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Seasonal Variations in Swimming Force and Training Adaptation

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Abstract

Gauging the optimal workload is a challenge for swim coaches. This study was designed to address whether seasonal hand force variations provide information for adjusting the workload to maximize the training effect. Nine national caliber swimmers from a team known for training with a substantial workload participated in the study. The swimmers were tested seven times over an eight month season. The average hand force over a 10 m swim at maximum swimming velocity was calculated for each trial. Each swimmer had a depressed hand force value in the middle of the season as compared to the baseline at the beginning of the season. Each swimmer's force value was elevated at the end of the season as compared to the middle of the season. However, only five of the nine swimmers (55%) had a higher force value at the end of the season as compared to the baseline. The results suggest that a workload that is too severe (because of training distance and/or intensity) may not allow swimmers to recover enough to improve performance. Periodic hand force testing can provide feedback about training adaptation, both to optimize performance and minimize the risk of illness and injury.

Introduction

A basic objective in training swimmers is to elicit a response that improves performance. To accomplish that goal, programs generally increase the workload (training distance and intensity) throughout most of the season and then decrease the load at the end of the season. However, even the most conventional training plan can have a variety of outcomes. Periodic information about how swimmers respond to training (so that adjustments can be made) is essential to ensure an optimal result.

Aerobic capacity is a key factor for performance and "will improve gradually in response to the appropriate training stress" (6). However, judging the most suitable workload is complicated. Many successful programs emphasize excessive training distance. In contrast, Costill (2) has shown that certain increases in training distance may have no value or may even be counterproductive. Calder (1) explained that the balance between "the overload threshold required for optimal improvement without the corresponding problems associated with overtraining is difficult for coaches to gauge."

Training performance times are the most readily available data for coaches to gauge workload adaptation. However, these measures are sometimes ignored and often for legitimate reasons. While a poor workout performance may indicate failing adaptation, it might also be attributed to other factors. (Lack of effort, motivation, or sleep sometimes explains slow training times.) Other tests that are more valid are difficult to administer, time consuming, or not specific to performance.

Because of the relationship of hand force and swimming velocity (3, 5), a test of hand force can indicate the status of a swimmer's readiness to perform. The test can be administered quickly and is completely specific to performance. As the standard test protocol requires only a maximum effort for 10 m of swimming, factors like motivation are less likely to impact test results. This study was designed to address the question: Can hand force variations over a season provide information for adjusting workload to maximize the training effect?

