

Simultaneous Singing and Dancing in Musical Theatre: Assessing Physical and Vocal Demands

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ABSTRACT: The study conducted a cross-disciplinary literature review of the physical and vocal impact of simultaneous dancing and singing within a musical theatre context. The review employed a hermeneutic methodology to implement a rigorous search strategy. A quality appraisal system formed part of the inclusion/exclusion criteria. Seventy-four papers were examined, and five key themes emerged from the data. The findings suggest that musical theatre performers may experience greater physical demands when dancing compared to performers in other dance genres. Physical and vocal demands are exacerbated when singing and dancing occur simultaneously or in close proximity to each other. The interplay between singing and dancing creates complex training and performance coaching needs, including athletic fitness training, vocal health strategies, and choreographic considerations that minimise the risk of injury, burnout, and vocal pathology.

KEYWORDS: Singing and dancing, triple threat performance, physical fitness, cardiorespiratory fitness, cardiovascular fitness

INTRODUCTION

The triple threat performer requires extensive training to prepare them for an industry that expects seamless integration of dancing, singing, and acting (Cuny, 2022). The nature of that training is evolving as we strive for a granular understanding of the challenges faced by professional performers (Fenton, 2024). When fused into one performance, the demands of each discipline create physiological constraints that require artistic compromise, and the performer may be faced with a fraught navigation process (Glasheen, 2017).

RESEARCH AIMS AND OBJECTIVES

This cross-disciplinary, qualitative review aims to evaluate the physiological and vocal implications of simultaneously dancing and singing within a musical theatre performance context. While two landmark studies (Stephens & Wyon, 2020; Sliiden et al., 2017) address this issue specifically within musical theatre, cross-disciplinary research is needed to elicit further understanding. The review aims to bridge the research gap by synthesising multidisciplinary peer-reviewed research. In doing so, it seeks to consolidate existing literature and highlight areas for further research.

To achieve this aim, the objectives were as follows:

- To review the research into the assessment of fitness levels of musical theatre performers in relation to other dance genres
- To evaluate the research into the physiological impact of simultaneous singing and dancing on the cardiovascular and respiratory systems of musical theatre performers
- To investigate the research into vocal demands experienced by musical theatre performers when singing without dancing
- To explore the available research into how vocal demands change when singing and dancing occur simultaneously or within proximity of one another

- To stimulate debate regarding the training needs of musical theatre performers that are strategically designed to mitigate the risks of injury, burnout and vocal pathology

METHODOLOGY

The narrative cross-disciplinary review employs a hermeneutic methodology in the application of inclusion/exclusion criteria and data analysis process (Boell & Cecez Kecmanovic, 2014). Winter (2023) highlights a methodological synergy between hermeneutics and voice-related disciplines due to their historical relationship with textual analysis (Lavery, 2003). The framework was selected for its compatibility with the discipline of musical theatre, which combines acting, dancing, and singing. It also offers a rigorous alternative to a systematic review where the search process revolves around a fixed question. Although systematic reviews are commonly used within medicine, they typically answer a formulated research question and are designed to evaluate a homogenous body of literature (Winter, 2023).

In a field where research is scarce, cross-disciplinary engagement is needed to reveal new areas of learning and valuable interconnections, which is challenging to achieve via a systematic review process (MacLure, 2005). A hermeneutic methodology enables the research questions to emerge from an iterative dialogue of reading and interpretation. In contrast, the systematic review process utilises the PRISMA protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analysis), a 27-item checklist designed to evaluate interventions through a meta-analysis (PRISMA, 2020). It depends on a sizeable body of interconnected knowledge that can be statistically evaluated. It is not appropriate for excavating disparate, cross-disciplinary studies with tenuous connections.

The hermeneutic methodology balances flexibility and interpretation with rigour and process, bringing a high degree of transparency to the excavation process inherent within cross-disciplinary research within a qualitative approach. It also provides a framework for the subjective nature of interpretation (Boell & Cecez Kecmanovic, 2014).

The Search Strategy

The search strategy adopted two hermeneutic circles that moved from repeated cycles of search and acquisition to analysis and interpretation (Boell and Cecez Kecmanovic, 2014). The strategy enabled a flexible and iterative search process that incorporated a pearl-growing approach utilising the two landmark studies (Sliiden et al., 2017; Stephens & Wyon, 2020) as a starting point. Both studies are pertinent because they are among the first to evaluate the physiological and vocal impact of singing and dancing together within a comparative performance context. They were retrieved after conducting two initial searches using the following search terms. The first was with specific reference to musical theatre and the second was without reference to the genre:

- “simultaneous dancing and singing”
- “singing while dancing”
- “dancing and singing together”

Layers of understanding developed through a cycle of “backward chaining” through the references and forward chaining through citation searches with each contributing study. The same practice was repeated with each new study that emerged from this structured process, allowing the discovery of relevant adjacent areas and unexpected, novel interpretations. It also harvested a broader spectrum of keywords, allowing for a thorough cross-checking process through further keyword searches, which added to the range of studies. The inclusion/exclusion criteria below evolved incrementally throughout the research and refinement process as new combinations of keywords emerged. This is reflected in the table below, where other potentially relevant papers were identified in the field of dance, voice, and sports science.

