Tactical Metabolic Training: Part 1

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IN A VERY REAL SENSE, strength and conditioning specialists are scientists who work in a weight room. We take such pride in this fact that we often get caught up in an exercise science mentality even when dealing with a sport science problem.

This is frequently manifested in metabolic conditioning programs in which "in the trenches" pragmatism toward what happens on the playing field—and how to train for it—may be eclipsed by an ivory tower focus on what's happening under the skin. Case in point, a train-the-energy-systems orientation is still prevalent in many conditioning programs, often at the expense of training for the game itself.

To be effective, the strength and conditioning coach must cultivate a movement oriented philosophy wherein training drills are progressively coupled with performance tasks to be executed in simulated competitions. While this may be addressed to some extent during speed and agility development, metabolic training presents a unique challenge in that it is frequently partitioned off from other parts of the training program. Yet at some point during training, game-like skills must be executed in game-like situations to get the best results.

This article presents a tactical metabolic training strategy that has been adapted from race-event coaching theory and can be effectively applied to "transitional" sports (characterized by varying work : relief patterns) to extend the self-scouting process. The objectives of this strategy are threefold: (a) optimize the efficiency and effectiveness of training; (b) motivate athletes, thus enhancing compliance, effort, and training effects; and (c) provide a simple way to unify training tasks.

A brief explanation of rationale will be followed with a discussion of procedures using an example based on two professional football teams that demonstrate contrasting offensive strategies (the second article in this series will elaborate on practical examples for other sports).

Effort Distribution Concept

Track and field and swimming coaches have long been respected for their skillful application of the tactical training concept. In simple terms, the strategy of race-event training is to develop reciprocal physical and technical qualities in order to achieve a predetermined "effort distribution" (or series of target paces) in competition. In addition to the caliber of athlete and his or her abilities, a number of factors affect decisions about training:

- Immediate level of competition;
- Event's relative importance in the competition schedule;
- Qualifying/placing criteria (and possible performance records at stake);
- Topography of the venue (length of track oval, terrain, banking of curves);
- Environmental conditions.

The point is that successful racing is not achieved by just "getting into shape" and then subjectively "going as fast as possible." It is achieved via a planned performance approach (19, 20). That is, the coach analyzes the task at hand and methodically trains his or her athletes via specific techniques that enable them to execute a tactical workload in competition.

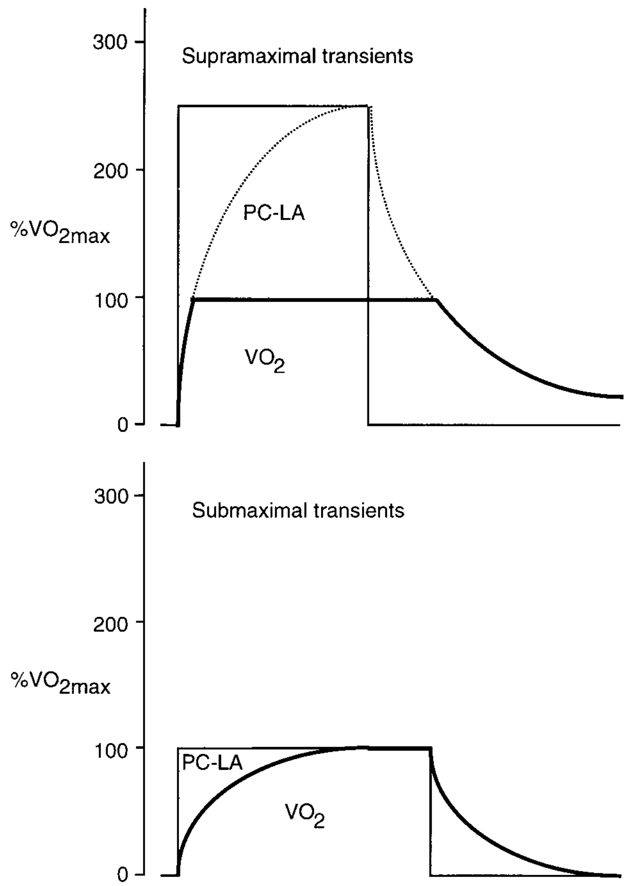
Furthermore, a race can be divided into "splits," each with target workloads or paces and corresponding physical/technical objectives, to be trained separately as well as collectively. In fact, most well-coached athletes can accurately estimate their pace or split time at any point during a training drill or race.

It seems odd that this concept—"special endurance" training (4, 11, 12, 26, 30, 35, 36) based on competition workload modeling—is not commonly applied to preparation for intermittent-activity sports characterized by a spectrum of work : relief patterns. Hopefully, the days of borrowed workouts based on personal experience or a precedent set by another coach or program are long gone.