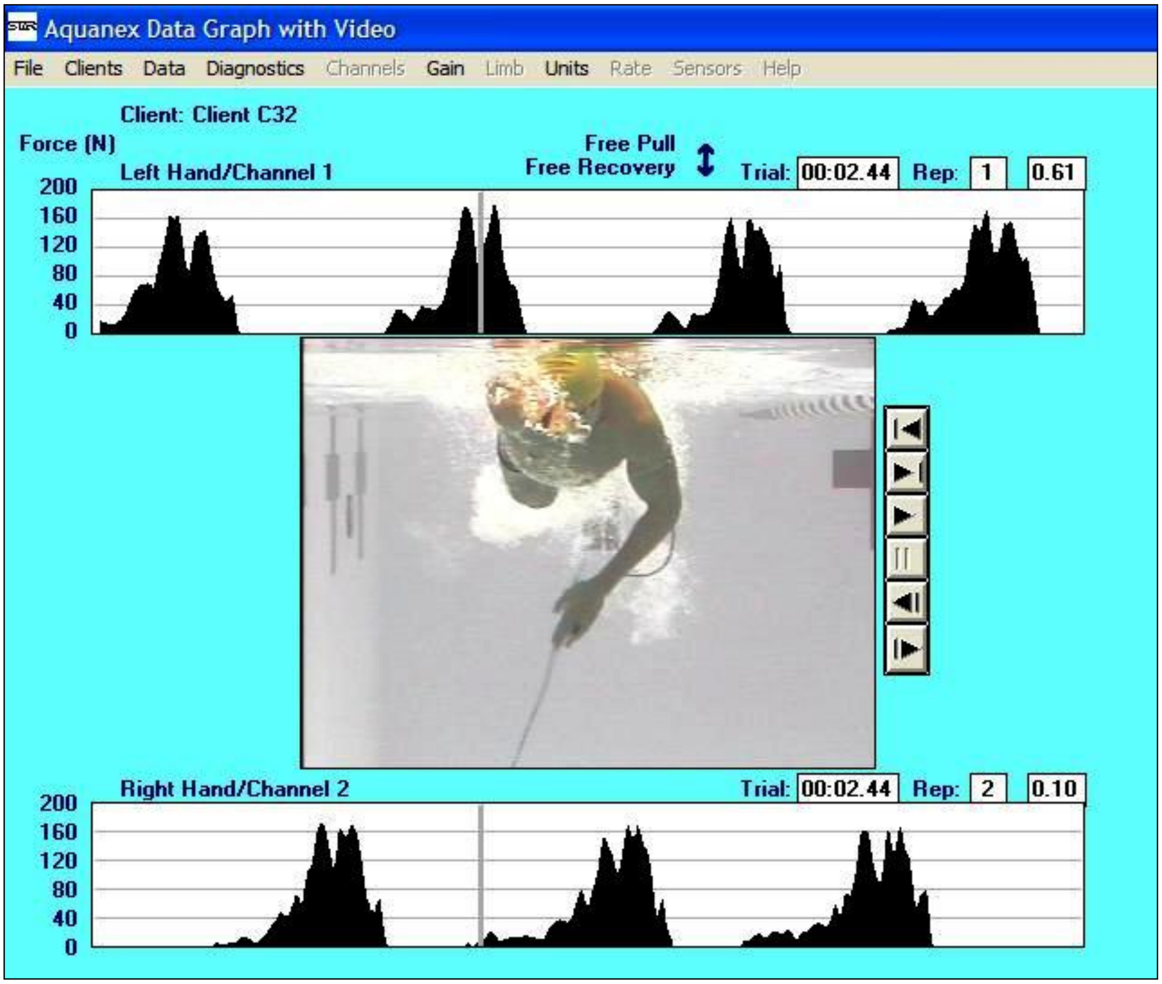
Methods

Nine national caliber swimmers from a team known for training with a substantial workload participated in the study. The descriptive statistics are shown in Table 1. Informed consent was obtained.

Gender	n	Age		Height (cm)		Mass (kg)		Career Best 100 m Freestyle (sec)	
		M	SD	M	SD	M	SD	M	SD
Male	4	17.0	.8	181	9	71.9	8.8	52.8	1.8
Female	5	16.4	.5	173	6	59.4	4.1	58.5	.8

Table 1. Descriptive statistics for the study participants.

The swimmers were tested with the standard Aquanex protocol (e.g. 3, 4) while swimming freestyle (Figure 1) during seven trials over an eight-month season. Tests were conducted in December, January, February, March, May, June, and July. Average hand force over a 10 m swim at maximum swimming velocity was calculated for each trial.



Client: Client C32

Trial: 00:02.44 Rep: 1 0.61

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Figure 1. Hand force curves for a freestyle trial using the Aquanex protocol. The vertical gray lines on the graphs are synchronized with the video image.

Results

The seasonal variation in average hand force for two males and two females is shown in Figure 2. The graphs show the general trend that was similar for all the participants. After the initial measurement in December, the force values decreased with the increase in training load. The force values were noticeably depressed during the heavy training at the middle of the season, but increased with the taper at the end of the season.

