SWIMMING SCIENCE BULLETIN

Number 43

Produced, edited, and copyrighted by

Professor Emeritus Brent S. Rushall, San Diego State University

ULTRA-SHORT RACE-PACE TRAINING AND TRADITIONAL TRAINING COMPARED[1]

Brent S. Rushall, Ph.D.

October 21, 2014

This paper documents features that should be of interest to swimming coaches. The formats of ultra-short race-pace training and traditional training are compared for effects and/or which method is better on a variety of features. It is difficult to define both formats exactly. Rather, some of the major features of the two are listed below to present pictures of each. Ultra-short race-pace training is more restrictively defined than the widely varied and inclusive traditional training. In this analysis, research that focuses on high-intensity training will be considered to be relevant for ultra-short race-pace training because race-pace training is of higher intensity than traditional training.

Ultra-short Race-pace Training (USRPT)

USRPT was defined by Professor Brent Rushall in 2011 (Rushall, 2011). It involves high-intensity swimming in sets that match the best achieved velocities of individuals' races. When certain criteria are reached in training sets, training velocities are increased. To facilitate the greatest volume of race-pace training, the ultra-short training format is used. That format generally consists of a high number of repetitions over short distances with brief rests (generally no longer than 20 seconds). The aim of the USRPT format is to cover the greatest accumulated distance at race-pace for every event of interest. The system is self-correcting, preventing swimmers from becoming systemically exhausted. Many activities involved in traditional training are not used in USRPT because they violate the Principle of Specificity as it applies to movement training. Practice session content involves activities that are directly relevant for racing as opposed to many irrelevant activities that are included in traditional training.

The full effects of USRPT are not achieved unless technique is developed concurrently. The principle reason behind that association is that both energy supply and technique are specific to particular swimming velocities. Thus, the only way to improve race-specific techniques and the energy that powers them is to train at race-paces.

Traditional Training

Traditional training is all training programs that are not USRPT. Features that may be programmed into traditional training are repetitions over distances of 200 or more yards/meters; specific training sets that aim to develop a physiological capacity (e.g., lactate tolerance sets, hypoxic training); an emphasis on completing every item scheduled for practice sessions; the inclusion of land training, swimming equipment, drill exercises, and any other activity that is not a direct replication of a race-specific activity; a variety of practice set intensities; an inclusion of

---

[1] An invited presentation at the 4th Annual Hall of Fame Coaches Clinic, August 28-30, 2013 in Clearwater, Florida.

variety in programs; low numbers of repetitions before an activity change occurs; sustained periods of exhaustion that require long (e.g., two weeks) taper experiences before important meets; difficulty in achieving personal best performances when not tapered; the correction of techniques at slow swimming velocities and/or through drills or equipment use; and a general acceptance of training procedures that are advocated by "status" coaches. At this time, traditional swimming training is the most common form of training in many countries.

Scientific Findings

Table 1 lists features that should be of interest to competent swimming coaches. The comparison between USRPT and traditional training for producing those features is indicated. The references for determining the comparisons are included as numbers, each reference number referring to the full report attribution in the Reference list at the end of the article. The large majority of the references can be accessed in abstract form by using the search option on the *Coaching Science Abstracts* (http://coachsci.sdsu.edu/index.htm) or to a lesser extent, the *Swimming Science Journal* (http://coachsci.sdsu.edu/swim/index.htm).

TABLE 1. COMPARISON OF USRPT AND TRADITIONAL TRAINING ON A NUMBER OF TRAINING AND SWIMMER FEATURES.

Feature	USRPT	Traditional Training	References[2]
Trains race physiology/fitness	Yes	No	25; 43; 57
Trains physiological capacities better	Yes	No	1; 5; 14; 22; 23; 24; 45; 47; 59; 61; 64
Primarily uses alactacid and aerobic energy	Yes	No	15
Varying work-to-rest ratios produce different metabolic responses. [Mixed sets are bad.]	No	Yes	19
Produces largest volume of beneficial work	Yes	No	2; 60
Produces greatest energy expenditure	Yes	No	52
Produces better carbohydrate and fat utilization	Yes	No	54
Best developer of aerobic adaptation	Yes	No	10; 37; 58; 63
Needed to improve maximal accumulated oxygen deficit	Yes	No	62
Best for developing lactate tolerance	Yes	No	9

[2] The Rushall 2011 reference is included because it reports the reasoning for the decision. Reasoning usually involves several premises whereas most studies conclude concerning only a single factor. As well, some references are not specifically for swimming but do reflect phenomena that are independent of the sport practiced (i.e., they are universal findings).