But rather than model endurance training on competitive workload patterns (as a function of tactical events) in order to develop requisite metabolic qualities, many strength and conditioning coaches still use theoretical energy system contribution as the primary conditioning criterion when training their athletes (1, 3, 6, 7, 17, 23, 24, 32).

Exercise Science Concepts

Certainly one cannot argue with the need for general drills that address basic physical and technical qualities during the off-season or early preseason for most sports, since fundamental mechanics and work capacity must be established before proceeding to specialized preparation (8, 18–22, 28, 31, 34–36). However, it is puzzling that such drills often pervade late preseason and competitive training phases as well:



Bioenergy transients at exercise onset/offset (adapted from Refs. 10 & 13). VO_2 on/off responses approach rectangular workload ceiling and abruptly level off at VO_2 max.

Figure 1

1. From a practical standpoint, nonspecialized tasks make inefficient use of training time and effort.
2. Athletes are usually more enthusiastic about specialized, task-oriented exercises that have direct transfer to competition.
3. Exercise science knowledge is an intimidating competency to acquire, especially for sport coaches who, due to staff or budget limitations, must oversee their own training programs but lack a background in exercise physiology.

Thus, while an "energy system" mentality may arise from the best intentions or worst circumstances—or perhaps from simply trying too hard—it is only part of the answer.

Bioenergetic kinetics have recently been clarified, and theoretically quantified (9, 10, 13), but they are still difficult to apply to sports consisting of a broad range of work : relief dynamics. Consider the factors complicating any attempt to infer relative metabolic pathway involvement:

- The "VO_2 on-response" exponentially approaches the workload's actual intensity ceiling, abruptly plateauing when VO_2 max is achieved (Figure 1), and is further influenced by warm-up, posture, training status, and workload intensity (9, 10, 13).

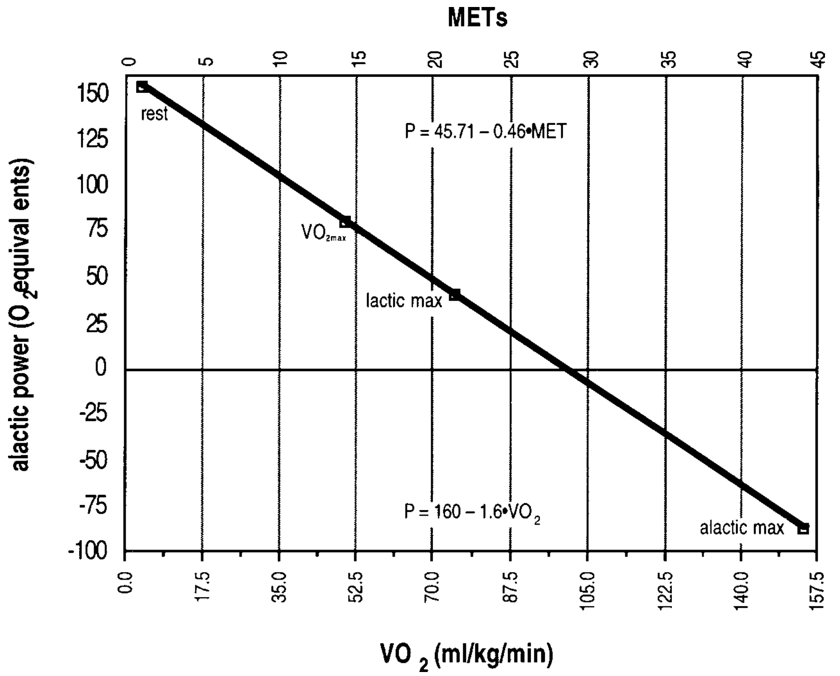


Figure 2 **Maximal "alactic" power availability (in equivalent O_2 units) as a function of workload (adapted from Ref. 13).**

- Available alactic (high energy phosphate system) power is an inverse linear function of VO_2 steady-state (Figure 2), and is therefore reduced while oxidative mechanisms are engaged (e.g., during continuous submaximal exercise or recovery from lactic intervals or alactic sprints) (9, 10).

The ramifications are profound: the dynamic interplay of bioenergetic pathways differs from the simplistic concept depicted in popular texts, in which VO_2 "on" and "off" responses are typically illustrated as gradually approaching steady-state, even during and after maximal workloads (2, 6, 7, 16, 32).

The picture does not get any clearer when work repetitions of varying intensities are superimposed on continuous activity or are stacked one after another with brief recovery allowance, as is the case during many sports and corresponding practice sessions.

It seems that bioenergetic kinetics are not as cut-and-dry as the classic "three energy system" and "deficit/debt" theories would suggest (2, 6, 7, 16, 32). Moreover, given the number of factors to consider, estimates of relative energy system contribution during various sports, based on intensity/duration generalizations from track events, are tenuous at best (2, 17, 23, 24, 29).

