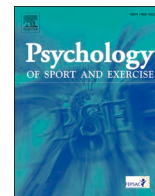




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Review

Dance and stress regulation: A multidisciplinary narrative review

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ABSTRACT

Background: Physical exercise is known to aid stress regulation, however the effects of specific exercise types are under-researched. Dance uniquely combines several characteristics that are known to have stress regulatory effects, such as music listening. Nonetheless, dance has received only little attention in studies examining the stress regulatory effects of exercise.

Objective: We used a multidisciplinary narrative review as a novel approach to explore the complex relationship between dance and stress by integrating psychological, neurobiological, physiological, and socio-cultural findings. In particular, we looked at the effects of music and rhythm; partnering and social contact; and movement and physical activity.

Findings: There is strong empirical evidence for the beneficial stress regulatory effects of music, social contact, and movement, illustrating that dance can promote coping and foster resilience. Neurobiological research shows that these findings can be explained by the effects that music, social contact, and movement have on, amongst others, dopamine, oxytocin, and β -endorphin modulation and their interplay with the stress system. Socio-cultural considerations of the significance of dance help to understand why dance might have these unique effects. They highlight that dance can be seen as a universal form of human expression, offering a communal space for bonding, healing, and collective coping strategies.

Discussion: This review is the first to integrate perspectives from different disciplines on the stress regulatory effects of dance. It shows that dance has a large potential to aid coping and resilience at multiple levels of the human experience. At the same time, we identified that the existing evidence is often still limited by a narrow focus on exercise characteristics such as intensity levels. This hinders a more holistic understanding of underlying stress regulatory mechanisms and provides important directions for future research.

1. Introduction

Chronic stress is seen as a major threat for physical and mental health (Marin et al., 2011; Wickrama et al., 2022). Scholars from the field of Sport and Exercise Psychology have examined and evidenced the beneficial stress-regulative effects of physical activity and in particular physical exercise¹ for decades (Aldana et al., 1996; Gerber & Pühse,

2009; Klaperski, 2017). Their findings form the basis for a multitude of guidelines and practical recommendations highlighting the importance of exercise to cope with stress (e.g., Anxiety and Depression Association of America, 2022; NHS, 2023). However, only a small minority of studies have actually examined the effects of *specific types* of exercise (Gerber et al., 2014; Norris et al., 1992). Correlational studies that examine the stress-regulative role of exercise do not usually differentiate

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¹ We follow the definitions provided by Caspersen et al. (1985) and define physical activity as “any bodily movement produced by skeletal muscles that results in energy expenditure” (p. 126). Two types of physical activity are exercise and sport; both require “planned, structured and repetitive bodily movement, the objective of which is to improve or maintain physical fitness” (Caspersen et al., 1985, p. 126). The terms “sport” and “exercise” are not always clearly distinguishable; however “sport” is often used to refer to competitive activities. In line with the review’s emphasis on non-competitive activities, we will subsequently focus on and discuss “exercise”.

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between different types of exercise but categorise participants as more or less active (e.g., Azagba & Sharaf, 2014; Yao et al., 2022). Experimental studies with specific exercise activities as intervention programmes predominantly use aerobic activities such as running or aerobic workouts but claim to draw conclusions about the effects of “exercise” (Arvidson et al., 2020; Klaperski & Fuchs, 2021). This leaves the field with only little knowledge on what particular types of exercise are most beneficial for stress regulation. This is a finding that is particularly surprising when considering the increasing evidence for the importance of individualised exercise recommendations (Schorno et al., 2022), as well as calls to move away from one-size fits all approaches in medicine and psychology (Purgato et al., 2021). We argue that this lack of attention on stress-regulative effects of individual exercise types could be a major oversight as different exercise types can have unique stress-regulative characteristics. Understanding these characteristics better could enable professionals to make more effective exercise recommendations. The aim of the current review is to contribute to a better understanding by providing an interdisciplinary synthesis of the stress-regulative role of dance.²