Table 1: Search criteria

Concept 1: Physical demands of musical theatre performers when dancing
(dance AND fitness) OR (dance AND cardiorespiratory) OR (dance AND “training intensity”) OR (dance AND “lactate acid”) OR (dance AND “oxygen uptake”)
(“Musical theatre” AND fitness) OR (“Musical theatre” AND cardiorespiratory) OR (“Musical theatre” AND “training intensity”) OR (Musical theatre AND “lactate acid”) OR (“Musical theatre” AND “oxygen uptake”)

Concept 2: Physical demands of musical theatre performers when dancing and singing ("Physiological impact") AND ("singing and dancing") OR ("singing while dancing") OR ("simultaneous singing and dancing") ("lactate acid levels") OR ("anaerobic energy") OR ("blood pressure") OR ("heart rate") AND ("Musical theatre performers") OR ("singing while dancing")
Concept 3: Physical impact of exercising and phonating ("lactate acid levels") OR ("anaerobic energy") OR ("blood pressure") OR ("heart rate") AND ("exercise and phonation") OR ("exercise while speaking") OR ("exercise while singing") ("fitness instructors") OR ("group exercise instructors") OR ("personal trainers") AND ("exercise and phonation") OR ("exercise while speaking") OR ("exercise while instructing") OR ("exercise while singing")
Concept 4: Vocal demands of musical theatre singing ("vocal demand") OR ("vocal fatigue") OR (hyperfunction) OR ("muscle tension dysphonia") OR ("vocal health") OR ("vocal dosing") OR (dosimetry) OR ("vocal loading") OR ("voice disorders") AND ("Musical theatre performers") OR ("Musical Theatre actors")
Databases searched Pubmed, Scopus, Web of Science, Taylor Francis and Wiley online, in addition to the University of Essex Advanced Search Boolean Operators (1902 results in total).
Rationale PubMed was chosen for its broad coverage of biomedical literature, including studies on physiology and health. Scopus and Web of Science were selected for their multidisciplinary scope. Taylor & Francis and Wiley Online Library provided access to specialised journals in performing arts, health, and education. The University of Essex Advanced Search Boolean Operators enhanced the search process with precise and targeted queries, ensuring a thorough and comprehensive review of the physical and vocal demands of simultaneous singing and dancing in musical theatre. It also provided access to lesser-known journals and additional sources.

The database searches detailed above revealed 1902 articles. The search strategy was interwoven with an iterative cycle of citation, reference, and author searches, resulting in the selection of 74 articles. The selection process evolved from a circular motion of literature

searching, reading, interpreting, classifying and mapping. The articles were selected based on their direct and indirect relevance to the research question, and all studies examined were related to the whole (Laverty, 2003), which required a constant reframing of the research questions. A total of 1828 studies were excluded based on their relevance and date range. While the search prioritised studies within the last ten years, earlier studies were included where the primary research relied on evidence from earlier work. The hermeneutic approach, in contrast to the systematic review process, enables the inclusion of relevant research, which was necessary when examining the studies related to respiration.

To provide an additional layer of rigour, the Quality Assessment Tool for Studies of Various Designs (Sirriyeh et al., 2012; Collonnaz et al., 2024) was chosen to suit the multi-disciplinary nature of the study. The tool comprises 16 criteria that enable the assessment of qualitative, quantitative, and mixed-methods studies. The criteria could also be adapted to incorporate systematic reviews. Each criterion is given a maximum score of three. Based on Collonnaz et al. (2024), each study was scored with a maximum score of 42 for quantitative studies, 39 for qualitative studies, 48 for mixed-methods studies, and 39 for systematic or literature reviews that employed a rigorous methodology. Theoretical papers could not be scored as the appraisal checker did not cater for this type of scholastic debate. They were included because they were deemed relevant to the points argued, which is reflected in the scoring.

Most of the studies were quantitative with small samples, which prevented the maximum scores associated with high-quality research from being awarded. To ensure study relevancy (Boell & Cecez Kecmanovic, 2014), a relevancy score was used to include lower-quality research/theory where it contributed to the debate. The relevancy scores are as follows:

1. Some relevance
2. Relevant
3. Highly relevant

Given the cross-disciplinary nature of the search, some studies appeared loosely relevant and were included because of their potential to become highly relevant if cross-extrapolation to Musical Theatre can be justified (Boell & Cecez Kecmanovic, 2014). The breakdown of the studies included is at Appendix 1.

Data Analysis

The data search and analysis processes occurred in a cycle, harnessing the concept of a continued spiral of meaning-making with the text (Boell & Cecez Kecmanovic, 2010). Braun and Clarke's (2022) thematic analysis framework was used to analyse the data because of its capacity to evaluate large data sets. This approach was selected for its flexibility and compatibility with qualitative, interpretive methodologies, particularly within cross-disciplinary contexts such as musical theatre. The approach is highly compatible with the hermeneutic philosophy as the iterative, interpretative nature reveals latent themes. It also acknowledges the active role of the researcher in the interpretative process.

Saldana's (2016) concept coding was used to analyse the vast dataset for the coding process. The nature of these codes allowed for the identification of broader patterns that were grouped into concepts and themes. However, manually analysing such a large quantity of data presented several challenges relating to consistency and subjectivity. In line with Clarke's (2021) argument, qualitative research must avoid rigid protocol standards and allow meaning to evolve through the lens of the researcher. The interpretative element of this review is made clear in the presentation of the findings, and it is entirely consistent with the dialogic approach of the hermeneutic methodology employed.

FINDINGS

The findings section is structured to answer the five central research questions, highlighting the key themes that emerged from the literature.

Research Question 1: What are the cardiovascular fitness levels required for musical theatre performers compared to other dance genres?

While the paper's primary purpose is to evaluate the complex relationship between simultaneous dancing and singing, it is important to understand the demands of each activity in isolation. Evaluating individual elements enables a deeper appreciation of the interconnection of the two when performed together. This section will explore the extent to which musical theatre performers require higher levels of physical fitness than other dance genres.

