The Value of Vocal Warm-up and Cool-down Exercises: Questions and Controversies

Rima A. DeFatta and Robert T. Sataloff

In singing and other athletic endeavors, the value of warm-up and cool-down exercises has not been defined clearly. Relatively few studies have researched the effects of these exercises on muscle function and even fewer have studied their effect on singing-specific outcomes. The value of warming up before singing is accepted widely despite the paucity of scientific evidence to support its benefit. Singers often report increased pitch range, smoother transitions, and overall improved ease of singing after warming up. Warm-ups are a component of most voice pedagogy programs and many voice therapy regimens. The importance and use of cool-down exercises after singing is more controversial, just as it is in sports medicine. Studies in exercise physiology literature both support and refute their value. Although no consensus can be reached based on available scientific evidence, singing teachers and voice therapists should be familiar with the current literature in order to guide and counsel students appropriately.

The findings of exercise research can be applied in broad terms to singing. Through a comprehensive review of the literature, Hoh showed that laryngeal and limb muscles share several properties.1 Fast and slow twitch fibers are found in both locations. Slow twitch fibers (type I) generally are considered to be fatigue resistant. They can generate a steady flow of energy (adenosine triphosphate, or ATP) by oxidative metabolism that is supported by a rich blood supply and high mitochondrial content. Fast twitch fibers (types IIa, IIx, and IIb) generally lack the endurance of slow twitch fibers. They possess a wider range of speed and power made possible through glycolysis (sugar metabolism to lactic acid). Each set of muscles in the larynx possesses unique functional capabilities owing to the variable composition of fast and slow twitch fibers. The thyroarytenoid (TA) has a high type II fiber content that gives it the shortest contraction time of all the intrinsic muscles. The cricothyroid (CT) contains a much higher ratio of type I fibers, which slows its contraction rate four fold. The range of TA contraction speeds parallels those of very fast extracircular muscles, whereas CT contraction speeds approximate those of fast limb muscles. Beyond the mentioned similarities, additional histochemical specialization gives the larynx exceptional speed and endurance that are absent from extremity muscles of the same species.
Before warm-up and cool-down exercises can be applied clinically, basic biochemical and physiologic effects should be understood. Bogdanis and colleagues studied the effects of cool-down on metabolic, cardio-pulmonary, and power output changes during repeated sprints.13 Thirteen young healthy male volunteers completed two 30-second cycle sprints. The sprints were four minutes apart and separated either by passive recovery (sitting still) or active recovery (cycling at 40% of maximal oxygen uptake). The active recovery group showed an expected higher heart rate during the recovery interval and a greater power output retrieval during the second sprint. Despite these findings, blood lactate and pH levels were not significantly different between groups. It has been suggested by Harris et al. that blood flow to recovering muscle is critical for the clearance of metabolites (such as lactic acid), which are assumed often to cause clinical muscle pain and fatigue.3 A recent study by Tenan and colleagues demonstrated no correlation between lactate levels and muscle fatigue as measured objectively by a decrease in the median frequency of electromyographic tracings.4 Although Bogdanis’s study did not assess subjective fatigue, Tenan’s findings call into question the correlation between metabolite buildup and muscle soreness. However, the study was small and cannot be considered definitive.

Law and Herbert attempted to quantify the effects of both warm-up and cool-down on delayed onset muscle soreness.5 Healthy, untrained runners were randomized into four groups: warm-up and cool-down, warm-up only, cool-down only, and neither warm-up nor cool-down. When cool-down was used, it was targeted specifically on similar muscle groups fatigued during exercise. At 48 hours, muscle soreness was measured subjectively using both a numerical and a visual analog scale. Soreness was measured objectively using a force transducer that applied increasing pressure to the gastrocnemius (calf) muscle. The study concluded that warm-up reduced muscle soreness by a mean of 13 mm on a 100 mm visual analog scale, but that cool-down had no effect on muscle soreness. Several authors have suggested that delayed onset muscle soreness results from damaged, poorly compliant myofibrils.6 Law and Herbert hypothesized that because warm-up increased muscle temperature, it may have improved myofibril compliance and consequently limited the damage and soreness associated with stretch injury. This compliance theory may explain also the anecdotal benefits of warm-up before singing.