The current review will focus on dance as dance seems to have particularly stress-reducing and health-strengthening effects. Some of the few studies that did examine stress regulatory effects of different exercise types found dance activities to mitigate negative effects of stress especially well (Gerber et al., 2014; Kim & Kim, 2007). Hanna (2006) refers to dance as “a stress vaccine” (p. 38) and Buck and Snook (2020) regard dance as “a pathway to increased mental resilience” (p. 302). A recent systematic review of the effects of dance interventions furthermore noted a unique potential for mental health effects inherent to dance as a specific form of physical activity (Fong Yan et al., 2024). The authors differentiated between dance and other forms of physical activity and focused on psychological and cognitive health outcomes; they concluded that structured dance can improve some psychological and cognitive health outcomes more than other types of physical activity. Building up on these findings, the present paper will, for the first time, provide an in-depth overview of the literature on the effects dance has on stress, one of the major threats for mental and physical health (Wickrama et al., 2022). More specifically, we will provide a multidisciplinary review of psychological, neurobiological, and socio-cultural findings to answer the research question how some of the key characteristics of dance contribute to stress regulation, with a focus on coping and resilience.

1.1. Key characteristics of dance

When Gerber and colleagues (2014) found that dancing activities were able to buffer detrimental effects of perceived stress on mental health, they speculated that this might be the case because dancing can distract from stressors, warrants high task concentration, provides social contact with peers, fosters competence, autonomy and relatedness, and because dancing is enjoyable. While all explanations are reasonable, they also relate to many other types of exercise activities. Furthermore, they do not account for the distinctive socio-cultural significance dance is assumed to have. A more holistic understanding of the unique key characteristics of dance can be derived from the work conducted by anthropological scholars. Pušnik (2010) defines dance as “human expression through movement” (p. 5) while highlighting that dance

should not only be reduced to its physical component as it also bears many symbolic roles and meanings for society, as for instance seen in religious dance. Similarly, Hanna (2006, p. 33) regards dance as, to paraphrase her work, exercise plus aesthetic communication. Hanna (2006) highlights the unique opportunities for the expression of emotions, for the perception of close social ties and synchrony, and for interaction with music.

These descriptions of dance clearly go beyond the intensity level-based view of dance typically provided in exercise psychological or sport scientific literature. As an exception and possibly a sign for new endeavours in the field, the very recent review by Fong Yan et al. (2024) highlighted that dance “is a unique form of physical activity requiring complex movements combined with aesthetics, music, choreographed movement sequences and planned interactions with other people” (p. 2). Christensen and colleagues (2021) capture the key characteristics of dance in their *Wheel of Dance* that consist of six health-relevant intertwined components: Music & Rhythm; Group-cohesion & Culture; Aesthetics, fitness & technique; Connection & connectedness; Flow & mindfulness; and Emotion & Fantasy (p. 9). In our eyes, only a multi-disciplinary review can account for this complex interplay between *the mind, the body, and culture* in dance. In the following, we will thus summarise and integrate psychological, neurobiological and physiological, as well as socio-cultural findings exploring the complex relationship between dance and stress. Based on some of the key dance characteristics highlighted above, we will do so in three different sections: 1. Music and rhythm; 2. Partnering and social contact; 3. Movement and physical activity (see also Fig. 1 for a conceptual overview of the structure and content of this review). The three sections were chosen by the authors of this narrative review, assuming that these topics were the most relevant ones that touched on many of the characteristics and dance components previously identified; the review is thus not comprehensive as there are still other dance characteristics that can have a stress regulatory role (see also the *Discussion* below).

Dance not only has different characteristics, it is also being practised within very different domains (Christensen et al., 2021) – we refer to these as dance types. The review will focus on recreational dance, meaning dance undertaken during leisure time rather than for professional or competitive reasons. This is because these two types of dance have different, often opposite, effects on stress and its perception. Competitive dance often triggers stress, e.g., by means of performance-related anxiety, overtraining, or injury (Wainwright et al., 2005). We will furthermore not expressly explore dance therapy although it is an important and widely applied means of supporting people with long-term disorders such as Parkinson’s disease (Houston, 2019) or various forms of dementia (Palo-Bengtsson & Ekman, 2002; Palo-Bengtsson et al., 1998). Following a distinction made by Hanna (1979a, p. 332), we examine dance as aesthetic non-utilitarian movement. Thus, we will not focus on dance movements as part of religious or ceremonial dance; it is important to be aware that this decision already reflects the predominant meaning dance bears in many Western cultures (Hanna, 2006; Pušnik, 2010). The text will refer to “dancers” when discussing people engaging in any form of recreational dance, on their own or with a partner or group. Before reviewing the evidence in each of the three subsections, we will firstly introduce the concepts of stress and stress regulation from the three different angles of psychology, neurobiology, and anthropology.