TABLE 1 Continued

Feature	USRPT	Traditional Training	References
Best for developing power	Yes	No	29
Conditions swimmers better to race	Yes	No	43; 53
Performances change but underlying physiological capacities may not	Yes	No	25
Produces better performances	Yes	No	4; 6; 33; 36; 41
Taper is not needed to swim best times	Yes	No	44
Trains factors in the shortest time	Yes	No	13; 18; 42; 49; 50; 55
When the other training is added performance improves	USRPT+TT No	TT+USRPT Yes	30
Variety or mixed training is emphasized	No	Yes	27
Not excessively stressful	Yes	No	38
Energy stores are depleted	No	Yes	3
Lactate accumulation interferes with learning and performance	No	Yes	3; 46
Recovery between training sessions usually occurs	Yes	No	7; 44
Heavy training and dryland training are not related to improvements in performance	No	Yes	16; 48
Lactate threshold training relatively useless for conditioned athletes	N/A	Yes	31
Teaches race-pacing	Yes	No	44
Predict when race times should improve	Yes	No	44
When athletes are not improving, use this	Yes	No	17; 21
Might lower some physiological capacity measures	Yes	No	39
Training is not always of a physiological nature	Yes	No	35
Trains race techniques	Yes	No	11; 12; 28; 44; 51

TABLE 1 Continued

Feature	USRPT	Traditional Training	References
Trains stroke technique retention best	Yes	No	40
Trains race skills (e.g., turns, underwater kicking)	Yes	No	44
Best for children	Yes	No	32
Tolerated better by children than adults	Yes	No	34
Gender differences are likely	Yes	Yes	20; 56

Closing Thoughts

When the above listed features are considered, USRPT dominates over traditional training. The scientific justification for each decision adds weight to the reliability and validity of the inferences that can be made. It is hard to imagine anyone rejecting the obvious conclusions drawn from the comparison of USRPT with traditional training. Most of that domination can be attributed to the Principle of Specificity of Training which is roundly rejected by traditional trainers.

A change in the way competitive swimmers are trained is in order!

References[3]

1. Astorino, T. A., Allen, R. P., Jurancich, M., Roberson, D. W., & Trost, E. (2010). *Effect of high-intensity interval training (HIIT) on cardiovascular function and muscular force.* Presentation 1027 at the 2010 Annual Meeting of the American College of Sports Medicine, Baltimore, Maryland; June 2-5. #
2. Astrand, I., Astrand, P-O., Christensen, E. H., & Hedman, R. (1960). Intermittent muscular work. *Acta Physiologica Scandinavica, 48,* 448-453. #
3. Astrand, P. O., & Rodahl, K. (1977). *Textbook for work physiology.* New York, NY: McGraw-Hill. #
4. Beckett, K. (1986). Swimming fast. *Swimming Technique,* August-October, 27-29.
5. Beidaris, N., Botonis, P., & Platanou, T. (2010). *Physiological and performance characteristics of 200 m continuous [4]swimming and 4 x 50 m "broken" swimming with different interval time demands.* A paper presented at the XIth International Symposium for Biomechanics and Medicine in Swimming, Oslo, June 16–19, 2010.
6. Belfry, G. R., Paterson, D. J., Overend, T., & Thomas, S. G. (2010). *Effects of high intensity intermittent and continuous endurance training on aerobic power and 60s performance.* Presentation 1029 at the 2010 Annual Meeting of the American College of Sports Medicine, Baltimore, Maryland; June 2-5. #
7. Bessa, A., de Oliveira, V. N., da Silva, R. J., Damasceno-Leite, A., & Expindola, F. S. (2010). *Biochemical tools for determining exercise intensity.* Presentation 876 at the 2010 Annual Meeting of the American College of Sports Medicine, Baltimore, Maryland; June 2-5. #
8. Bogdanis, G. C., Saraslanidis, P., Petridou, A., Galanis, N., Tsalis, G., Kellis, S., Kapetanos, A. G., & Mougios, V. (2009). *Muscle metabolism and performance improvement after two training programs of sprint running.* A paper presented at the 14th Annual Congress of the European College of Sport Science, Oslo, Norway, June 24-27. #
9. Christensen, E. H. (1962). Speed of work. *Ergonomics, 5,* 7-13. #

[3] References concluded with a # indicate that they are not swimming-specific articles.

