Issues of stamina in modern music: Answers from sports science

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Background. As composers extend the boundaries of music, performers are stretched beyond their limits. This creates a chasm between those who are able (at least temporarily) to cope with these new demands and those who are not. There are some things that one may personally risk, but cannot responsibly teach.

Aims. A survey done among university flute majors showed that only 40% had any experience with any new music and of those, 0% had any experience with works of extreme complexity. Even professional new music specialists reference difficulty with stamina in performing these complex works. Discussions about over-practicing abound among pedagogues, but solutions have not been tested or proven. In new music, demands on breath control are often excessive. To date, a teaching method that covers such issues has not been developed. Athletes have known for years how to train themselves. Why don’t musicians?

Main contribution. The author applies knowledge gained from courses in Periodization Training taken in conjunction with coaching certification programs at the University of Delaware. This medically based theory stemming from General Adaptation Syndrome of Hans Selye has been modified by sports scientists since the 1950's. It has been applied to numerous sport disciplines and the theory itself remains the training standard. In short, periodizing a training program involves systematically alternating sport-specific practice with multi-lateral training and rest to maximize efforts while minimizing the risk of overuse and fatigue. The author applies these principles to modern music with regard to developing breath capacity and stamina.

In much music with extreme complexity, physical demands are out of reach for most flutists. One might simply ask, why play it? The reason is: there are flutists who have already figured out, without the help of a specific method, how to do so. This means that composers are continuing to write more and more complicated things, not because the masses of flutists can play it, but because some can. As a consequent, some of this repertoire makes in way onto competition, lists as required repertoire because of the challenges that it showcases.

While this is true, there are certain things that one may be willing to play, but can not responsibly teach. The physical intensity in much new music is beyond what many flutists are prepared for. Flutists have traded stories of becoming nauseated while performing the L’opera per flauto by Salvatore Sciarrino. This comes from the intense push of the diaphragm. Sciarrino writes repeated jet whistles, where one quickly expels large volumes of air and fourth octave harmonics. These are tones above the normal range of the flute, fingered with first octave fingerings, simply overblown. Some have said that they require an adrenalin rush to hit them all.

With the involvement of such tiny finger and lip muscles in flute playing, an adrenalin rush is something to avoid. In sports, there is an optimal level of arousal for an optimal performance for each athlete. This is known as the "Inverted-U Hypothsis." Sports requiring the highest level of arousal are those requiring gross motor skills such as weightlifting. Sports requiring the lowest levels of arousal are those requiring fine muscle control such as figure skating. Flute playing requires a degree of fine muscle control beyond any sport. The mechanics of the embouchure and fingers require steel nerves, and it is highly probable that any adrenalin rush would disturb one or both of —

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those systems. Adrenalin runs through the entire body, and one cannot regulate it to just the breathing, keeping the fingers and lips adrenalin free. As said by Frank R. Wilson, flooding these [smaller] muscles with adrenalin is like urging a mouse with a cattle prod: the result is spasm and collapse.\textsuperscript{2}

Looking further into the psychological effects of adrenalin in the body, the author found numerous studies about adrenalin injections causing feelings of fear. While these studies were inconclusive, one study did find [...] a positive correlation [...] between the intensity of emotional arousal, whatever its quality, and [...] adrenalin.\textsuperscript{3} One can clearly see the disadvantage this presents for musicians striving to stay calm an “in control” during a performance. Musicians have busied themselves with stress relieving techniques\textsuperscript{4} to minimize the exact symptoms that this repertoire seems to call for. The most typical symptoms of performance anxiety are a racing heart and shaking,\textsuperscript{5} and playing a piece with extreme breathing requirements causes the heart rate to increase. This does not mean that one will necessarily feel afraid during the piece, what it does mean is that the physical demands aren’t ones we are conditioned for.

It has been surprising to find a deficit of literature about physical conditioning for musicians. The body can be trained to do just about anything. Thinking of a flutists needs, what comes to mind is the athleticism of gymnasts on a balance beam or figure skaters jumping and landing on a thin blade. They explode with energy yet maintain control. They’ve simply trained themselves to be at the appropriate level of arousal at the right time. What is missing for musicians is a plan. Flutists can benefit from sport science regarding both muscle building and endurance training. The missing link to teaching such complex repertoire is by developing physical conditioning.