A comprehensive understanding of bioenergetics is emerging in the scientific community, but it is still incomplete, and several key concepts are not yet common knowledge among coaches. Indeed, even from a physiologist's perspective, bioenergetic pathway function and regulation are closely interrelated and should be trained as such. Thus a more pragmatic coaching approach is warranted.

Tactical Evaluation

If designed and implemented as part of a unified plan, sport-specific endurance training allows the practitioner to turn something ordinarily viewed as a mere foundation into a very real weapon. After all, when the objective is to win—and coaches' or athletes' jobs are on the line—there need be nothing gentle or politically correct about being more athletic, more physical, or otherwise better prepared than one's opponent.

Simply put, conditioning drills can and should do more than train the bioenergetic pathways utilized in competition. Ideally, they should progressively couple metabolic, tactical, and technical tasks in order to complement self- and opponent scouting efforts and make good use of training time and effort.

Procedure

Following is a tactical modeling checklist that can be adapted to virtually any sport or athletic event to establish specialized endurance test/drill criteria:

1. Identify competition modeling criteria.
   - Level: professional, college, high school, club, conference, division, league, etc.
   - Scheme/style/system: offensive, defensive.
   - Time period: contest, game, match, half, period, quarter, round, etc.
   - Personnel: team, platoon, shift, etc., position.
2. Identify the nature and scope of tactical events.
   - Intensity level: subjective, objective.
   - Outcomes, goals, objectives: "settled" events (e.g., attack, possession, rally, series); unsettled/transitional events (e.g., clear, fast break, spe-

cial teams, turnover); power play, extra-man/man-down situation, etc.

3. Videotape specific competitions or segments with respect to selected tactical events and assignments.
4. Evaluate.
   - Fundamental work/relief pattern: frequency distribution, central tendency vs. variability.
   - Subdivisions: sprints or transitional events superimposed on continuous activity.
   - Set-groupings as a function of extended-recovery intervals consequent to: injuries, penalties, scores, media/official/tactical time-outs.
5. Select core training/testing drills: workload intensity/duration; position- or situation-specific assignments and techniques.

Advantages

As mentioned earlier, the most obvious advantage of tactical modeling is that unified training tasks optimize time and effort, especially if an athlete progressively executes mock technical assignments (e.g., football positional single blocks, run paths, pass routes) that mimic competitive work : relief patterns.

While applicable in all situations, this has obvious implications for improving the ability of college coaches to comply with NCAA rules on daily and weekly hour limitations for "countable athletically related activities."

Note that during the off-season, drill organization and sequence must be randomized such that offensive/defensive alignments are not set up, and so that athletes at different positions do not execute corresponding assignments that would constitute "out-of-season practice activities" under NCAA by-laws (27).

Second, the potential for athlete compliance, education, and motivation is evident. Training goals that are task oriented rather than effort oriented provide a powerful incentive and confidence builder if reinforced as part of the overall education process and may yield superior learning effects.

A third advantage of tactical modeling is that it circumvents the equipment and painstaking effort required of heart rate, telemetric, or time-motion analyses.

From a practical aspect, the only resources needed are (a) someone with a VCR; (b) competition videotapes, preferably with self-scouting reports in order to identify game segments to be modeled; (c) a stopwatch, clipboard, and calculator; and (d) index cards listing position assignments to be called out during the recovery period after each repetition.

While this approach cannot substitute for an in-depth exercise science background, it is an invaluable complement to it. In this context, tactical evaluation is relatively easy and quick and the results are well worth the effort.

Disadvantages

A work : relief model based on play suspension/resumption patterns may not reflect the full extent of an athlete's work output in competition because activity does not necessarily stop altogether at the whistle (e.g., after a score, penalty, time-out).

Depending on the sport, various players may realign themselves between plays, run on or off the field for substitution, or, in football, run to and from the huddle and go in motion prior to the snap. But in general such events dictate an underlying tempo of the game and thereby provide a useful training model.

A second limitation of this method is that it does not provide a direct measure of competitive workload intensity unless accompanied by one of the data collection methods mentioned previously. Target training pace must therefore be established for observed interval durations.

This can tentatively be accomplished, at least for athletes who participate in noncontact sports, by "reversing" the track coaching method of projecting running time as a function of distance (11, 28, 37, 38) and then empirically adjusting them according to the athlete's developmental level and fatigability.

Furthermore, reasonably accurate estimates of energy cost as a function of velocity are possible for a variety of locomotion modes such as cycling, rowing, running, ice skating, Nordic skiing, front-crawl swimming, and walking (14). This allows the coach to establish equivalent workloads for different modalities and thereby expand the training menu.