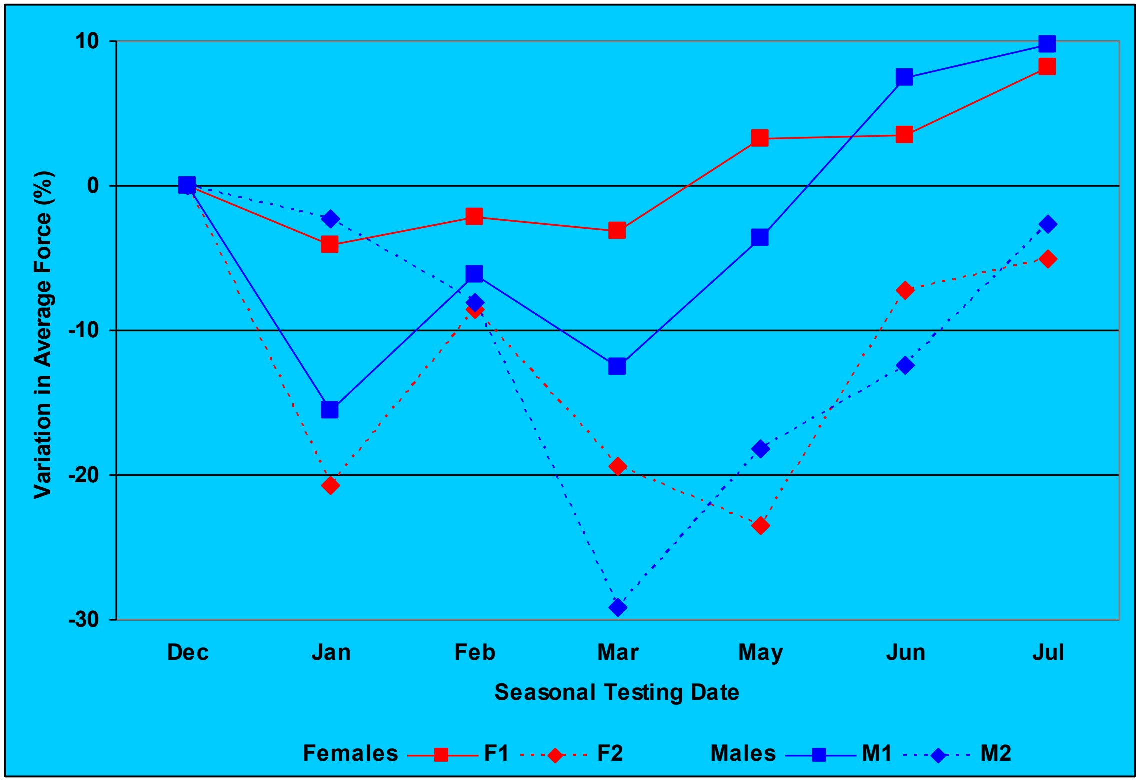

Figure 2. Variation in average hand force values by seasonal testing date for four swimmers. The solid lines connect data points for swimmers that had taper values greater than baseline. The dotted lines connect data points for swimmers with taper values lower than baseline.

The highest average hand force from the December and January tests was used as the baseline value (early season). The lowest average force from the February, March, May, or June tests was used as the value for the heaviest workload (middle season). The average force from the July test was used as the taper value (late season). The three seasonal values for all nine swimmers are graphed in Figure 3. The mean average hand force values were 47.3 N (SD = 12.1) for early season, 39.7 N (SD = 10.8) for middle season, and 47.5 N (SD = 12.7) for late season.

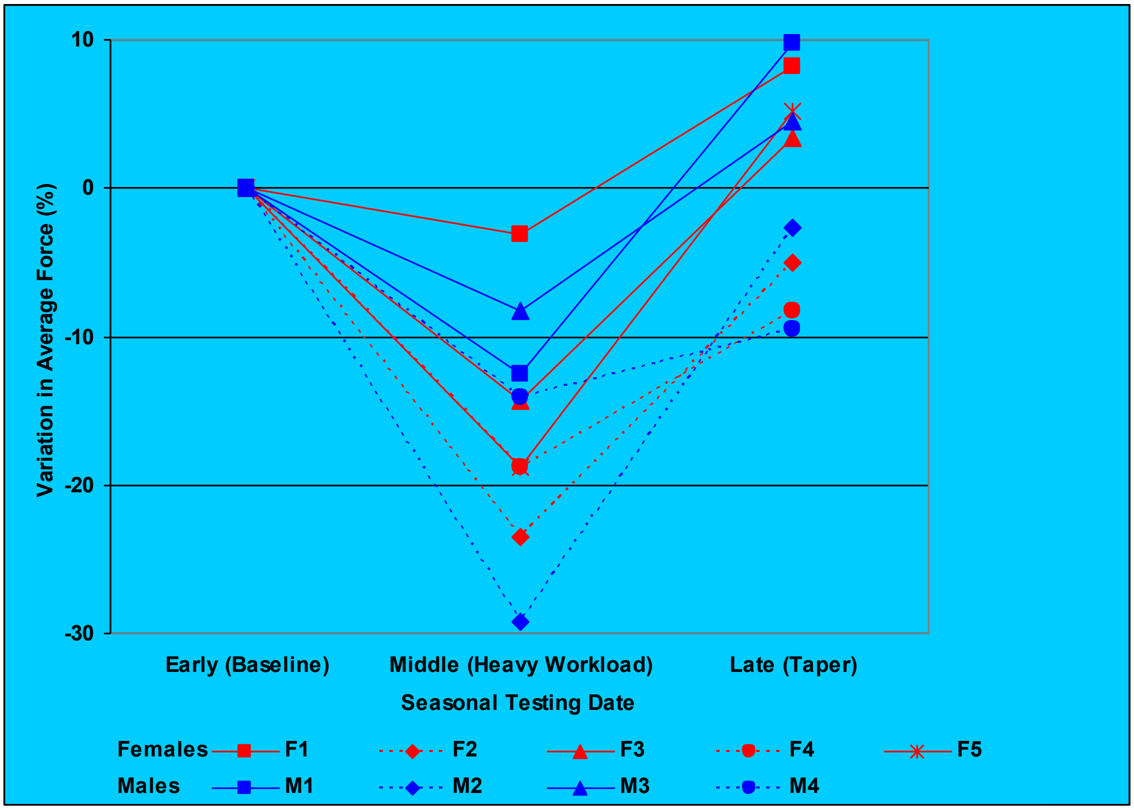

Figure 3. Variation in average hand force values by seasonal testing date for all nine swimmers. The solid lines connect data points for swimmers that had taper values greater than baseline. The dotted lines connect data points for swimmers with taper values lower than baseline.