**Periodization Training: A Possible Answer**

Periodization training, in its simplest explanation, is alternating periods of work and rest so that the physical arousal is optimal at the right moment. The goal of periodizing an exercise program is to optimize training during short as well as long periods of time. Periodized cycles can be created for periods as short as a practice session or as long as an entire year. The origins go back to Hans Selye’s model, known as the General Adaptation Syndrome\textsuperscript{6}, which has been used since the late 1950s. General Adaptation Syndrome says that after an initial stage of alarm, a person will adapt to the stress which is called the stage of resistance. When a specific stress doesn’t alleviate itself, or when the body can no longer adapt, the third stage enters which he calls the stage of exhaustion. In Selye’s medical work, this is what causes death, or the lack of ability to adapt to life. In sports science, this means that the ability to cope will be less than it previously was. Periodization is a development of this theory. By increasing stress and alternating it with rest, one is able to do more.

Periodization gives a good lesson in preparedness. It eliminates the last minute panic practice, since at that point, the work is done. The motto in sports right before a competition would be, “trust your training.” Many musicians, especially those deciphering new scores, are still learning notes and working on technique at the last minute.

The percussionist Steven Schick writes about the muddied waters between learning and performing a piece often found among musicians:

> So often, out of the pressure to learn music increasingly quickly, these two distinct states of mind become confused. The learning of a piece becomes a necessary expedient of performance, but is rarely savored for its own unique qualities.\textsuperscript{7}
He wrote this in an article about learning a work of Brian Ferneyhough, which makes this comment even more applicable to this discussion.

**A model from sports scientists**

Looking into a model for sports enlightens the concept of periodization further. A sport that is analogous to flute playing is figure skating, because of its fine muscle control. The level of arousal is needed is at the lower end of the inverted U mentioned earlier. A team of sports scientists at the University of Delaware Ice Skating Science Development Center have developed a periodization schedule for the most elite skaters. In addition to numerous articles and studies done there, the team has published a plan that can be analyzed for musicians. (see figure 1)

There are several noticeable components of their plan which are often missing from a musician’s idea of practice. These new areas of exploration are

1) transition
2) the concept of tapering work and
3) multi-lateral training.

**Transition**

The periodized season begins with transition or active rest. This means a time of each year set aside for recovery. Athletes might participate in recreational sports during this time. They might also take a vacation. Musicians, especially professional ones, often do not have this luxury. The year is not so neatly organized where one can plan a few weeks every spring for recovery. Nor are the most taxing points of any season so easily defined. When, however, a piece of extreme physical difficulty or complexity will be performed, most musicians could find a time to rest in the before beginning a new work as well as after the performance, even if rest means playing concerts with traditional repertoire. This plan could also be applied to a specific competition or to a concerto performance. In preparing for such a performance, the flutist could use these concepts and schedule in rest or active rest to begin the preparation phase for a performance. This time is perfect for learning the notation and doing readings about the composer and his or her compositional style.

**Taper**

The second eye catching term in the plan is the word taper. Not only is this a concept that is often missing for musicians, but the placement of it in the chart is worth noting. While writing this chapter, the author talked to several musicians who said that they do taper off their work before a performance, adding that they practice very little the day before a performance. Athletes are tapering off their training up to two weeks before their competition. When athletes transition into the in-season phase of training, they report feel guilty for not being exhausted at the end of the day. The point of this phase is that one can not practice at a maximum level all day, or the days and weeks before, and expect to be at a peak level for the performance. During this in-season time, the training that had been previously done will not be lost in the competition phase. One will actually feel at a higher level of fitness since the body will recover some lost energy.