Decision Making: An Example

As scientific and pragmatic as this approach can be, it does not eliminate the strength and conditioning coach's decision-making responsibility but instead points to a need to involve the team coaching staff in the process.

Since one objective of training is to improve execution, a logical question follows: Should the tactical model be based on our own team or on a better team using a similar scheme? If for example our offense is ineffective, a first step toward increasing productivity may be to model other teams that execute a similar playing style more successfully.

1991–92 NFL Playoffs

Washington Redskins Offense

• No. of series	12.3 per game, 3.1 per quarter
• Field position	–44-yd line
• Yards gained	5.5 net yds per play
• No. of plays	64.7 per game, 16.2 per quarter 10.2 per ideal series 5.3 per actual series
Idealistic drill/test	Simulate one 10-sprint series: • 4–5 sec work : 40–45 sec relief, based on mode values (Figure 3) • 5 sec work : 36 sec relief, based on mean values (Figure 4)
Realistic drill/test	Simulate one quarter, divided into series of 6, 5, and 5 sprints: • e.g., repeat 40-yd dash or pro-agility (20-yd) shuttle • e.g., mock positional assignments mixed according to play selection

Buffalo Bills Offense

• No. of series	13.3 per game, 3.3 per quarter
• Field position	–30-yd line
• Yards gained	4.3 net yds per play
• No. of plays	74.7 per game, 18.7 per quarter 16.3 per ideal series 5.6 per actual series
Idealistic drill/test	Simulate one 16-sprint series: • 3–4 sec work : 20–25 sec relief, based on mode values (Figure 3) • 5 sec work : 27 sec relief, based on mean values (Figure 4)
Realistic drill/test	Simulate one quarter, divided into 3 series of 6 sprints: • e.g., repeat 40-yd dash or pro-agility (20-yd) shuttle • e.g., mock positional assignments mixed according to play selection

Likewise, if an upcoming opponent exploits unusual tactics (e.g., a no-huddle offense in football against a defense accustomed to the “power” game), it would make sense to conduct such an evaluation in concert with the usual scouting reports in order to prepare defensive players in advance—even if only mentally as in the case of weekly (or more frequent) contests.

The next question addresses the nature and scope of game events to simulate in training: How much of an actual contest should one conditioning session mimic? If for example one quarter of football play is selected, does it make more sense to emulate a realistic quarter consisting of three 5- or 6-play series (see chart), or an ideal quarter consisting of one or more 10- to 16-play series (based on how many plays it takes to get to the endzone)? Since scoring a touchdown is the objective of each series, the latter “unrealistic” option is perhaps the more viable one by virtue of an aggressive mentality.

The same question can be asked in another way: Should objective or subjective criteria be the basis for tactical event modeling (e.g., yards gained, first downs, or points scored vs. the coach’s perception of “playing well” or “with good intensity”)? This is a relatively easy decision in American and Canadian football, due to the possession and down/distance principles that divide each game into sets of discrete work : relief intervals, thereby simplifying the tactical model when compared with other ballgames such as soccer, rugby, Australian or Gaelic football.

Such decisions can be further streamlined with the use of self-scouting software, but they become more complicated in sports with a continuous or transitional