Stephens and Wyon (2020) provide an insight into the relationship between singing and dancing in a performance context. It also builds incrementally on a series of studies related to dance, representing an accumulation of knowledge and technological development (Wyon et al., 2004; Wyon et al., 2007; Wyon et al., 2016; Wyon et al., 2018). The study examined the cardiovascular fitness of 21 final-year undergraduate students of musical theatre (MT); it concluded that MT dancers had higher aerobic fitness level profiles than other dance genres, based on a cross-comparison with five previously conducted studies (Cohen et al., 1982b; Rimmer et al., 1981; Rodrigues-Krause et al., 2014; Shantz & Astrand, 1984; Wyon et al., 2016). The evidence suggests that musical theatre performers require more athleticism than performers in other dance genres, raising questions about how best to coach and facilitate maximal cardiorespiratory fitness while achieving a stylistic balance between all three components.

Conversely, Tiemens et al. (2023) provide a cautionary warning when cross-comparing data between individual studies. The authors question the validity of cross-comparison due to the heterogeneous nature of studies within the dance field and the incompatibility of diverse methodological approaches and cardiorespiratory testing devices. Stephens and Wyon (2020) acknowledge issues of generalisability due to the low participant numbers and limited knowledge regarding the training practices of the research subjects, while Sliiden et al. (2017) highlight the varied vocal demands of each song extract. Therefore, direct application to practice should be approached with this in mind.

Regarding the physical demands placed upon the musical theatre performer, Stephens and Wyon (2020) distinguish between performance and rehearsals/classes, with the former placing more significant strain on the lactate threshold, requiring dancers to exercise close to their cardiorespiratory threshold. It is necessary to evaluate the strength of these claims due to the risk of injury, burnout, and the implications for choreography and employment scheduling. Where blood lactate levels are close to the threshold, there is a risk that the muscles are producing more lactate than the body can clear. This results in fatigue, pain, discomfort and a deficit of oxygen (Seiler & Kjerland, 2004). A study relating to ballet confirms the need to ascertain the physical endurance of dancers to enable appropriate training that minimises the likelihood of fatigue and injury (Rodrigues-Krause et al., 2014). This

was further corroborated by a recent systematic review of the cardiorespiratory fitness tests used on dancers. The review supports regular cardiorespiratory testing to ensure that dancers have sufficient endurance for their performance demands (Tiemens et al., 2023). Cross-disciplinary evidence suggests a link between a high VO₂ max and an improved ability to recover from bouts of high-intensity exercise (Tomlin & Wenger, 2001). A further link between injury and respiratory fitness is confirmed by Biernacki et al. (2021), who found a correlation between poor aerobic fitness and injury as an influencing factor. Dang et al. (2023) conducted a systematic review that confirmed the value of physical fitness training, with 80% of the ten studies chosen reporting a significant link between fitness training and injury rates, recovery rates, and pain intensities. Tiemens et al. (2023) dismiss the quality of the evidence within the dance field because of the problem of small, often convenient samples. While it is important to acknowledge these limitations, it is also necessary to safeguard performers. A cautious link between fitness and injury can be drawn, enabling cross-industry practices to evolve.

Training institutions and employers owe a duty of care to their students and employees. Further research is required to understand innovative practices within colleges and theatre companies. Redding and Wyon (2003) suggest that regular dance-specific cardiorespiratory fitness testing should be employed across the industry. They provide practical suggestions on suitable testing models to minimise the risk of injury. Although this study is outdated, Tiemens et al. (2023) stress that this has yet to be implemented. Additionally, training could be improved by incorporating standardised aerobic fitness and strength training at the trainee and professional career levels. It could minimise the high risks of injury (Biernacki et al., 2021) and further aesthetic competence, jump performance, and dance technique (Angioi et al., 2009). It is likely that some training institutions are already engaged in innovative, cutting-edge strategies. Further research could identify promising practices for the industry, ensuring that safeguarding initiatives are consistently applied across the profession.

Research Question 2: How does the simultaneous performance of singing and dancing impact the cardiovascular and respiratory systems of musical theatre performers?

The simultaneous process of dancing and singing creates additional challenges to physical fitness. Stephens and Wyon (2020) compared the performances of two four-minute sections of *A Chorus Line*. One was performed with dancing only, and the second was performed with both singing and dancing. Although the results concluded that the two groups were similar in maximal and threshold heart rates, there was a significantly reduced mean breathing frequency and an increased blood lactate level in the performers who combined singing and dancing. However, this effect was more pronounced when the singing occurred after the dancing rather than simultaneously. In the observed sample, singing and dancing often occurred together, but more frequently, singing immediately followed dancing. The authors suggested that singing immediately after dancing is more problematic than simultaneous dancing and singing because it reduces mean breathing frequency, which harms recovery due to increased blood lactate levels. Interspersing singing and dancing could potentially hinder subsequent dance/singing sequences, impair performance, and increase the risk of injury. The study cites earlier corroborating research by Yamamoto et al. (1988), which showed that reduced breathing frequency inhibits lactate removal from working muscles during exercise.

Sliiden et al. (2017) also hypothesised that combining singing with dancing would yield more significant respiratory measures than tasks involving either singing or dancing alone. Although the study did not confirm this hypothesis, the data confirmed that aerobic and anaerobic respiration were used to compensate for the additional effort required. Anaerobic respiration coincides with increased blood lactate. On this basis, the authors speculate the potential for causative physical strain and injury. Stephens and Wyon (2020) also highlight the implications for choreography, especially a chorus line that maintains complex dance sequences for sustained periods, interspersed with singing both with and without dancing. To mitigate risks, choreography needs to allow for adequate recovery when singing and dancing or singing immediately after dancing.