10. Christensen, E. H., Hedman, R., & Saltin, B. (1960). Intermittent and continuous running. *Acta Physiologica Scandinavica, 50,* 269-286. #

11. Craig, A. B., Jr., & Pendergast, D. R. (1979). Relationships of stroke rate, distance per stroke, and velocity in competitive swimming. *Medicine and Science in Sports and Exercise, 11,* 278-283.

12. D'Acquisto, L. J., & Berry, J. (2002). Energetic and technique characteristics of trained collegiate male swimmers. *Sixth IOC World Congress on Sport Sciences*, abstract, p. 23.

13. Dunham, C., & Harms, C. A. (June 03, 2010). *The effects of high intensity interval training on pulmonary function.* Presentation 2095 at the 2010 Annual Meeting of the American College of Sports Medicine, Baltimore, Maryland; June 2-5. #

14. Enoksen, E., Tonnessen, E., & Shalfawi, S. (2009). *The effect of high vs. low intensity training on aerobic capacity in well-trained middle-distance runners.* A paper presented at the 14th Annual Congress of the European College of Sport Science, Oslo, Norway, June 24-27. #

15. Fernandes, R. J., Sousa, A., Figueiredo, P., Keskinen, K. L., Rogriguez, F. A., Machado, L., & Vilas-Boas, J. P. (2011). Modeling off-transient oxygen uptake kinetics after maximal 200-m swims. *Medicine and Science in Sports and Exercise, 43(5)*. Supplement abstract 1663.

16. Filho, P., Müller, D., Reis, J., Alves, F., & Denadai, B. S. (2010). *Oxygen uptake kinetics around the respiratory compensation point in swimming*. A paper presented at the XIth International Symposium for Biomechanics and Medicine in Swimming, Oslo, June 16–19, 2010.

17. Gaskill, W. E., Serfass, R. C., Bacharach, D. W., & Kelly, J. M. (1999). Responses to training in cross-country skiers. *Medicine and Science in Sports and Exercise, 31*, 1211-1217. #

18. Gibala, M. J., Little, J. P., van Essen, M., Wilkin, G. P., Burgomaster, K. A., Safdar, A., Raha, S., & Tarnopolsky, M. A. (2006). Short-term sprint interval versus traditional endurance training: similar initial adaptations in human skeletal muscle and exercise performance. *Journal of Physiology, 575(Part 3),* 901-911. #

19. Gosselin, L. E., Kozlowksi, K. F., Bevinney-Boymel, L., & Hambridge, K. (2010). *Metabolic and cardiovascular response of different high intensity aerobic interval exercise protocols.* Presentation 1028 at the 2010 Annual Meeting of the American College of Sports Medicine, Baltimore, Maryland; June 2-5. #

20. Graef, J. L., Kendall, K. L., Smith, A. E., Walter, A. A., Beck, T. W., Cramer, J. T., & Stout, J. R. (2008). The effects of acute high-intensity interval endurance training in men and women. *ACSM 55th Annual Meeting Indianapolis*, Presentation Number, 1296. #

21. Helgerud, J. (2009). *Aerobic high-intensity intervals improve maximal oxygen uptake more than moderate training.* A paper presented at the 14th Annual Congress of the European College of Sport Science, Oslo, Norway, June 24-27. #

22. Helgerud, J., Høydal, K. L., Wang, E., Karlsen, T., Berg, P. R., Bjerkaas, M., Simonsen, T., Helgesen, C. S., Hjorth, N. L., Bach, R., & Hoff, J. (2006). Differential response to aerobic endurance training at different intensities. *Medicine and Science in Sports and Exercise, 38(5),* Supplement abstract 2581. #