**Multi-lateral training**

A third component seen in this chart that is also often missing from a musicians practice is that of multi-lateral training. Look at the amount of off-ice training time and notice aerobic sessions, anaerobic sessions which consist of intense work such as plyometrics and interval training which includes weight training. In plyometric training, the skaters will simulate jumps and landings by jumping over boxes and on and off of boxes. This develops the explosiveness in the muscles without taxing the body or mind with the specific technique. This also minimizes injury since there are fewer falls on the floor or mat than there are on the ice. This helps build confidence since the strength is developed apart from a testing atmosphere of an on-ice session.
Practical application of periodization for flutists

For a teacher guiding a student through this process, a new schedule needs to be developed. In the early off-season, the athletes learn new elements and increase overall fitness. While introducing new works, a lot of the preliminary work should be done without the flute. This eliminates stress while allowing the student the time to adjust to new notations and rhythms. Any new techniques can be experimented with. This is also the time for mapping out the physical difficulties of the piece that need attention. These areas can be divided into the following components:

- preliminary work with new notations
- fingerings and traditional playing techniques
- extended techniques requiring a higher degree of embouchure strength
- sections of the piece requiring a higher degree of breath control and stamina

Once those work areas have been defined, one can further apply periodization to the development of physical conditioning. Those needs are embouchure strength and stamina with breath control.

Embouchure Strength

Where flutists spend years doing very gentle stretching exercises to refine the embouchure, facing a piece with a new embouchure requirement needs to be done much more quickly, without disturbing the normal embouchure. This needs to be done with minimal strain and fatigue so that the flutist can continue playing normally. The author has not found a teaching method describing how one builds muscle. Trumpet embouchure and third and fourth octave harmonics require muscle strength in the lips that would be very strenuous for most flutists.

Stamina

Another problem is that flutist’s ideas on stamina building are faulty. The current philosophy is that if the player can play the entire program though twice, then the recital will be easy. This does not account for the fatigue that the very practice of playing a program twice through causes. Nor does it acknowledge any type of time frame so that there is adequate recovery between these marathon practice sessions and the performance itself. A marathon runner would never think of running a practice marathon the day before the real race. Nor would he or she run the marathon six months in advance and hope that the conditioning remained at a high level.

Regarding stamina with breath capacity, challenges already exist in the traditional repertoire. Dr. Brad Garner recommends playing the second movement of the J. S. Bach’s Sonata in C Major twice through, with all repeats, to build stamina. The movement consists of long phrases with only one chance to take a breath lasting one full beat. The flutist must practice taking short catch breaths between the beats. Playing the movement twice through highlights the problem where one cannot take in enough air during a catch breath. Each phrase would then have less and less air making the movement very uncomfortable. The process of playing the movement twice through teaches the flutist how to maximize the amount of air one takes in during a catch breath. This idea is fine. What is missing is when and how often it should be done. There is also not any mention of what happens psychologically when it is not possible.

While studying breath control in traditional repertoire, flutists learn that all of the breaths within a piece should be planned well in advance of a performance. This minimizes the risk of running out of air in the middle of a phrase. In order to cope with performance stress, flutists often mark optional breaths in parentheses for those phrases where they might feel stretched beyond what is comfortable. Therefore, during the performance, the probability of not having enough air is minimized. The flutist who does not have enough air, or who does not exhale
before the air gets stale, will feel a real physical emergency. The heart will race. But, in new music, how does one cope with a situation that requires breath holding? Breathing was something previously under a performer’s control. Flutists have been taught to use air in the most musical way, playing phrases and lines independent of the breath marks. “As Arnold Jacobs would say, the music must be the priority in how we play. Creating wonderful music may mean that some people cannot get through certain phrases in one breath.”

Practical Application in Heinz Holliger’s (t)air(e)

Breathing Challenges

What is one to do when a composer takes away the flutists control over breathing? Heinz Holliger’s (t)air(e) for solo flute, is such a piece. It is organized as a series alternating inhalations and exhalations with breath holding in between. The player is asked to empty the lungs and then hold the breath as long as possible, inhaling only when it becomes absolutely necessary. Then he or she is asked to hold the breath while filled with air, exhaling only when necessary. This causes a build up of carbon dioxide in the lungs. Carbon dioxide in the lungs causes an increased heart rate and stresses the vascular system which causes pressure in the head and ears. When runners run the 100 meter dash, they compete so intensely for such a short time that they use more oxygen than they have for those nine or ten seconds. Their bodies allow them to compete with the depletion because it knows that it will simply take in more oxygen after the race. The tiredness that flutist would feel later in the piece has to do with just that. The breath holding is the sprint. The more that this is trained, the faster the recovery will be.

Looking into the score, the first phrase ends with, "with the last of your air" which is followed by the instruction “do not breathe”. The next inhalation is not a normal one. The player inhales with the lips covering the embouchure hole, through the flute tube. Then the player waits for seven seconds without breathing. With all of the air gained in the previous phrase, the air stays in the lungs and waits for the explosive relief.