Each swimmer had a depressed hand force value in the middle of the season as compared to the baseline at the beginning of the season. Each swimmer's force value was elevated at the end of the season as compared to the middle of the season. However, only five of the nine swimmers (55%) had a higher force value for the taper as compared to the baseline.

The five swimmers with taper values greater than baseline were depressed by an average of 11% during the middle of the season. They responded to taper with a 17% increase for an overall (seasonal) improvement of 6%. The four swimmers with taper values below baseline were depressed by an average of 21%. They responded to taper with a 15% increase for an overall decrease of 6%.

The three swimmers (F1, M1, and M3) with middle season values that were depressed the least (less than 13%) had taper values above baseline. The two swimmers (F2 and M2) with middle season values that were depressed the most (more than 23%) had taper values below baseline. Four swimmers (F3, F4, F5, and M4) had middle season values that were depressed between 14 and 19%. Two of these swimmers had taper values above baseline and two had taper values below baseline.

Discussion

The depressed hand force values in the middle of the season are consistent with the heavy workload. It was expected that swimmers would be able to generate less force during the heaviest training phase. The increase in force from middle season to taper is consistent with the reduced workload and was also expected. However, the comparison of the taper values with the baseline shows that only about one-half of the swimmers (5 of 9) had taper values greater than baseline. Only taper values above baseline are consistent with the goals of an effective training program.

Variability between Swimmers in Training Effect

There is considerable variability in the magnitude of the change in force during heavy training (between 3% and 29% below baseline) with an average decrease of 16%. The variability is explained by individual adaptations to training (including consistency and effort), as well as injury and illness. There is also considerable variability in the changes from heavy training to taper (4% to 26%) with an average increase of 16%. While the variability cannot be ignored, the average values present a mediocre outcome: a 16% force decrease during heavy training followed by a 16% increase during taper. It appears that a workload that depresses hand force values by 16% is too large to elicit an improvement in performance.

An examination of individual variation supports the findings from the mean data. As shown in Figure 2, the two swimmers with the most depressed heavy training force values (over 20%) had taper improvements of at least 20%. (Both swimmers were below baseline after taper.) As also shown in Figure 2, there were two swimmers with heavy training force values depressed by less than 15% with taper improvements of at least 20%. (Both swimmers were above baseline after taper.) The individual results suggest that a training workload that decreases the ability to generate force by more than 15% may not be necessary to elicit a maximum training effect.

Swimmer Stratification based on Training Response

The data suggest that stratification of swimmers by the change in average hand force from early to middle season is appropriate to evaluate workload. If the mid-season values are depressed by less than 10%, there may be a good chance of a taper force that is greater than baseline. If the mid-season values are depressed more than 20%, there may be little chance of a taper force that is greater than baseline. If the mid-season values are depressed between 10 and 20%, there appears to be an even chance of a taper force greater than baseline.

The swimmers were grouped according to the amount that their force values were depressed: less than 15% (least depressed, 3 swimmers), 15 to 20% (average depressed, 4 swimmers), and 20% or more (most depressed, 2 swimmers). The average seasonal changes were calculated from early to middle, middle to late, and early to late and graphed in Figure 4.