23. Helgerud, J., Høydal, K., Wang, E., et al. (2007). Aerobic high-intensity intervals improve VO_{2max} more than moderate training. *Medicine and Science in Sports and Exercise, 39,* 665-671. #

24. Hsu, H., Ivy, J. L., & Kuo, C.-H. (2008). Effect of high and moderate intensity training on endurance, glucose metabolism and parasympathetic activity. *ACSM 55th Annual Meeting Indianapolis*, Presentation Number, 1299. #

25. Hughes, S. C., Burgomaster, K. A., Heigenhauser, G. J., & Gibala, M. J. (2003). Six bouts of sprint interval training (SIT) improves intense aerobic cycling performance and peak anaerobic power. *Medicine and Science in Sports and Exercise, 35(5),* Supplement abstract 1875. #

26. Johansen, L., Jørgensen, S., Kilen, A., Larsson, T. H., Jørgensen, M., Rocha, B., Nordsborg, N. B. (2010). *Increased training intensity and reduced volume for 12 weeks increases maximal swimming speed on a sprint distance in young elite swimmers*. A paper presented at the XIth International Symposium for Biomechanics and Medicine in Swimming, Oslo, June 16–19, 2010.

27. Kame, V. D., Pendergast, D. R., & Termin, B. (1990). Physiologic responses to high intensity training in competitive university swimmers. *Journal of Swimming Research, 6(4),* 5-8.

28. Konstantaki, M., Winter, E; & Swaine, I. (2009). Effects of arms-only swimming training on performance, movement economy, and aerobic power. *International Journal of Sports Physiology and Performance, 3,* [on line].

29. Laursen, P. B., Blanchard, M. A., & Jenkins, D. G. (2002). Acute high-intensity interval training improves Tvent and peak power output in highly trained males. *Canadian Journal of Applied Physiology, 27,* 336-348. #

30. Lindsay, F. H., Hawley, J. A., Myburgh, K. H., Schomer, H. H., Noakes, T. D., & Dennis, S. C. (1996). Improved athletic performance in highly trained cyclists after interval training. *Medicine and Science in Sports and Exercise, 28,* 1427-1434. #

31. Londeree, B. R. (1997). Effect of training on lactate/ventilatory thresholds: A meta-analysis. *Medicine and Science in Sports and Exercise, 29,* 837-843. #

32. Mascarenhas, L. P., Neto, A. S., Brum, V. P., DaSilva, S. G., & De Campos, W. (2006). The effects of two aerobic training intensities on aerobic and anaerobic power of prepubescent boys. *Medicine and Science in Sports and Exercise, 38(5),* Supplement abstract 1486. #

33. Mujika, I., Busson, T., Geyssant, A., & Chatard, J. C. (1996). Training content and its effects on performance in 100 and 200 m swimmers. In J. P. Troup, A. P. Hollander, D. Strasse, S. W. Trappe, J. M. Cappaert, & T. A. Trappe (Eds.), *Biomechanics and Medicine in Swimming VII* (pp. 201-207). London: E & FN Spon.

34. Muller, J., Engel, F., & Ferrauti, A. (2009). *Children tolerate intensive intermittent exercise better than adults.* A paper presented at the 14th Annual Congress of the European College of Sport Science, Oslo, Norway, June 24-27. #

35. Myburgh, K. H., Lindsay, F. H., Hawley, J. A., Dennis, S. C., & Noakes, T. D. (1995). High-intensity training for 1 month improves performance but not muscle enzyme activities in high-trained cyclists. *Medicine and Science in Sports and Exercise, 27(5),* Supplement abstract 370. #

36. Oliveira, M. F., Caputo, F., Dekerle, J., Denadai, B. S., & Greco, C. C. (2010). *Technical and physiological changes during continuous vs. intermittent swims at and above maximal lactate steady state.* A paper presented at the XIth International Symposium for Biomechanics and Medicine in Swimming, Oslo, June 16–19, 2010.