Fitness instructors also phonate and exercise simultaneously, and a chain of evidence strongly

supports Stephens and Wyon (2020). Venkataram et al. (2023) argue that combined phonation and exercise further challenges the cardiovascular system. They assert that combining the two exacerbates cardiovascular strain. As the exercise intensity builds incrementally, a threshold is reached when the two become unsustainable, and vocal discomfort increases, accompanied by elevated blood lactate levels. In response, anaerobic energy sources are required to sustain the metabolic requirements, negatively impacting exercise performance. The study asserts that fitness instructors are likely to cross this threshold regularly. The increase in blood lactate levels found in Stephens and Wyon (2020) confirms similarities between the two professions. Venkataram et al. (2023) suggests the need for individual awareness of exercise intensity thresholds as an important strategy for mitigating harm. The study also argues that maintaining levels of cardiorespiratory fitness is an important factor in avoiding the consequences of detraining, where a complete loss of training adaptations occurs. It could tentatively be argued that there is a need for research into the extent to which musical theatre performers are at risk of detraining within the industry.

Earlier studies reveal that combined phonation and exercise increases blood lactate, blood pressure, and end-tidal CO₂ levels (Meckel et al. 2002). Within the Meckel et al. (2002) study, 14 research subjects participated in speech production tasks that required consistent and sustained phonation. While it differs from singing, it is still a worthwhile comparison as the research subjects were required to engage in sustained phonation while reading a passage, and the reading pace was set to a metronome. While it may not be comparable to singing, keeping pace with the metronome is similar to a singer keeping pace with a musical line. The research subjects performed the task at three intensity levels, equalling 65%, 75%, and 85% of the VO₂ max. The increase in blood lactate levels occurred only at the first intensity and the authors were unable to determine why, as they had anticipated an increase in blood lactate levels with increased intensity. While the conclusion called for further research, they confidently asserted that evidence of increased CO₂ levels (mild hypercapnia) was caused by hypoventilation resulting from decreased breathing frequency. The study concluded that although speech production can be sustained through intense exercise due to voluntary changes to breathing patterns, it may occur at the expense of efficient gas exchange and a compromise in

energy production. Tentative parallels can be drawn with Stephens and Wyon (2020), who detected increased blood lactate levels in their sample cohort. Both fitness instructors and musical theatre performers are engaged in regular, lengthy bouts of phonating while exercising, and further research is required to ensure adequate safeguarding.

Trained specialists are required to assess blood lactate levels in performers, making it difficult to assess the efficacy of a training strategy. The specialist equipment required limits its use to elite athletes where higher financial investment is available (Rodríguez-Marroyo et al., 2013). A recent study by Konstantopoulos et al. (2021) found that measuring Maximum Phonation Time can effectively detect increased blood lactate levels. According to the study, the blood lactate threshold was reached where the MPT had decreased to 9 seconds, and it recommends a 9.5-second screening cut-off. They posit that increasing CO₂ accumulation produces an urge to inhale, reducing MPT. Without an increase in breathing frequency, a rise in blood lactate levels is inevitable. If this study is applied to the earlier study of Sliiden et al. (2017), it is possible to speculate further. The study examines the impact of singing and dancing on the MPT of a sample of musical theatre performers, where the research subjects combined singing and dancing. The MPT dropped to 7.1 seconds, and if Konstantopoulos et al. (2021) were accurate, then the dancers in the Sliiden et al. (2017) study were physiologically compromised. It is plausible, although not conclusive, that the participants were experiencing an increase in blood lactate levels beyond the threshold level (4mmol/L). Further research with direct lactate measurements in musical theatre performers is needed to confirm this relationship.

Understanding the significance of blood lactate levels as a biomarker for training is contentious, as the production is integral to mitigating stress (Poole et al., 2021). The blood lactate threshold is used as a training methodology for enhancing physical endurance with training models that actively train athletes at their lactate threshold intensity and models that train below it for 75% of the time and above it for the remainder (Poole et al., 2021). Seiler and Kjerland (2004) recognise that these training methods rely on the organisation of training zones that lack physiological specificity. They advocate three training zones: a low lactate training zone, a lactate accommodation zone, and a lactate accumulation zone. With the latter zone, muscle fatigue is imminent due to inadequate clearance

mechanisms. According to this study and other endurance athlete studies, training below lactate thresholds for 75% of the time is crucial for endurance athletes. The study conducted by Konstantopoulos et al. (2021) could prove an important asset for quickly assessing physical endurance during both rehearsals and training, particularly if lactate accumulation zone training is used as a strategy.

This creates further implications for fitness training in musical theatre shows, as it raises questions regarding training performers as a group (Mahony, 2022). While the Mahony (2022) study focused on group training and performance anxiety, it provides evidence of the common practice of group training at the college level. Research is required to determine the need for individualised fitness programs balanced against the artistic demands of working and training as a collective during the rehearsal process and within educational settings. Individual role demands also factor into the training needs, providing other important issues for consideration (Zuim et al., 2023).

Research Question 3: What are the vocal demands placed on musical theatre performers when singing without dancing?