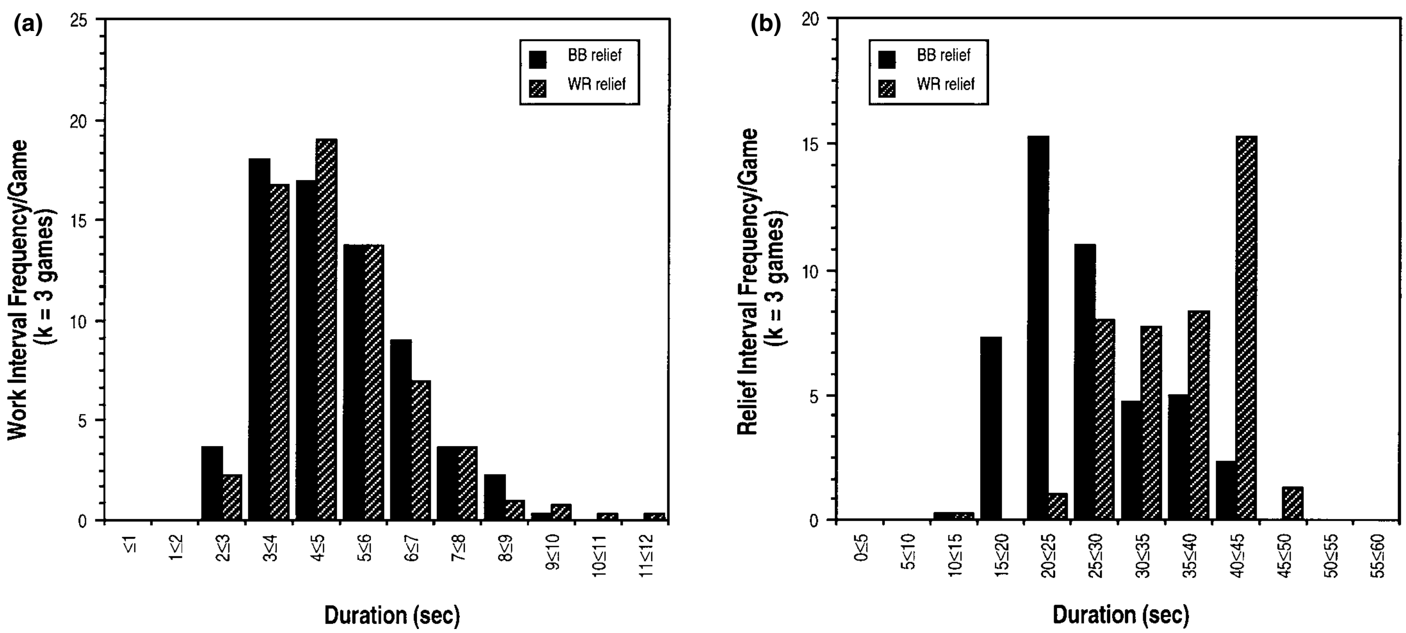


Figure 3 **1991–92 NFL Playoffs, Buffalo Bills (BB) vs. Washington Redskins (WR). Left: play work-interval frequency distribution. Right: post-play relief-interval frequency distribution.**

character such as basketball, hockey, or lacrosse.

Once the previous decisions have been made, core conditioning drills and tests can be selected. One option is to design them from scratch; another is to adapt or modify a standard sprint (e.g., 40-yd dash) or agility/endurance drill (e.g., line, ladder, 20- and 300-yd shuttle) (5, 29).

In either case the demands of training, testing, and competition must be interrelated. Highly motivated athletes invariably "train for the test." If tested differently than they train or compete, they will focus on nonspecific qualities during the final weeks of the preseason.

It is important to consider respective work : relief interval frequency distributions, ranges, and modes as well as mean ± *SD* at Procedural Step 4 (Evaluate). For example, in Figure 3 the 1991–92 Buffalo Bills' and Washington Redskins' offense periods, as a function of snap-to-whistle play time, are arbitrarily distributed into 1-sec intervals while the postplay relief periods are divided into 5-sec intervals, based on 3-game samples (i.e., two respective AFC/NFC Playoff contests each, and the head-to-head meeting in Super Bowl XXVI).

As can be seen, relatively narrow interval ranges tended to occur, and corresponding frequency distributions were skewed such that: (a) mode *work interval* ranges for each BB (3–4 sec) and WR (4–5 sec) (Figure 3a) do not encompass the respective mean (5.0 ± 1.6 vs. 5.0 ± 1.5 sec) (Figure 4c); and (b) mode *relief interval* ranges for each BB (20–25 sec) and WR (40–45 sec) (Figure 3b) do not encompass the respective mean (26.9 ± 6.9 vs. 36.4 ± 6.6 sec).

Thus, neither mean nor mode observations alone provide the whole picture when analyzing work : relief intervals. In most sports it is necessary to consider measures of variability as well as central tendency, for several reasons:

1. To determine drill duration according to the work : relief frequency distributions observed in competition;
2. To compare and contrast the most frequent (Figure 3) vs. average (Figure 4) interval duration when designing a core test/drill (chart);
3. To progressively shift emphasis along the interval duration spectrum on a cyclical basis such that training drills can be systematically varied within competition-specific ranges.

Model Specificity

The tactical model is specific to the selection criteria outlined in Procedural Step 1 and should not be generalized between or within levels, schemes, styles, or systems. Tactical events observed in professional competition cannot be applied to the college or high school levels of the same sport, or vice-versa.

Likewise, varying trends may preclude interconference, division, or league generalizations; and even intraconference or intradivision generalizations may be inappropriate if one or more teams employs an atypical style. Thus, just as race results and qualifying criteria differ at various levels, there is no "one size fits all" training model for any given sport.