1.2. Stress

Stress is a neurobiological phenomenon that alters the normal functioning of the body and brain, and requires multi-level coping with changing physical, chemical, psychological or social factors (stressors) to maintain the physiological range of balanced functioning (homeostasis). Homeostasis is a self-regulating dynamic phenomenon that maintains physiological stability in living organisms. In principle, external or internal factors or conditions that are beyond physiological

² Noteworthy, while we criticise the undifferentiated usage of the term “exercise”, it is also important to highlight that the term “dance” is in itself also still too general: “Dance is a broad umbrella term that encompasses a wide variety of styles from highly structured, planned movement sequencing to entirely unplanned, intuitive forms of body movement” (Fong Yan et al., 2024, p. 23) and of course also involves different music styles. Thus, our review is still a simplification of the subject; publications like the one by Christensen and colleagues (2021) provide further differentiation and specification.

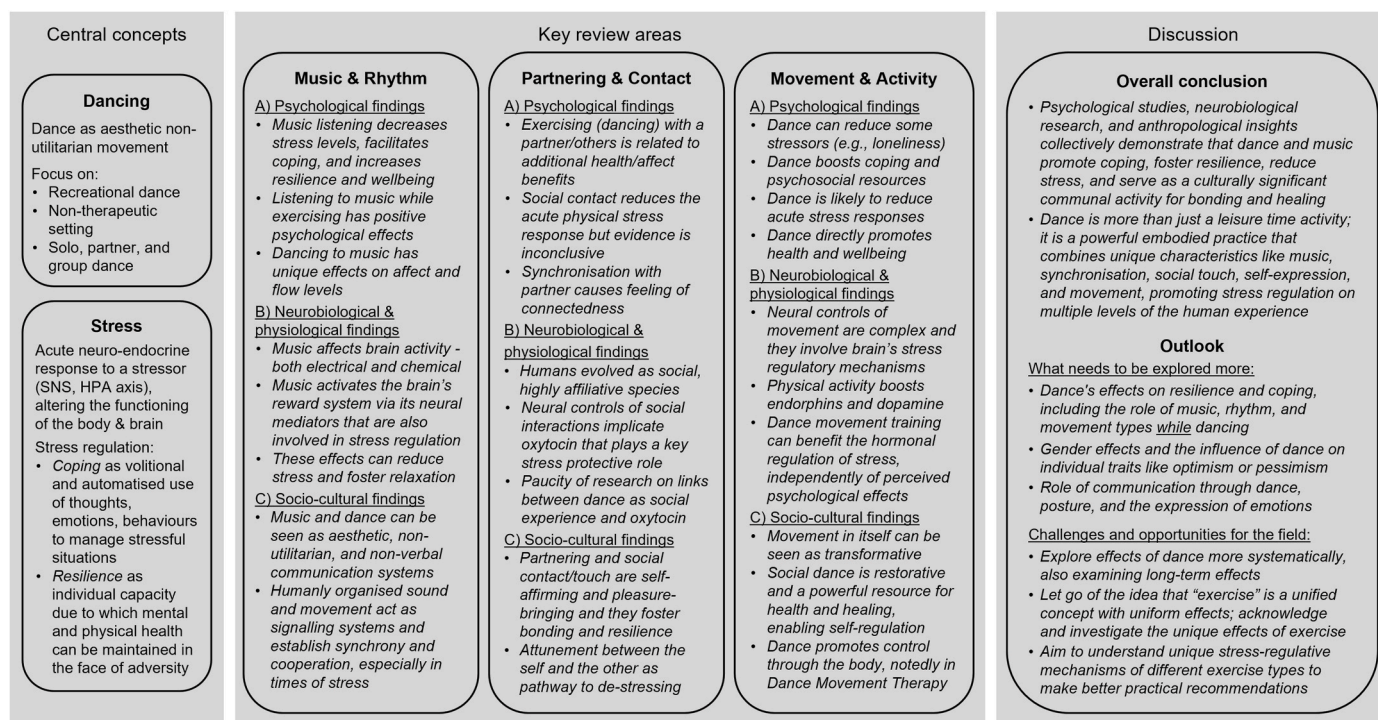


Fig. 1. Conceptual Overview of the Structure and Content of this Review

Note. SNS = sympathetic nervous system; HPA = hypothalamo-pituitary-adrenal.