In addition to the physical challenges of musical theatre performance, performers also face demanding vocal requirements. Musical theatre performers are expected to master a broad spectrum of styles (Bourne et al., 2011) as it is an evolving fusion of many art forms and trends encompassing pop/rock belt to relaxed folk styles. This smorgasbord of voice qualities requires a multiplicity of vocal approaches. Contemporary voice research affords an evidence-based understanding of physiological, anatomical, and acoustic properties of a range of voice qualities (Echternach et al., 2014; Flynn et al., 2018; Kayes, 2015, 2019; McGlashan et al., 2017). In addition to the need for this knowledge base for the musical theatre voice teacher, there is a requirement for the performer to receive rigorous, expert training that provides a pathway to vocal flexibility and agility. While contemporary research affords an evidence-based understanding of physiological, anatomical, and acoustic properties of a range of voice qualities (Echternach et al., 2014; Flynn et al., 2018; Kayes, 2015, 2019; McGlashan et al., 2017), it does not diminish the need for rigorous, expert training and vocal flexibility and agility on the part of the performer.

Freeman et al. (2015) further confirms the demands of the musical theatre voice. The study examines the audition criteria for female musical theatre performers on Broadway and found that 84% of the musical theatre productions required belting, and over half of the belted notes were required on E5. In addition, when professionally engaged, the musical theatre performer is expected to deliver up to eight shows per week, alongside a demanding rehearsal schedule that involves multiple repetitions of specific sections of the score, thereby increasing the risk of vocal trauma (Zuim et al., 2023). Rehearsals typically focus on refining fine details, and the repetition of a small and often challenging frequency range can overburden the voices of soloists and ensemble cast members, leading to vocal trauma (Roll, 2016; Assad et al., 2017).

Exploring the concept of vocal loading is essential to assess its impact on vocal health. Hunter et al. (2020) categorised vocal loading as heavy, moderate, or light. Solomon (2008) identified vocal loading as problematic when phonation occurs at higher-than-normal frequency and intensity. Titze et al. (2007) describes it as the accumulated voicing within a set duration. Echternach et al. (2014) defines vocal loading capacity as the load a voice user can endure before experiencing a negative vocal impact.

The exposure of vocal fold tissue to vibration is referred to as the vocal dose. High vocal dosing leads to long-term changes in the vocal folds (Jiang et al., 2000), which impact voice production and increase the likelihood of voice disorders in the singing population (Pestana et al., 2017). It is caused by repeated stress on the vocal fold tissue (Toles et al., 2021), exacerbated by fatigue and persistent intraglottal pressure (Palaparthi et al., 2019; Titze et al., 2003). A baseline of safe vocal dosing for singers has yet to be established. However, the unpredictable demands placed on performers within rehearsal processes stress the need for greater granularity concerning specific musical theatre roles (Zuim et al., 2023).

If the vocal dose of each role and its potential impact was made apparent, musical theatre singers may be better equipped to manage their voices during rehearsals and performances using appropriate strategies. Directors, teachers, and performers could more effectively develop strategies to establish and maintain the vocal stamina required throughout rehearsals and eight performances per week.

Concerns regarding vocal health are corroborated by primary research. In an earlier

study regarding the levels of required laryngeal tension, as opposed to additional tension linked to vocal disorder, Koufman et al. (1996) found that musical theatre singers ranked in the top three musical genres requiring high laryngeal muscle tension (74%), after bluegrass/country and Western singers (86%) and rock/gospel singers (94%). Bretl et al. (2022) also found that musical theatre students were at a significantly higher risk of developing vocal health issues than students in other genres. The study examined the vocal pathologies of classical, musical theatre and contemporary commercial music at year one and year three of their undergraduate studies. While all genres experienced an increase in the number of vocal fold pathologies over the three-year longitudinal study, intense voice usage linked to the musical theatre genre was confirmed to be professionally problematic both prior to and at the end of training, reflecting previously voiced views that the demands of belt, mix, and legit are vocally challenging, requiring careful vocal hygiene and performance scheduling (Bourne & Kenny, 2016; Edwin, 2009; Green et al., 2014; LoVetri, 2002).

Excessive voice use is another factor in laryngeal tension (Roy et al, 2003). Laryngeal tension has been attributed to extraordinary voice demands and repeated use. The pressure on professional performers to use the voice as a vehicle for entertainment can lead to excess stress being placed on the vocal system, leading to eventual decompensation of the voice (Van Houtte, 2011). Professional voice users experiencing overwhelming pressure to perform can result in the use of excessive muscular effort to maintain vocal presence. This muscular overcompensation is called “hyperfunctional phonation” (Mathieson et al., 2009). Hyperfunction phonation causes problematic changes in vocal function, including the use of laryngeal muscles, both intrinsic and extrinsic, the articulatory muscles, as well as the size and shape of the resonators (Mathieson et al., 2009). The inappropriate function of the vocal tract muscles results in a range of unwelcome symptoms, including voice loss and hoarseness, difficulties with voice resonance, problems with pitch, an inability to sustain loudness, neck tightness, and vocal fatigue (Ahmadi et al., 2022; Sielska-Badurek et al., 2017).

Research Question 4: How do the vocal demands change when singing and dancing occur simultaneously or within proximity of one another?

In addition to the vocal challenges posed by the demands of the repertoire, a complex landscape emerges when we examine the combined impact of singing and dancing on vocalisation. Stephens and Wyon (2020) focus on the cardiovascular implications of the two combined, but there are also potential vocal implications of the two working in tandem. The study by Sliiden et al. (2017) is another significant addition to the field as it highlights the impact of dancing on vocalisation. The study raises concerns about musical theatre performers’ physical and mental well-being because of the challenges created by the incompatible demands of simultaneous singing and dancing. The authors argue that when the two activities are combined, oppositional forces are at work, undermining the capacity for vocalisation. The study was conducted on a sample of 20 students and Maximum Phonation Time (MPT) was measured, revealing a 65.2% drop in MPT when singing and dancing. The results highlight difficulties in engaging in singing during physically challenging performances. The complex interrelationship between tone, glottal adduction and subglottic pressure when singing requires the respiratory mechanism to constantly adapt to the changing lung volumes required to sing (Leanderson & Sundberg, 1988).