The cycle starts again, alternating inhalations, exhalations and not breathing. Holliger adds another symbol here, an upwards arrow, which means a “short noisy taking of breath”.

This does not give the flutist complete control over how much air to take in. The first real break comes on line twelve with the fermata standing alone. That is the first chance for the flutist to take a relaxed and controlled breath. When the teacher plans the work period for this piece, the breathing work should come early on. (see figure 2 for a complete time schedule for the piece) What can be learned from the athlete’s multi-lateral approach is that practice can start without the instrument. Using a metronome and visually scanning through the piece, the flutist can practice all of breaths alone. A technique that is very valuable is to play the piece through a normal drinking straw. The flutist can articulate through the straw and listen to the air by itself. This shows how much air is being used. The benefit of this is to focus solely on breathing so that muscles develop and the body is conditioned with minimal stress. Isolating the breathing in this way allows the flutist to work harder on breathing than he or she normally would since other factors aren’t in the way.

During this phase of practice, fingerings, rhythms and other techniques should be practiced without the breathing requirements. The flutist should breathe whenever necessary. In periodization training, hard work is always balanced out. When isolating the breathing work, the flutist will feel tired. In time the body will adjust. This work falls into the off season; learning new elements. To increase confidence with the breathing sections, the player could practice sections back to back, without a pause in between. This is helpful but one needs to remember...
that this is done in advance, at the latest, in what would be the pre-season phase. At this time, the player should also have developed enough control over technical passages that they can be played with the flute.

Breathing Work by Multi-Lateral Training

Another possibility is to cross training and building overall endurance. What happens in this piece is similar to anaerobic conditioning. The word anaerobic means “without air, or without oxygen”. Anaerobic exercises are short and intense, not lasting longer than a few minutes. Athletes use these to train for when they do not have enough oxygen. For example, a runner will add short sprints into a jog in order to build endurance. The exercises would begin for short intervals of time, between thirty seconds and one minute, with about the same time of rest in between. This would be increased to two minutes with thirty seconds rest. Short explosive exercises like jumping rope or sprinting accomplish this. The high-intensity phase should be long and strenuous enough that a person is out of breath and recovery periods should not last long enough for their pulse to return to its resting rate. "Coaches advise that, ideally, people should not do interval work on consecutive days. More than 24 hours between such taxing sessions will allow the body to recover and help them avoid burnout." A word of caution, the point is not to jump around and then try to play the piece. That only adds stress. One puts the body through a similar stress so that it adapts. Simulate the situation, but certainly not with the flute in hand. While this is a direct route to conditioning oneself for the fastest recovery time possible, it can not be recommended for all flutists. This is an extension of exercise for those who are already aerobically fit.

One could also work with a breath builder. These small, portable machines work with a resistance knob on the end so that one breaths in and out through the mouthpiece with an increase in resistance. Breath builders have been used by patients recovering from various lung illnesses as well as by elite athletes. They increase lung capacity. By increasing lung capacity, anaerobic endurance is greater. Adding exercise or work with a breath builder can not be recommended without caution by the author. When one has been exercising, one could certainly add to the intensity of the routine. When a breath builder is already being used, one could increase resistance. Starting from scratch with such methods over a short time period could add unnecessary stress. These examples are therefore meant as an example of what is possible regarding multi-lateral training.

Building Embouchure Muscles

The next area of work in (b)air(e) is building new embouchure muscles. Holliger writes in the fourth octave, and also uses a trumpet-like embouchure with vibrating lips. Both of these techniques can tire lip muscles and cause some swelling. However, one needs to produce a refined tone immediately following. One needs control until the very end of the piece. The pppp dynamic found at the end with harmonic fingerings needs extreme embouchure control. This is preceded by a section with delicate quarter-tone tuning. One can not risk fatiguing the muscles earlier in the performance.