As indicated earlier, football is no exception. As distinctive as this sport is, even subtle tactical variations can have dramatic implications. One recent innovation has been the "'no-huddle" attack with its underlying strategy of debilitating opponents' defensive adjustments and substitutions while also forcing them to deviate from the metabolism they are accustomed to during power oriented series. This is illustrated in Figures 3 and 4, which chart a comparative profile of the Washington Redskins' and Buffalo Bills' offensive work : relief patterns. In addition to the trends discussed above, simple t-tests reveal the following ($p < 0.05$):

- There are no significant team differences in rushing play *work-interval* duration (Figure 4a), passing play *work-interval* duration (Figure 4b), or combined rushing/passing play *work-interval* duration (Figure 4c).
- Post-rushing play *relief-interval* duration (Figure 4a), post-passing play *relief-interval* duration (Figure 4b), and combined post-play *relief-interval* duration (Figure 4c) are each significantly different between teams.
- Passing is slightly longer than rushing play *work-interval*

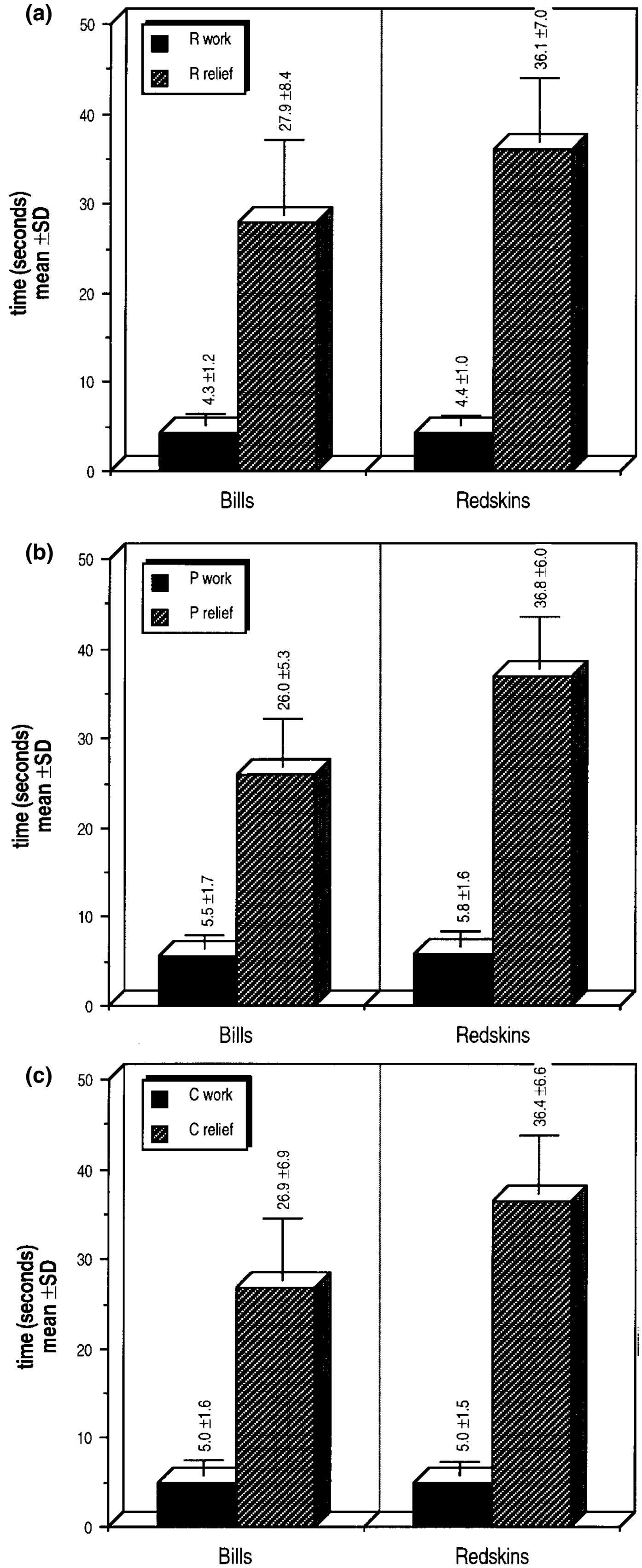


Figure 4

1991–92 NFL Playoffs, Buffalo Bills vs. Washington Redskins. Comparison of work interval and post-play relief interval durations. Top: rushing plays; Center: passing plays; Bottom: combined rushing and passing plays.

duration for each team, and post-passing is longer than post-rushing play *relief-interval* duration for the WR offense but shorter for the BB offense; thus the characteristic differences in WR (rush 57.2%, pass 42.8%) vs. BB (rush 41.5%, pass 58.5%) play-calling selection tend to broaden the team difference in combined post-play *relief-interval* duration.

With this information and that itemized in the chart, it is possible to identify the differences between idealistic (successful) and realistic (successful + unsuccessful) series executed by each offense, and in turn propose training protocols specific to the scheme, personnel, and desired/achieved execution.

Endurance training must address the task specific need for metabolic capacity, and recoverability, as well as power.