According to Estes (2020), combining physical exercise and phonation increases phonation threshold pressure and perceived phonatory effort. They argue that this leads to potentially unwelcome increases in laryngeal effort and hyperadduction of the vocal folds. Although there is further support for this claim (Andrews & Shank, 1983; Wolfe et al., 2002), neither study presents compelling evidence. Sandage et al. (2013) are more cautious in their claims. The small-scale study involving 18 participants tested the hypothesis that an eight-minute period of submaximal exercise would increase Phonation Threshold Pressure (PTP), perceived phonatory pressure, and decreased pharyngeal temperature. Zhuang et al. (2013) suggest that the PTP Phonation Threshold Pressure can indicate changes in voice production parameters, potentially leading to voice disorders or diseases. It does bear significance for those who phonate immediately after exercise, as the respiratory rate will remain elevated before the body returns to homeostasis. They highlight

potential applicability to fitness instructors who intermittently exercise and then use their voices to engage in verbal direction. It could also be applied to musical theatre singers, as Sliiden (2017) confirms a decrease in maximum phonation due to an increased respiration rate. Although the study's results confirmed the hypothesis, the researchers were cautious in their claims. Further studies are required to confirm whether the increased laryngeal effort and glottal closure forces create a higher risk of voice disorders. Although definitive claims cannot be made in this regard, raising awareness within the musical theatre industry of possible elevated risks of vocal misuse precipitated by simultaneous dancing and phonation could lead to changes in practice designed to mitigate adverse outcomes.

Much of the research relating to respiratory kinematics relates to the classical singer. Although there is little agreement as to how classical singers engage with respiratory techniques (Sand & Sundberg, 2005; Watson & Hixon, 1985; Watson & Hixon, 1990), there is some consensus that respiration is important (Solomoni et al., 2016; Thomasson & Sundberg, 1985; Thorpe et al., 2001; Watson & Hixon, 1985). There is also some agreement that classical professional singers initiate musical phrases at higher lung volumes (Thomasson & Sundberg, 1997; Watson & Hixon, 1990) to prepare for lengthy musical phrases at a loud volume (Leanderson & Sunberg, 1988), and this differs from country singers whose respiratory kinematics are closer to speech (Hoit et al., 1996). The dramatic drop in MPT highlighted by Sliiden (2017) demonstrates the challenges of singing and dancing at the same time. For legit styles, the performer may struggle to harness the pre-phonatory inward movement of the abdominal wall required to sustain lengthy musical phrases (Salomoni et al., 2016). Recent research also reveals sudden diaphragmatic contractions in downward pitch jumps (Traser et al., 2020); the diaphragm may play a significant role in singing phrases that contain pitch jumps. As musical theatre repertoire contains regular pitch jumps, significant respiratory control is required.

It is unclear whether the belt and neutral singing styles within musical theatre harness distinct breathing patterns. Sundberg and Thalen (2015) suggest that breathing strategy differences are absent when belting and that the differences between neutral singing and belt lie in the degree of glottal adduction and articulation characteristics. If this is the case, performers with a dramatic reduction in MPT due to dancing may struggle to maintain sufficient lung volumes (Hoit

et al., 1996) required for singing musical phrases regardless of style.

It is also difficult to cross-extrapolate respiratory research conducted on singers studied in a semi-supine position (Traser et al., 2020) because of the impact of gravity (Traser et al., 2021) on the respiratory system. That said, research consistently reiterates the importance of breath management on the control of subglottic pressure to ensure pitch accuracy and loudness (Leanderson et al., 1987; Traser et al., 2021), which is challenging to maintain with a significant reduction in MPT brought on by the combination of singing and dancing (Sliiden et al., 2017).

Venkataram (2023) highlights an increased risk of dehydration when engaging in dual exercise and phonation. The literature study focused on exercise instructors, arguing that intense exercise induces the need for mouth breathing, thereby increasing the risk of dehydration and phonotrauma. Mouth breathing is common in sleeping, loud reading, and exercise (Sivasankar & Erickson-Levendoski, 2012). Clinically, superficial vocal fold dryness is problematic because it increases phonatory effort (Vermeulen et al., 2021). Musical theatre performers may engage in exercise-induced mouth breathing, although research is needed to confirm whether this is the case. Sivansankar and Erickson (2012) evaluated 63 adults divided between a control and an experimental group and measured phonation threshold pressure and perceived phonatory effort for 15 minutes of mouth breathing without any additional activity, exercise during mouth breathing, and reading during mouth breathing in both low and high humidity. The study found increased phonation threshold pressure for mouth breathing during reading and exercise between both groups in low and high humidity. Neither the experiment nor the control group experienced increased perceived phonatory effort. The extent to which this study can be applied to musical theatre performers is questionable and possibly tenuous, but it highlights the need for further research. It would prove clinically useful to know how much hydration is compromised by the addition of mouth breathing induced by simultaneous dance routines and phonation.

There may also be overlaps with group fitness instructors and musical theatre performers regarding their freedom to hydrate regularly while working. In Rumbach (2013), group fitness instructors could not drink during 60-minute classes because of the pre-choreographed nature of the classes. There may be comparisons with

musical theatre productions and rehearsals, as these can last up to four hours (Zuim et al., 2023).