or psychological control or perceived to be such can disrupt homeostasis and act as potentially harmful stressors when posing a challenge or threat to an individual (McEwen, 2017; Sapolsky, 2000; Ward et al., 2021, pp. 3–14). Organisms have developed different physiological responses to stressors; these responses restore the normal physiological and biochemical state and are essential for the maintenance of life. Thus, it is important to note that the physiological stress response is principally protective and/or adaptive (Sapolsky, 2000). However, long-term stress can break homeostasis and lead to physiological imbalances or even a disease in response to persistent stressors in the form of psychological, social, and cognitive stimuli (e.g., McEwen, 2017).

Even if the stress process comprises an inseparable combination of physiological, psychological, and psychosocial factors, stress initially depends on the acute neuro-endocrine response to a stressor (Hutmacher, 2021). This response entails the activation of the sympathetic nervous system (SNS) and that of the hypothalamo-pituitary-adrenal (HPA) axis (Herman et al., 2016). The SNS triggers an increase in blood pressure (systolic and diastolic) and heart rate, while the HPA axis executes an increase in circulating concentrations of cortisol as a main end-point hormonal responder to the stressor. As this review will touch on specific aspects of the HPA axis, we very briefly recall that it starts at its top tier - the hypothalamus where the corticotropin-releasing hormone (CRH) is released from the hypothalamic paraventricular nucleus (PVN) in response to stress. The CRH travels via the hypothalamo-pituitary portal system down to the anterior pituitary where it triggers secretion of adrenocorticotropic hormone (ACTH). The ACTH stimulates secretion of several steroid hormones from the adrenal cortex, among them cortisol that exerts a major impact on the body and brain's functional responses to stress. Currently, salivary cortisol is widely accepted as a biomarker of acute stress alongside alpha-amylase, often in combination with measurements of heart rate variability (Hellhammer et al., 2009; Kim et al., 2018). To follow patterns of long-term stress, some researchers also measure hair cortisol (Russell et al., 2012; Stalder et al., 2017).

While stress depends on innate biological mechanisms, it does not only "exist inside the brain" as Hutmacher (2021, p. 5) puts it. Stress,

Hutmacher (2021) highlights, is unthinkable without the way individuals relate to, interpret, and deal with their bodies' reactions. It is thus key to also consider the individual's subjective stress perceptions and cognitive, behavioural, and emotional reactions. These can be measured by means of self-report, e.g., by assessing perceived acute and chronic stress levels, anxiety, and health detriments. From a socio-cultural perspective, it is noteworthy that the understanding of one's stress response also strongly depends on society and social practices, expectations, and notions of stress itself. In modern society, stress has become an endemic condition, and Hutmacher (2021) claims that "being stressed out has become a way to be a person" (p. 5) as (Western) societies have developed intersubjectively understandable ways of relating thoughts and behaviour to the bodily experience of stress, and of dealing with or regulating stress.

1.3. Stress regulation

Empirical evidence shows that higher physiological stress levels and aggravated perceptions of stress amplify the negative effects of stress on health (Schulz & Vögele, 2015). Yet, research has also identified different neurobiological mechanisms that regulate the net response to stress as well as psychological and psychosocial factors that mitigate stress levels and negative effects of stress.