Motel and colleagues specifically studied the effect of warm-up on the soprano voice.7 Their experimental design was based on the assumption that submaximal exercise leads to increased viscosity of the superficial vocal fold. Although the viscosity of the underlying vocalis muscle may decrease as a result of metabolite concentration and water influx, the shear and compressive forces from vocal fold oscillation limit water transport to the mucosa by temporarily collapsing the capillaries. Ishizaka’s vocal fold oscillator model predicts that a viscosity increase should increase the phonation threshold pressure and make singing more effortful.8 They found that phonation threshold pressure (P_{th}) increased in six out of nine soprano study volunteers. These findings seemed to contradict the common observation that warming up permits less effortful singing. The authors recognized that standardizing the warm-up might not have prepared each of the variably experienced subjects optimally. The singers’ different rating of their readiness to perform following the prescribed warm-up regimen supports this. Although the study did not detail whether low readiness scores correlated well with an increase in P_{th}, none of the singers perceived a worsening of their vocal quality. This variability in response to similar training routines is predicted by the individuality principle of athletic training and should be kept in mind when recommending exercise routines for vocal performers, and when evaluating the results of research.9

In an attempt to answer questions regarding cool-down, the majority of authors have focused on studying its immediate effects on muscle physiology. In contrast, Spencer and colleagues investigated the long-term effects of active recovery.10 Nine healthy male participants completed a cycle sprint trial every seven days over a four-week period. Each trial consisted of six four-second repeated sprints separated by either passive or active recovery. Capillary blood samples and muscle biopsies were collected to supplement performance measure findings. Final peak power and muscle phosphocreatine (a high energy molecule) were significantly lower in the active recovery group. Despite the suggested negative effect of active recovery in this study, it is important to note that no difference was found in work decrement between the active and passive recovery groups.
We can safely draw some conclusions about vocal performance based on exercise physiology literature, but it is important to keep in mind the limitations. Many experiments utilize repeated sprint cycles to tailor the applicability of results to team sports. Virtually none have studied warm-up and cool-down in long distance running, which is more similar to singing than are sprints. So, application of various studies to singing must be made with caution. For example, one study asked subjects to walk backward downhill on an inclined treadmill for 30 minutes. The intent was to fatigue the gastrocnemius muscle. It is difficult to similarly isolate muscles of the vocal tract in singing, as they typically work in unison to produce a particular sound.11 The same is true of warm-ups and cool-downs, since they typically represent performance of an exercise at a submaximal threshold. Warming up or cooling down a group of vocal tract muscles may produce different short and long-term physiologic effects on the voice than can be predicted by experimental results that test an isolated extremity muscle, or even a group of muscles performing activities that differ from singing. This variability in the type of muscle exercises tested makes comparison of the results challenging. In turn, a range of recommendations can be made regarding specific warm-up and cool-down exercises based on these results. Although some studies failed to show benefit from warm-up and cool-down, no study has shown measurable adverse outcomes as a result of these maneuvers. Scientific studies specific to singing are needed. Until reliable scientific evidence is available to guide our recommendations, the continued use of warm-up and cool-down exercises based on anecdotal observations of experienced voice pedagogues seems appropriate and prudent. The choice of exercises should be individualized based on the singer’s classification, type of performance and range expected, general fitness level, and individual response to various exercises and approaches to training. Singers should recognize the existence of a knowledge gap and welcome opportunities to participate in research on warm-up and cool-down exercises so that we all can learn more.

NOTES


11. Elliot, Sundberg, and Gramming.

Rima A. DeFatta, M.D. completed her residency at Albany Medical College. Dr. DeFatta completed her fellowship under Dr. Robert Sataloff’s mentorship in Philadelphia and is currently practicing in Eau Claire, Wisconsin.