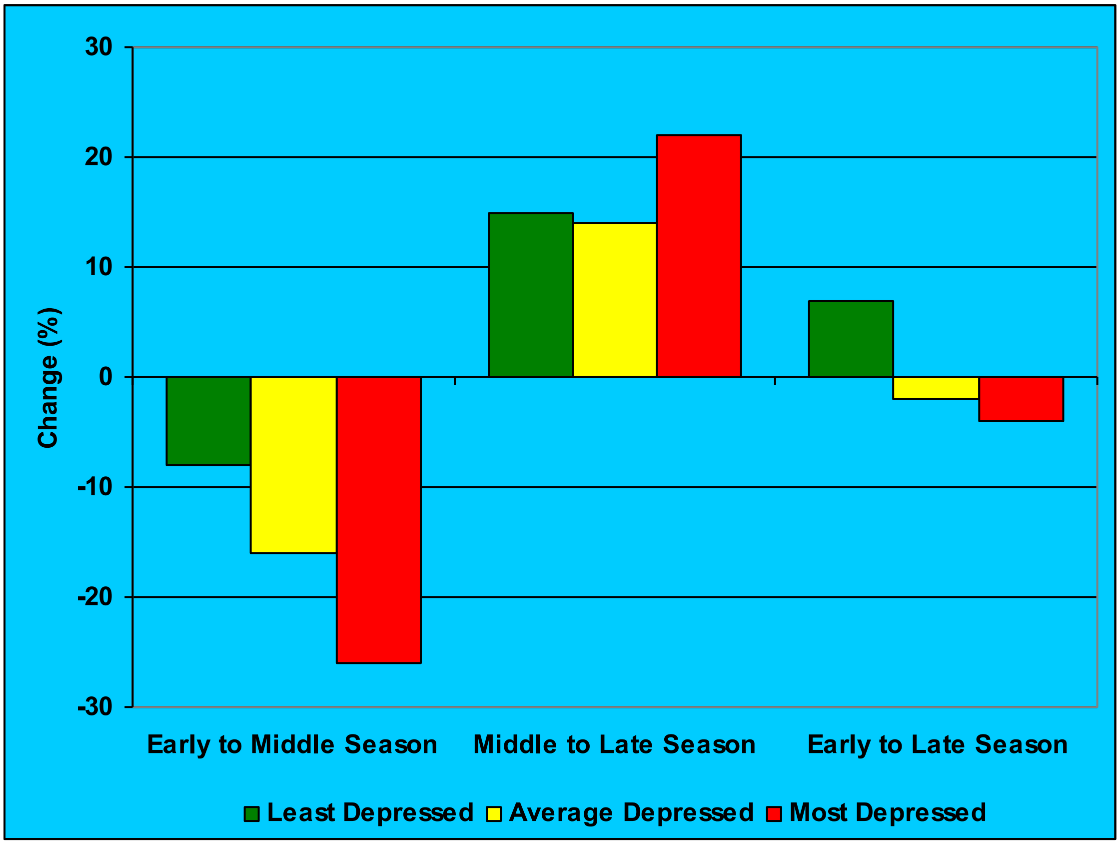

Figure 4. Changes in hand force values by group and seasonal testing date.

For the average and most depressed groups, the taper effect was slightly less than the training effect. For the least depressed group, the taper effect was almost double the training effect. The results suggest that a workload that is too severe (because of training distance and/or intensity) may not allow swimmers to recover enough to improve performance. A more moderate training effect may have benefits other than performance. In addition to less chance of illness and injury, swimmers with less depressed force values during the middle of the season can be more competitive in swim meets other than the championship at the end of the season. Swimmers with more of an ability to generate force during the season will probably be healthier and faster for competitions throughout the entire season.

Conclusion

Periodic hand force testing can provide feedback about training adaptation. If the force value is depressed from baseline by less than 10% during the heaviest seasonal workload, continuation of the training plan seems appropriate. If the force value is depressed by more than 10%, an increase in testing frequency is warranted. If the force value continues to drop, an adjustment in workload may be appropriate.

If the force value is depressed by more than 20%, an immediate reduction in workload, a complete (although temporary) cessation in training, or even a medical evaluation may be necessary. A regular hand force testing program can help to optimize training adaptation and performance, while minimizing risk of injury and illness.

References

1. Calder, A. Recovery: Restoration and regeneration as essential components within training programs. Retrieved from: http://www.swimmingcoach.org/articles/9712/article5.htm, 1995.

2. Costill D. L., Thomas, R., Robergs, R. A., Pascoe, D., Lambert, C., Barr, S., & Fink, W.J. Adaptations to swimming training: influence of training volume. *Med Sci Sports Exerc*, 1989, *23*(3), 371-377.

3. Havriluk, R. Performance Level Differences in Swimming: Relative Contributions of Strength and Technique. In P-L. Kjendlie, R. K. Stallman, & J. Cabri (Eds.) *Biomechanics and Medicine in Swimming XI*. 2010. Norwegian School of Sport Science, Oslo.

4. Havriluk, R. Magnitude of the effect of an instructional intervention on swimming technique and performance. In J. P. Vilas-Boas, F. Alves, A. Marques (Eds.), Biomechanics and Medicine in Swimming X. *Portuguese Journal of Sport Sciences*, 2006, *6*(Suppl. 2), 218-220.

5. Havriluk, R. *Hand force and swimming velocity*. Paper presented at the XVth FINA World Sports Medicine Congress, Indianapolis, IN, October, 2004.

6. Richards, R. Reduction of Swimming Training Loads - 'Taper'. Retrieved from: http://www.wasa.asn.au/articles/article.asp?GroupID=2&ArticleID=78, 1999.