Among the biological processes that regulate the response to stress, there is a feedback mechanism via cortisol and glucocorticoid receptors signalling back to the HPA axis, including the hypothalamus (Pariante & Lightman, 2008). Also of relevance, β -endorphins, the brain's own (endogenous) opioid-like modulators, are closely linked with the response to stress. In more detail, CRH that initiates the HPA axis also triggers the release of β -endorphins alongside ACTH within the anterior pituitary (Nakao et al., 1978). In turn, β -endorphins being opioid receptor agonists co-regulate the HPA axis (Bilkei-Gorzo et al., 2008). As a rule, opioid agonists buffer the cortisol response to stress (Drolet et al., 2001) contrary to opioid antagonists (Kreek, 2001; Lovallo et al., 2012). The link between the response to stress and β -endorphins is so close that β -endorphins are at times used as a possible index of HPA activity (Takai

et al., 2007). Furthermore, the neuropeptide hormone oxytocin has been found to play a stress regulatory role. In response to various stimuli, including sensory stimuli such as touch and warmth, oxytocin is released into the general circulation from the posterior pituitary gland (Uvnas-Moberg & Petersson, 2005). Oxytocin facilitates social and emotional behaviour in humans and rodents, including enhancement of trust and bonding, and reduction of aggression and anxiety (for review see Heinrichs & Domes, 2008).

Beyond such biological mechanisms, in this review, we refer to *stress regulation* as an overarching term for two protective factors which alter and reduce negative effects of the response to stressors: *coping* and *resilience* (Crum et al., 2020; Maiorano et al., 2020). *Coping* can be defined as the volitional and automatised use of thoughts, emotions, and behaviours to manage internal and external stressful situations (Stanislawski, 2019). Its main purpose is the reduction of the stress response (Crum et al., 2020). *Resilience* can be defined as an individual's capacity due to which physical and mental health can be maintained also in the face of stress and adversity (Rademacher et al., 2023; Wu et al., 2013). Resilience levels can be increased by strengthening physiological, psychological, and/or psychosocial factors (Zueger et al., 2023). Naturally, coping and resilience are closely associated: coping efforts affect an individual's resilience, and a person's resilience affects their coping strategies (Ward et al., 2021, pp. 3–14). Resilient individuals are, for instance, more likely to remain optimistic and execute effective coping strategies in health and disease (Haglund et al., 2007).

Previous evidence has shown that individuals use exercise as a coping strategy, i.e., they intentionally engage in exercise to manage stress (Elliott et al., 2021). Exercise can also lead to increases in resilience levels, enabling individuals to better overcome stressful events (Arida & Teixeira-Machado, 2021; Lancaster & Callaghan, 2022). However, little is known about the mechanisms that underlie this relationship, i.e., what particular physiological, psychological, and psychosocial factors are strengthened by what characteristics of exercising. It is key to better understand these mechanisms to make better use of stress regulatory processes initiated by different types of exercise. In this review, we will therefore explore whether and in what way one particular type of exercise, namely dance, can strengthen resilience levels and be used as a coping strategy to help regulate stress.

While the concepts of coping and resilience stem from psychology, research in this area has also become a focus of physiology and neuroscience, integrating psychosocial and biological factors (Rutter, 2006). Following a multidisciplinary approach, we will therefore present neurobiological findings to better understand the biological basis of the psychological phenomena. Studies have for instance found that differences in coping styles are related to variations in the serotonergic and dopaminergic inputs to the medial prefrontal cortex (Algorani & Gupta, 2023). The neural network of this part of the brain is essential for behavioural flexibility as an attribute of an individual's coping style (Coppens et al., 2010). In addition, the prosocial neuropeptide oxytocin, which is an important anxiolytic neuromodulator, and its counterpart vasopressin, have been implicated in coping styles (Algorani & Gupta, 2023), and oxytocin has been found to be associated with resilience (Yehuda et al., 2006). It is plausible to expect that studying the effects of dance on such biomarkers for resilience, a contested concept in psychology (Rademacher et al., 2023), might reveal what factors related to dance enable a person to better regulate stress. A simultaneous consideration of the socio-cultural perspective will furthermore provide a comparative point of view on what dance means and what dance does for the so-called social dancer. Drawing from the literature on the anthropology of dance, this review engages with the context of dance in the community and in wider society, also considering dance as an act of enjoyment and passion, and as self- and group-expression. This allows us to explore coping and resilience as core concepts of stress regulation in a variety of locations and diversity of dance forms (also referred to in the literature as *movement systems*).

2. Method

The aim of the current review was to provide an interdisciplinary synthesis of the stress-regulative role of recreational dance. More specifically, we wanted to summarise psychological, neurobiological, and socio-cultural findings on the links between stress, coping, and resilience and; 1. Music and rhythm; 2. Partnering and social contact; 3. Movement and physical activity. Considering the goal and the multidisciplinary approach described above, a narrative review approach was adopted.