There may also be similarities regarding environmental pressures between the group fitness instructor population and musical theatre performers. Estes et al. (2020) analysed the phonotraumatic injury of 24 fitness instructors. They cited “teaching over music and other sources of noise and teaching in poor acoustic spaces” as an environmental factor contributing to phonotrauma (p. 2). Loudness levels in 65 high-intensity fitness classes averaged at 93.1 dB(A) (Beach et al., 2014), which, when paired with the Lombard Effect (involuntary increase in vocal loudness caused by the presence of background noise), further contributes to the risk and severity of phonotrauma. Comparing this to the limited literature available on musical theatre singers, Zuim et al. (2023) gives some insight into the variability of the rehearsal process where singers may be engaged in lengthy rehearsals with background chatter and repetitive cycles of practice that may or may not be accompanied by dancing.

Amplification is also an issue for fitness instructors, with many complaining of inconsistent amplification, a lack of knowledge of equipment, or amplification systems that do not work effectively (Davis, 2020). According to Estes (2020), this inconsistency exacerbated voice disorders in the research subjects. Amplification is now an important facet of musical theatre performance (Macpherson, 2019), and further research is required to establish the consistency of amplification, especially within a rehearsal context.

Research Question 5: What are the complex training needs for musical theatre performers to manage the simultaneous demands of singing and dancing?

Slidden et al. (2017) highlight the complex training needs of musical theatre performers because of the contradictory physiological demands of simultaneous singing and dancing. In addition to testing MPT, the study also conducted a questionnaire of all research participants agreeing that dancing negatively impacts the prosody and phraseology of singing. Seventy per cent of the 20 research subjects knew that repertoire required constant modification of breathing strategies for singing while dancing, and most respondents received little or inadequate training in this regard. Although rigorous research into training methodologies is scarce, a shared consensus has

emerged regarding the methodological contradictions of teaching singing, dancing, and acting (Hagen et al., 2017; Pulliam, 2009). Hagen et al. (2017) explore the confusion experienced by students who receive contradictory instruction relating to singing and dancing, echoing the earlier reflective work of Pulliam (2009), who recounts the distress of a student navigating the challenges.

This paper contends that the physiological constraints posed by singing and dancing simultaneously raises important questions relating to the complexities of triple threat performance. Musical theatre performers are not only vocal athletes (Freeman et al., 2015); they are physical athletes too (Stephens and Wyon, 2020), and sports science and physical fitness training need to be fused into the educational framework at conservatoire level and maintained throughout their subsequent performance careers. Without the requisite fitness, the performer cannot navigate the oppositional forces at work, and taught methodologies alone are unlikely to provide useful navigational strategies.

The questionnaire undertaken by Slidden et al. (2017) demonstrates that performers experienced a disconnect between the fitness required for a rehearsal and the fitness demands of a performance. The study corroborated Wyon et al. (2004), in which dancers similarly felt physically unprepared for performance demands. There is a pressing need for further research into current practice to ensure that safeguarding the profession can be optimised.

CONCLUSIONS

When concluding the discussion, it is important to acknowledge the quality of the studies before inferring generalisability. The methodology examines the limitations of the studies evaluated. Although it is impossible to draw firm conclusions, it is possible to speculate on potential applications for practice and garner further research.

Some evidence suggests that musical theatre performers require higher levels of fitness than other dance genres (Cohen et al., 1982b; Rimmer et al., 1981; Rodrigues-Krause et al., 2014; Shantz & Astrand, 1984; Wyon et al., 2016). Further research would help determine the best approach to coaching and facilitating maximal cardiorespiratory fitness while achieving a stylistic balance among all three components.

A recent systematic review (Tiemens et al., 2023) supports the need for regular cardiovascular

testing, and further research highlighting good practice could be beneficial, especially as a higher VO2 max is linked to lower injury levels (Biernacki et al., 2021). As a duty of care is owed to professional-level performers, training could be improved by incorporating standardised aerobic fitness and strength training at trainee and professional career levels.

Tentative conclusions can be drawn regarding the strenuous impact of combined singing and dancing due to reduced breathing frequency, recovery time, and increased blood lactate levels (Stephens & Wyon, 2020; Sliiden et al., 2017). Cross-disciplinary research into fitness instructors further supports this (Venkataram, 2023).

Konstantopoulos et al. (2021) have contributed significantly by providing a potentially valuable tool for measuring blood lactate levels that could easily be applied across training institutions and theatres. While further studies would corroborate the strength of this research, the test is easy to apply, non-invasive and does not carry any risks.

A broad spectrum of research demonstrates the vocal demands placed on musical theatre performers regarding technical challenges and repertoire (Bourne & Kenny, 2016). It provides insight into the vocal health risks endured by the demands of performing eight shows per week (Flynn, 2022). When singing is combined with dancing, the risk of harm is potentially exacerbated. It reveals the scale of the challenges for trainers to devise and implement effective pedagogical strategies and potential implications for choreography.

IDENTIFIED RESEARCH GAPS AND FUTURE DIRECTIONS

This review has also revealed several underexplored areas in the literature that warrant further investigation. While Sliiden et al. (2017) and Stephens and Wyon (2020) define and illuminate the gaps within the research, further longitudinal studies are required to address the cumulative and long-term effects of musical theatre performance. Further research is required to examine training models, rehearsal and performance environments. The following points provide greater specificity.

- Physiological studies measuring lactate accumulation, respiratory strain, or cardiovascular load in musical theatre

performers during performance would provide a significant contribution to the research. The landmark studies are both conducted within a short timeframe.