37. Olson, E. C., Christensen, K. V., Jajtner, A., Copeland, J., Unthank, M., & Mitchell, J. B. (2012). *The effect of short and long recovery periods on the contribution of oxidative processes to energy expenditure during multiple bouts of supramaximal exercise.* Presentation 1336 at the 59th Annual Meeting of the American College of Sports Medicine, San Francisco, California; May 29-June 2, 2012. #

38. Ormsbee, M. J., Kinsey, A. W., Chong, M., Friedman, H. S., Dodgez, T., & Fehling, P. C. (2011). Short-term high-intensity interval training and the physiological stress response. *Medicine and Science in Sports and Exercise, 43(5)*. Supplement abstract 3138. #

39. Pedersen, M. T., Kilen, A., Larsson, T. H., Jørgensen, M., Rocha, B., & Nordsborg, N. B. (2010). *Increased training intensity and reduced volume for 12 weeks has detrimental effects on swimmers' maximal oxygen uptake.* A paper presented at the XIth International Symposium for Biomechanics and Medicine in Swimming, Oslo, June 16–19, 2010.

40. Pelarigo, J. G., Denadai, B. S., Fernandes, B. D., Santiago, D. R., César, T. E., Barbosa, L. F., & Greco, C. C. (2010). *Effect of time and exercise mode on metabolic, stroking parameters, and stroke phase responses in continuous and intermittent exercises.* A paper presented at the XIth International Symposium for Biomechanics and Medicine in Swimming, Oslo, June 16–19, 2010.

41. Rinehardt, K F., Axtell, R. S., Kleine, S., Upson, D., Woznica, D., Quill, T., Weitzner, J. M., Ordway, P., Kovi, D. L., & Carabetta, J. L. (2002). Response in performance, metabolic indices, and perception during a season of collegiate competitive swim training. *Medicine and Science in Sports and Exercise, 34(5),* Supplement abstract 1099.

42. Rozenek, R., Funato, K., Junjiro, K., Hoshikawa, M., & Matsuno, A. (2003). Physiological responses to interval training at velocities associated with VO_{2max}. *Medicine and Science in Sports and Exercise, 35(5),* Supplement abstract 493. #

43. Rushall, B. S. (1999). *Programming considerations for physical conditioning* (page 2.3). Spring Valley, CA: Sports Science Associates and Rushall, B. S. & Pyke, F. S. (1991). Training for sports and fitness. Melbourne, Australia. McMillan Educational. #