Narrative reviews allow one to examine a complex topic from different perspectives to develop new insights by delivering a general overview and thoughtful interpretation of the current body of knowledge (Sukhera, 2022). Our review can be best identified as an empirical integrative narrative review, as classified by Sukhera (2022). While this review approach allows for the incorporation of diverse methodologies and perspectives, it bears a risk of bias when not all relevant sources are identified (Whittemore & Knaf, 2005). To reduce this bias, we first tried to search in a centralised, systematic way for literature that looked at *dance* and *stress*. We intended to develop an article collection with all relevant literature, to then derive psychological and/or neurobiological and/or socio-cultural insights that would be synthesised in the corresponding subsections. However, upon closer examination of the identified literature, we realised that the sources were not sufficient to answer the research question of this review (see the Supplementary Online Material for a detailed description and the outcomes of the initial search). There were fewer studies that had examined stress regulatory effects of recreational dance than we had anticipated. We thus decided to adopt a more subjective subsection- and discipline-specific, decentral iterative and purposive search strategy to identify relevant literature (Sukhera, 2022). The goal of the adjusted scope of the review was to not specifically search for “dance” literature anymore, but to also identify and synthesise relevant literature that did not address dance as a specific activity (e.g., studies examining the effects of movement in synchrony without a dance-link).

This altered approach meant that each author writing on a subsection purposefully searched for and synthesised literature that related to their discipline and the topic of a subsection. This was done by a) examining the sources identified in the initial centralised literature search, b) examining sources already known to the authors as experts in the field,³ and c) searching for additional literature using a much broader search strategy. For the latter, different databases (see the Supplementary Online Material) mainly with the keywords “dance”, “music”, “rhythm”, “partnering”, “social contact”, or “movement” in combination with the keywords “stress”, “coping”, or “resilience” were used, as well as backward and forward snowballing. Considering the breadth of this adapted search strategy, it was not feasible to screen all abstracts and to exclude studies in a systematic manner. The focus that we had adopted initially remained however unchanged, aiming to review published academic evidence (stemming from journal articles and books) on non-clinical samples and recreational dance; a few exceptions were made to make important points, e.g., links to research on Parkinson Disease or Dance Movement Therapy.

The literature search and synthesis approach described above allowed us to deliver a relevant multidisciplinary overview that answers the research question of how key characteristics of dance contribute to stress regulation, with a particular focus on coping and resilience; yet, it is important to explicitly recognise that we might not have identified and/or included all relevant literature on the topic (Sukhera, 2022). The current review therefore does not provide a comprehensive synthesis, instead it should be regarded as a first interdisciplinary interpretation of the evidence on the stress regulatory role of dance that aims to advance

³ In the peer review process, several additional sources were included based on the reviewers' expertise in the field. This also illustrates that a different author team might have included different studies in their review.

new ideas and research foci (Sukhera, 2022; see also the *Discussion* below). In the following, we will review our findings separately for each discipline for each of the three subsections. In the subsequent discussion section, we will summarise and integrate the results of the review. Please consult Fig. 1 for a brief summary of the main points of each of the separate sections.

3. Music and rhythm

This first section of the review considers music and rhythm as two key aspects of recreational dance, as seen from the multidisciplinary perspective of psychology, neuroscience (neurobiology and physiology), and anthropology (socio-cultural perspective). We acknowledge that music is inherently linked to the body (Putkinen et al., 2024) and as such has potent and well documented effects on the response to stress and its perception, depending on the type of music. Even passive listening to music can have relevant physiological and psychological effects. In some aspects, the unique role of rhythm appears to be less researched than the role of music. Yet, it needs to be acknowledged that dance and music are closely interconnected, and that in particular in a dance context with rhythmic music a clear differentiation between the two concepts is difficult (Orgs & Howlin, 2020).

3.1. Psychological findings

While music plays a pivotal role in dance, there are a lack of studies examining the stress-regulative effects music and/or rhythm have while engaging in dance. To gain deeper insights into these potential effects, we will first scrutinise research concerning the impact of music listening on coping and resilience factors in general. Subsequently, we will synthesise findings on the psychological effects of music listening while dancing.