- The research on the cumulative effects of rehearsal and performance schedules on vocal health and physical endurance is currently limited. Longitudinal studies would enable a clearer picture of the risks posed to musical theatre athletes.
- Further research is required to explore interdisciplinary training models that integrate voice science, dance medicine, and performance pedagogy.
- Research into the environmental and situational factors, such as hydration, background noise, and amplification during rehearsals and performances.
- Further data on individualised training needs is required, particularly in relation to role-specific demands and physical capacities.
- Research is required to provide standardised metrics for vocal load, recovery, and safe vocal dosing within a musical theatre context.
- Practitioner research is needed to highlight effective fitness training practices. In turn, this could lead to standardised protocols that ensure physical health.
- Further research into training methodologies and good practice could enable a greater understanding of triple-threat demands.

Addressing these gaps through interdisciplinary, longitudinal, and practice-informed research would support the development of evidence-based training and safeguarding strategies. Such work is essential to ensure the health and sustainability of musical theatre performers.

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BIOGRAPHY

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APPENDIX

Table 2 Included Studies

Codes: QNT (Quantitative), QL (Qualitative), MIX (Mixed Methods), SYS (Systematic Review), NLR (Narrative Literature Review, ILR (Integrative Literature Review, ThP (Theoretical Paper), OP (Opinion Piece), REL Score (Relevancy)							
Study Name	Type	Score	Rel Score	Study Name	Type	score	Rel Score
Ahmadi et al., (2022)	QNT	35/42	2	Rodrigues-Krause et al., (2014)	QNT	35/42	2
Andrews & Shank (1983)	QNT	30/42	1	Rodrigues-Morroyo et al. (2013)	QNT	34/42	1
Angioi et al. (2009)	SYS	39/39	2	Roll (2016)	QL	35/42	1
Assad et al. (2017)	ILR	39/39	3	Roy, (2003).	QNT	38/42	2
(Beach et al., 2014)	QNT	34/42	2	Rumbach (2013)	QNT	28/42	2
Biernacki et al. (2021)	SYS	39/39	2	Sand & Sundberg, (2005)	QNT	33/42	1
Bourne et al. (2011)	ThP	N/A	1	Seiler and Kjerland (2004)	QNT	35/42	1
Bourne and Kenny (2016)	QL	28/42	3	Rimmer et al. (1981)	QNT	34/42	1
Bretl et al. (2022)	QNT	35/42	3	Shantz and Strand (1984)	QNT	34/42	2
Cohen et al. (1982)	QNT	34/42	1	Sielska-Badurek et al., (2017)	QNT	38/42	2
Dang et al. (2023)	SYS	39/39	3	Sivasankar & Erickson (2012).	QNT	35/42	2
Davis, (2020).	QNT	15/42	1	<i>Sliden et al. (2017)</i>	MIX	44/48	3
Echternach et al. (2014)	QNT	34/42	3	Solomon (2008)	NLR	17/39	3
Edwin, (2009)	OP	N/A	1	Solomoni et al., (2016)	QNT	33/42	2
Estes (2020)	QNT	35/42	3	Sundberg and Thalen (2015)	QNT	35/42	2
Flynn et al. (2018)	QNT	35/42	3	<i>Stephens and Wyon (2020)</i>	QNT	34/42	3
Freeman et al. (2015)	QNT	14/42	3	Tiemens et al. (2023)	SYS	39/39	3
Green et al., 2013	QNT	30/42	2	Thomasson & Sundberg, (1985)	QNT	35/42	2
Hagen et al. (2020)	QL	15/42	2	Thorpe et al., (2001)	QNT	35/42	2
Hoit et al., (1996).	QNT	35/42	1	Titze et al., (2003)	QNT	34/42	2
Hunter et al. (2020)	QL	33/39	1	Titze (2007)	ThP	N/A	2
Jiang et al. (2000)	ThP	N/A	1	Toles et al., (2021)	QNT	34/42	2
Kayes (2019)	ThP	N/A	1	Tomlin and Wenger (2001)	NLR	9/39	1
Konstantopoulos et al. (2021)	QNT	34/42	3	Traser et al., (2020)	QNT	34/42	3
Koufman et al. (1996)	QNT	34/42	3	Traser et al., (2021)	QNT	34/42	2
Leanderson & Sundberg, (1988)	ThP	N/A	2	Van Houtte, (2011)	NLR	39/42	1
Leanderson et al., (1987)	QNT	35/42	2	Venkatraman et al. (2023)	NLR	9/39	3
LoVetri (2002).	ThP	N/A	2	Vermeulen et al., (2021)	QNT	35/42	2
Macpherson, (2019)	ThP	N/A	2	Watson & Hixon, (1985)	QNT	34/42	2
Mahony et al. (2022)	Mix	44/48	1	Watson & Hixon,	QNT	34/42	2

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				(1990)			
Mathieson et al., (2009)	QNT	35/42	2	Wolfe et al., 2002;	QNT	34/42	3
Meckel et al. (2002)	QNT	34/42	3	Wyon et al. (2004)	QNT	34/42	2
McGlashan et al., (2017)	QNT	35/42	2	Wyon et al. (2007)	QNT	35/42	1
Palaparthi et al., (2019)	QNT	42/42	1	Wyon et al. (2016)	QNT	35/42	2
Pestana et al., (2017)	QNT	39/39	2	Wyon et al. (2018)	QNT	35/42	2
Poole et al. (2021)	ThP	N/A	1	Zhuang et al. (2013)	QNT	35/42	1
Pullam, (2009)	ThP	N/A	2	Zuim et al. (2023)	QNT	35/42	2