44. Rushall, B. S. (2011). Swimming energy training in the 21st century: The justification for radical changes. *Swimming Science Journal*, *Swimming Science Bulletin #39*. On line at http://coachsci.sdsu.edu/swim/bullets/energy39.pdf.
45. Sandbakk, O., Welde, B., & Holmberg, H. C. (2009). *Endurance training and sprint performance in elite junior cross-country skiers.* A paper presented at the 14th Annual Congress of the European College of Sport Science, Oslo, Norway, June 24-27. #
46. Simoes, H. G., Campbell, C. S., & Kokubun, E. (1998). High and low lactic acidosis training: Effects upon aerobic and anaerobic performance. *Medicine and Science in Sports and Exercise, 30(5),* Supplement abstract 932. #
47. Sokmen, B., Beam, W., Witchey, R., & Adams, G. (2002). Effect of interval versus continuous training on aerobic and anaerobic variables. *Medicine and Science in Sports and Exercise, 34(5),* Supplement abstract 509. #
48. Sokolovas, G. (2000). Demographic information. In *The Olympic Trials Project* (Chapter 1). Colorado Springs, CO: United States Swimming.
49. Sperlich, B., Haegele, M., Achtzehn, S., De Marees, M., & Mester, J. (2009). *High intensity exercise in children: Results from different disciplines.* A paper presented at the 14th Annual Congress of the European College of Sport Science, Oslo, Norway, June 24-27.
50. Sperlich, B., Haegele, M., Heilemann, I., Zinner, C., De Marees, M., Achtzen, S., & Mester, J. (2009). Weeks of high intensity vs. volume training in 9-12 year-old swimmers. *ACSM 56th Annual Meeting, Seattle, Washington.* Presentation number 959.
51. Toussaint, H. M., Knops, W., De Groot, G., & Hollander, A. P. (1990). The mechanical efficiency of front crawl swimming. *Medicine and Science in Sports and Exercise, 22,* 402-408.
52. Trapp, G., Boutcher, Y. N., & Boutcher, S. H. (2004). Oxygen uptake response to high intensity intermittent cycle exercise. *Medicine and Science in Sports and Exercise, 36(5),* Supplement abstract 1900. #
53. Treffene, B. (2010). Interpreting and implementing the long term athlete development model: English swimming coaches' views on the (swimming) LTAD in practice – A commentary. *International Journal of Sports Science and Coaching, 5(3),* 407-412.
54. Usaj, A., Lojen, S., Kandare, F., & von Duvillard, S. P. (2009). The influence of two types of endurance training on carbohydrate and fat oxidation rates. *ACSM 56th Annual Meeting, Seattle, Washington*, Presentation Number 981. #
55. Villani, A. J., Fernhall, B., & Miller, W. C. (1999). Effects of aerobic and anaerobic training to exhaustion on VO_{2max} and exercise performance. *Medicine and Science in Sports and Exercise, 31(5),* Supplement abstract 1093. #
56. Vogt, M., Breil, F., Weber, S., Weisskopf, R., Schlegel, C. H., & Hoppeler, H. (2009). *Effects of block periodization of high-intensity interval training sessions on VO_{2max} in subelite and elite athletes.* A paper presented at the 14th Annual Congress of the European College of Sport Science, Oslo, Norway, June 24-27. #
57. Wakayoshi, K., D'Acquisto, J. D., Cappaert, J. M., & Troup, J. P. (1996). Relationship between metabolic parameters and stroking technique characteristics in front crawl. In J. P. Troup, A. P. Hollander, D. Strasse, S. W. Trappe, J. M. Cappaert, & T. A. Trappe (Eds.), *Biomechanics and Medicine in Swimming VII* (pp. 152-158). London: E & FN Spon.
58. Weber, S., Gehlert, S., Weidmann, B., Gutsche, K., Frese, S., Graf, C., Platen, P., & Bloch, W. (2011). Exercise induced slow and fast myofiber transitions in response to low intensive endurance exercise. *Medicine and Science in Sports and Exercise, 43(5)*, Supplement abstract 1399. #
59. Wee, R. K., McGregor, S. J., & Light, W. (2007). Intermittent 30s intervals performed at 100 and 70 % VO_{2Peak} Power (pVO_{2peak}) allow trained cyclists to maintain VO_{2peak} longer than continuous intervals at 100% pVO2peak. *ACSM Annual Meeting New Orleans*, Presentation Number, 2417. #
60. White, A. T., VanHaitsma, T. A., Light, A. R., Light, K. C., Hughen, R. W., & Yenchik, S. (2012). *Effect of short vs. longer duration strenuous exercise on afferent fatigue signaling.* Presentation 1153 at the 59th Annual Meeting of the American College of Sports Medicine, San Francisco, California; May 29-June 2, 2012. #
61. Yamamoto, N., Isaka, T., Wada, T., Sakurama, K., Takenoya, F., Yanagi, H., & Hashimoto, M. (2004). The maintenance of anaerobic power in intermittent short-duration high intensity exercise. *Medicine and Science in Sports and Exercise, 36(5),* Supplement abstract 1427. #

62. Zacharogiannis, E., Tziortzis, S., & Paradisis, G. (2003). Effects of continuous, interval, and speed training on anaerobic capacity. *Medicine and Science in Sports and Exercise, 35(5),* Supplement abstract 2066. #

63. Zafeiridis, A., Sarivasiliou, H., Dipla, K., & Vrabas, I. (2009). *The effects of interval vs. heavy continuous exercise programs on oxygen consumption, heart rate, and lactate responses in adolescents.* A paper presented at the 14th Annual Congress of the European College of Sport Science, Oslo, Norway, June 24-27. #

64. Zuniga, J., Berg, K., Noble, J., Harder, J., Chaffin, M., & Hanumanthu, S. H. (2008). Physiological responses and role of VO_2 slow component to interval training with different intensities and durations of work. *ACSM 55th Annual Meeting Indianapolis,* Presentation Number, 1277. #