Earlier, Holliger writes tones which are meant to be played while vibrating the lips while inhaling. Using principals of overload, the flutist can begin with short burst of sound and gradually increase the number of times this is done in a practice session. At first, five attempts would fatigue the lip muscles. Immediately after, relaxed first octave passages should be practiced. Once the sound is achieved, the flutist can practice lengthening it until the required four seconds is reached. The difficulty with this limited amount of allowable practice is that there is limited time to refine the embouchure and experiment with the most economical way to produce the sound. This can be thought of in
advance of an attempt so that a) the muscles relax in between attempts, and b) there aren’t any wasted attempts. As with all intense exercises, this should not be done every day. Practicing every other day gives the lips adequate time to recover. Also, this is done early in the practice period, and tapered off before the performance.

Concluding Remarks
All of the recommendations above are guidelines and this does not mean that any one individual must follow it exactly. What has been described is the theory, and this theory can be put into practice in a number of ways. Foremost, the time frame is variable. The proportions should be observed when setting up a personal time schedule. The benefit is that physical conditioning is done in the most responsible way possible. The strength of multi-lateral training is that the work area is set apart from the music. When one only works with the instrument, the repertoire itself becomes a test, leading to a negative, if not exhausting experience with the music. Multi-lateral training eliminates this aspect of practice. It does not mean that the performance will be perfect. The periodization theory seeks to eliminate fatigue, injury, testing and competition in practice sessions and ultimately, stress. It gives flute teachers tools they need to introduce such challenging works into their studios.

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i. This is also referred to as Yerkes Dodson Law, Hanoch (2004)


iii. Levi (1965)

iv. Adina Mornell in, Lampenfieber und Angst bei ausübenden Musikern cites twenty-six various therapies aimed at reducing performance anxiety (pp. 70–71). These therapies are not only practiced by many musicians, but her table shows multiple studies done on each form of therapy. In addition to this, her book cites hundreds of articles dealing with this theme.


vi. Selye (1952)

vii. Schick (1994)

viii. Plyometrics was originally known as “jump training” and has expanded to include numerous exercises that link strength with speed in order to produce power.
This technique was learned at the 2001 Lake Placid Institute of the Arts with Linda Cheis, Manhattan School of Music Faculty member.

An aerobic exercise: Energy without oxygen

Anaerobic exercise: Energy without oxygen

Figure 1

Periodization Chart for Cardiovascular Training

Reprinted with Permission from the United States Figure Skating Association
**Table 2.**
Periodization Chart for Heinz Holliger’s *(t)air(e)*, Borkowski

<table>
<thead>
<tr>
<th></th>
<th>Preliminary Period or Active Rest</th>
<th>Early Preparatory Period</th>
<th>Late Preparatory Period</th>
<th>Pre-Concert Period</th>
<th>Concert Period</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stamina Work</strong></td>
<td>Two to Three Weeks Duration</td>
<td>Four to Six Weeks Duration</td>
<td>Two Weeks Duration</td>
<td>Two Weeks Duration</td>
<td>One Week Duration</td>
</tr>
<tr>
<td></td>
<td>Divide up the work areas. Preparatory listening and reading work. Cross referencing other works of Holliger.</td>
<td>Stamina building, breath holding passages. Daily practice without the flute, increasing work while decreasing rest.</td>
<td>Put sections together, back to back run-throughs of small sections to continue building stamina. Increase to run-throughs of larger sections with less rest in between.</td>
<td>Trial run-throughs of the entire piece for teachers or colleagues. Back to back run-throughs of the entire piece should be avoided now.</td>
<td>Performances</td>
</tr>
<tr>
<td><strong>Embouchure Work</strong></td>
<td>Beginning extended techniques practice, experimenting in addition to practice without the flute.</td>
<td>Begin with whistle tones and alternate days with work on trumpet embouchure and fourth octave practice.</td>
<td>Begin to taper embouchure work, fewer repetitions. Whistle tones continue without change.</td>
<td>Continue to taper embouchure work.</td>
<td>Embouchure work is finished.</td>
</tr>
<tr>
<td><strong>Finger Technique</strong></td>
<td>Slow controlled practice of fingerings without extended techniques.</td>
<td>During regular practice, tempi are increased and extended techniques are gradually added.</td>
<td>Refine finger technique.</td>
<td>Technique is secure allowing the emotions to become honest.</td>
<td>Technique is prepared and emotions are honest.</td>
</tr>
</tbody>
</table>

*Figure 2.*
Periodization Chart for Heinz Holliger’s *(t)air(e)*, Borkowski