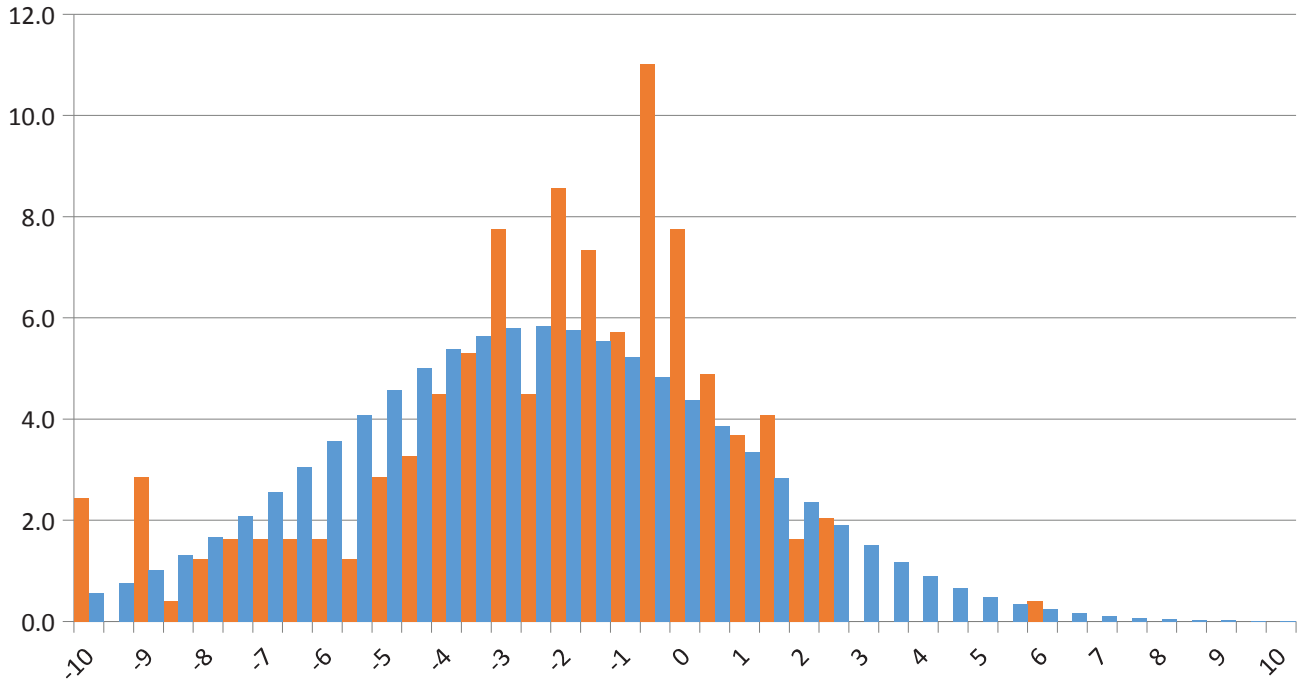
Once again, in the preceding tables, it becomes clear that tapering has a significant affect on the probability of swimming a personal best time at meets.

Figure 9: Non-Tapered Results vs. Normal Distribution (Filtered)



The above graph (Figure 9) shows the filtered data for non-tapered results in comparison to a normal distribution which has the same mean and standard deviation as the sample set. This is done so it can be seen that our non-tapered filtered data is very closely correlated to a normal distribution.

Figure 10: Tapered Results vs. Normal Distribution (Filtered)



Above, Figure 10 shows the filtered data for tapered results against a normal distribution with the mean and standard deviation of the tapered sample set.

This graph clearly does not follow the normal distribution as closely as the non-tapered data. Instead the results are negatively skewed and the data is clustered nearer the mean. In the context of my study, this means that the probability of swimming slower after tapering is minimal and that probability of going faster is increased. As well, most swimmers fell fairly close to the mean percent improvement which is -2.63. In other words, the standard deviation is smaller.

Even though the average decrease in time for the tapered column in Figure 6.1 shows that there was a 2.63% increase with tapering, I'd like to expand on that with the below table, Figure 11. This table classifies my data according to the length of the race.

Figure 11: Race Distance vs. Time Improvement – Non-Tapered vs. Tapered

Distance (m)	Non-Tapered Percent	Tapered Percent
50	-0.86	-1.84
100	-1.18	-2.64
200	-1.29	-3.04
400	-0.99	-4.32
800	-2.85	-3.42
1500	-0.14	-2.29

Reflection

The table above shows that without tapering the range of improvements is much smaller than the range with tapering, with the tapered 400 m races generally having the most improvement at a 4.32% decrease in time. This is because most swim clubs don't have the luxury of separate pool space for sprinters, middle distance and distance swimmers. Ideally, distance swimmers will taper for only a week or less, while sprinters (50 m-200 m) taper for up to 3 weeks.[8] The fact that most swim clubs do a sort of a general "one size fits all" taper with all swimmers completing the same practices, the results above that show that middle distances have the most improvement is very fitting and proves that tapering is quite effective, if done correctly.

The chances of human error are high in this study as each of the approximately 700 times used had to be converted from minutes to seconds by hand and then manually entered into a spreadsheet on the computer. This data entry in itself was no easy task either, and took approximately eight hours. Another possible cause of error in the study is mechanical error. At swim meets, there are electronic touch-pads in the water that stop the clock when the swimmer touches

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the wall. If these touch-pads malfunction, there are officials with stopwatches as a backup. If some of the data used in the study was recorded by a person with a stopwatch, it will very likely be less accurate than data gathered by a computerized touch-pad. One more possible cause of error could be the growth of the swimmers used in the study. While some data was removed to help combat this, each and every swimmer that participated in this study can be considered youth and thusly are still growing and becoming stronger and faster simply due to growth; not the training.

With these results, I can help my swim team to train smarter for upcoming meets by knowing that tapering is indeed an effective training method.

Citations

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Houmard, J., & Johns, R. (1994, April 1). Effects of Taper on Swim Performance: Practical Implications. Sports Medicine, Pp. 224-232.

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