This example was chosen because it was a classic showcase between two distinct offensive philosophies. It may only scratch the surface of potential parameters to consider, but it underscores the need to address the common ground between tactics and training—and also to respect intrasport specificity. In this light, it is likely that different tactical variations can be characterized and strategically exploited, and that similar approaches can be devised for other sports.

Training Compatibility

With the exception of events involving a limited number of brief, maximal efforts (e.g., field event jumpers/throwers, football punters/kickers, powerlifters, weightlifters), the endurance training compatibility issue (25) is irrelevant for most sports and activities.

Some degree of specialized endurance is essential if only to achieve the desired training volume. As an example, consider the *speed/endurance* contribution to an event as *speed/strength* oriented as the 100-m dash, indicated by the attention it receives in track coaching circles (15, 28, 30, 37, 38). Furthermore, most "transition" sports consist of multiple series of explosive sprints superimposed on a backdrop of submaximal activity. Endurance training must address the task specific need for metabolic *capacity*, and recoverability, as well as power.

Periodization

The proposed competition modeling method, while unified in concept, is not intended to be an exclusive approach to conditioning for any sport. As part of a long-range plan, it should be viewed as a specialized element of late preparatory training to be preceded by endurance (e.g., general sprint/interval drills), motor skill (remedial agility/running mechanics), and strength and flexibility training such that a requisite fitness and technique base is developed.

The principles of manipulating fundamental training variables such as work : relief ratio, repetition intensity and duration, and training volume and frequency should govern general endurance drills in the early preparatory period (2, 5, 8, 15, 17, 26, 33–36). This should be followed with a progressive, methodical shift in emphasis toward specialized drills, manipulated according to situation-specific criteria, as the competitive season nears.

Summary

It is time to revise our traditional view of, and re-engineer our approach to, metabolic training. In terms of athleticism, "strength" and "conditioning" mean much more than the improvement in power or endurance indices as ends in themselves.

Collectively they must be viewed as a means toward an end: to enable the athlete to execute his or her specific tactical assignments with optimal effort. In this light, they are really the components of distinct athletic techniques characterized by the task-specific application of explosive force: against resistance, through a range of motion, at a certain velocity, over a period of time and/or repeatedly.

In simple terms, the time/repetition requirement of executing a given sport skill indicates the need for specialized endurance. But it is even more important to understand that each corresponding physical quality (power, flexibility, speed/agility, endurance) is trainable, and all must be trained in unison because they are parts of a larger whole. None is a separate entity, nor more important than another. The problem is straightforward but challenging, requiring the strength and conditioning specialist to be both an *exercise* and *sport* scientist.

While the proposed tactical modeling method has its limitations, perhaps one commonly perceived shortcoming of many strength and conditioning programs—training for physical qualities rather than performance itself—can be rectified with an integrative approach.

The European sport science literature has made reference to the *special endurance* concept for many years without going into detail on procedures, probably because their training methods are so pragmatic and self-evident.

And yet many coaches miss the lesson to be learned from the popular race events: special endurance training involves more than simplistic sprint-interval conditioning based on bioenergetic system contribution; ideally, it involves methodical competition evaluation and preparation with respect to tactical events and inherent physical/technical skills. ▲

References

1. Allsen, P.E., G. Dudley, S. Fleck, C.M. Maresh, and M.H. Stone Roundtable: Aerobic training in power sports. *NSCA Journal* 6(5):10-19. 1984.
2. Astrand, P.O., and K. Rodahl. *Textbook of Work Physiology*. New York: McGraw-Hill, 1986.
3. Berg, K. Anaerobic conditioning: Training the three energy systems. *NSCA Journal* 4(l):48-50. 1982.
4. Bompa, T.O. *Theory and Methodology of Training* (3rd ed.). Dubuque, IA: Kendall/Hunt, 1994.
5. Bouchard, C., A.W. Taylor, J.A. Simoneau, and S. Dulac. Testing anaerobic power and capacity. In: *Physiological Testing of the High Performance Athlete* (2nd ed.). J.D. MacDougall, H.A. Wenger, and H.J. Green, eds. Champaign, IL: Human Kinetics, 1991. pp. 175-221.
6. Bowers, R.W., and E.L. Fox. *Sports Physiology* (3rd ed.). Dubuque, IA: W.C. Brown, 1992.
7. Brooks, G.A., T.D. Fahey, and T.P. White. *Exercise Physiology: Human Bioenergetics and its Applications* (2nd ed.). Mountain View, CA: Mayfield, 1996.
8. Brunner, R., and B. Tabachnik. *Soviet Training and Recovery Methods*. Pleasant Hill, CA: Sport Focus Publ., 1990.
9. Cerretelli, P., D. Shindell, D.R. Pendergast, P.E. diPrampero, and D.W. Rennie. Oxygen uptake transients at the onset and offset of arm and leg work. *Respir. Physiol.* 30:81-97. 1977.
10. Cerretelli, P., and P.E. diPrampero. Gas exchange in exercise. In: *Handbook of Physiology 3: The Respiratory System IV: Gas Exchange*. A.P. Fishman, L.E. Farhi, S.M. Tenney, and S.R. Geiger, eds. Bethesda, MD: American Physiological Society, 1987. pp. 297-339.
11. Dick, F.W. *Sprints and Relays*. London: British Amateur Athletic Board, 1987.
12. Dick, F.W. *Sports Training Principles* (2nd ed.). London: A & C Black, 1989.
13. diPrampero, P.E. Energetics of muscular exercise. *Rev. Physiol. Biochem. Pharmacol.* 89:143-222. 1981.
14. diPrampero, P.E. The energy cost of human locomotion on land and in water. *Int. J. Sports Med.* 7:55-72. 1986.
15. Doherty, J.K. *Track & Field Omnibook* (4th ed.). Los Altos, CA: Tafnews Press, 1985.
16. Edington, D.W., and V.R. Edgerton. *The Biology of Physical Activity*. Boston: Houghton Mifflin, 1976.
17. Fox, E.L., and D.K. Mathews. *Interval Training*. Philadelphia: Saunders, 1974.
18. Gambetta, V. Planned performance training: The application of periodization to the American system. In: *TAC Track & Field Coaching Manual* (2nd ed.). V. Gambetta, ed. Champaign IL: Leisure Press, 1989. pp. 37-45.
19. Gambetta, V. Some thoughts on new trends in training theory. *NSCA Journal* 13(1):24-26, 33. 1991.
20. Gambetta, V. Concept and application of periodization. *NSCA Journal* 13(5):64-66. 1991.
21. Harre, D. Endurance—Classification and development. *Modern Athlete and Coach* 16(4):19-21. 1978.
22. Harre, D. (ed.). *Principles of Sports Training*. Berlin: Sportverlag, 1982.
23. Kraemer, W.J., and S.J. Fleck. Anaerobic metabolism and its evaluation. *NSCA Journal* 4(2): 20-21. 1982.
24. Kraemer, W.J., and S.J. Fleck. Anaerobic metabolism, training and evaluation. *NSCA Journal* 4(5):52-54. 1982.
25. Kraemer, W.J. General adaptations to resistance and endurance training programs. In: *Essentials of Strength Training and Conditioning*. T.R. Baechle, ed. Champaign IL: Human Kinetics, 1994. pp. 127-150.
26. Matveyev, L. *Fundamentals of Sports Training*. Moscow: Fizkultura i Sport Publishers, 1977.
27. NCAA Legislative Services Staff. Bylaw, article 17: Playing and practice seasons. In: *1996–97 NCAA Manual*. L.E. Bollig, ed. Overland Park, KS: NCAA, 1996. pp. 253-393.
28. Schmolinsky, G. (ed.). *Track & Field: The East German Textbook of Athletics*. Toronto: Sport Books Publ., 1993.
29. Semenick, D. Anaerobic testing: Practical applications. *NSCA Journal* 6(5):45, 70-73. 1984.
30. Shephard, R.J., and P.O. Astrand (eds.). *Endurance in Sport*. Oxford: Blackwell Scientific, 1992.
31. Siff, M.C., and Y.V. Verkhoshansky. *Supertraining*. Johannesburg: University of the Witwatersrand School of Mechanical Engineering, 1993.
32. Stone, M.H., and M.S. Conley. Bioenergetics. In: *Essentials of Strength Training and Conditioning*. T.R. Baechle, ed. Champaign IL: Human Kinetics, 1994. pp. 67-85.
33. Verkhoshansky, Y.V. *Programming and Organization of Training*. Moscow: Fizkultura i Sport Publishers, 1985.

34. Verkhoshansky, Y.V., and V.V. Lazarev. Principles of planning speed and strength/speed endurance training in sports. *NSCA Journal* 11(2):58-61. 1989.
35. Viru, A., P. Korge, and J. Parnat. Classification of training methods. *Modern Athlete and Coach* 14(5/6):31-33. 1976.
36. Viru, A. *Adaptation in Sports Training*. Boca Raton FL: CRC Press, 1995. pp. 241-299.
37. Wilt, F. Training for competitive running. In: *Exercise Physiology*. H.B. Falls, ed. New York: Academic Press, 1968. pp. 395-414.
38. Wilt, F. (ed.). A logical basis for the training of runners. In: *How They Train, Volume 1: Middle Distances* (2nd ed.). Los Altos, CA: Track & Field News, 1973. pp. 9-28.

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