Whether music can improve coping in challenging situations has been researched by examining the effects of music listening on the acute stress response to artificial stressors. Thoma et al. (2013) did not find support for the assumption that music listening *in anticipation* of an artificial stress task (the Trier Social Stress Test) would reduce the acute psychological stress response to the stress task. Labbé et al. (2007), however, found that participants who listened to self-selected relaxing or classical music *after* being exposed to a stressful cognitive speed test reported lower anxiety levels and more feelings of relaxation than participants who had listened to heavy metal music; participants who had not listened to any music also reported higher state anxiety levels, yet, their relaxation ratings were similar to the self-selected and classical music conditions (Labbé et al., 2007). A review on the effects of music on stress-induced arousal likewise found support for a reduction in arousal, anxiety, and/or stress levels when participants who were exposed to artificial stressors listened to music (Pelletier, 2004). Thus, while the existing evidence regarding the effects of music on the acute stress response is not fully consistent, music has been found to possess the potential to positively contribute to the coping process.

Another branch of studies has tried to answer the question whether listening to music can improve mental health and well-being, e.g., by examining effects on stress and anxiety levels (Corbijn van Willenswaard et al., 2017; Pelletier, 2004). The evidence shows that music-based interventions can indeed have positive effects. Two large reviews looking at patients concluded that music interventions can lead to reductions of psychological distress in individuals with coronary heart disease (Bradt & Dileo, 2009), as well as decreases in anxiety levels in cancer patients (Bradt et al., 2016). Corbijn van Willenswaard and colleagues (2017) found no clear evidence that listening to music for at least 30 min a day for 2 weeks significantly reduced general stress levels in pregnant women. However, the authors did find that music-based interventions reduced anxiety levels. Overall, there are fewer reviews examining stress-regulative effects of passive music listening in non-clinical populations. Yet, when considering a review of findings in non-medical and

medical settings by de Witte et al. (2020), a similar result pattern for both settings emerges. The authors found, irrespective of the setting, an overall significant medium-to-large effect of music interventions that were found to have positive effects on both physiological arousal and psychological stress-related experiences. More specifically, music interventions reduced state anxiety, nervousness, restlessness, and feelings of worry, as well as salivary cortisol levels, heart rate, and blood pressure, with overall larger effects for heart rate compared to blood pressure and hormonal levels (de Witte et al., 2020). These positive effects were found for predetermined relaxing music as well as for self-chosen music, for instrumental music, music with lyrics, and for music therapy as well as music interventions; yet, most studies used only short-term interventions.

In their discussion, de Witte et al. (2020) present two different psychological explanations for the observed effects: first, that listening to pleasant music could have a positive influence on emotional valence; and second, that music could potentially distract from stress-increasing thoughts and thus have positive effects. Interestingly, findings of an ambulatory assessment study on the stress-reducing effect of music conducted by Linnemann et al. (2015) do support neither of these two explanations: while music listening reduced subjective stress levels when participants listened to music to relax or when they listened to music in the presence of others, these effects were *independent* of the music's valence or arousal; the reason to listen to music for distraction was even associated with *increased* stress levels (Linnemann et al., 2015, 2016). Overall, it can thus be concluded that passive listening to music has positive psychological effects. It can also lead to decreases in stress levels, in particular when participants listen to music to relax or when it is done together with others. The majority of studies thus provide additional support for the assumption that music facilitates coping and that it increases resilience levels by strengthening important health and well-being factors; however, studies examining these effects in the dance setting are currently lacking. Similarly, it is not well-understood what role rhythm, as an important temporal quality of music, plays for the stress-regulative effect found for music listening (Kim et al., 2018; Levitin et al., 2018). Empirical findings from the field of music therapy suggest that dynamic rhythmic entrainment processes could be of particular importance: in 2018, Kim et al. found a larger psychophysiological relaxation response when relaxation music was matched with a listener's heartbeat, with the tempo gradually decreasing, compared to a condition in which relaxation music was played at a fixed beat. Yet, overall, the existing evidence is sparse; more and larger studies are needed to explore the particular stress-regulative role of rhythm (Kim et al., 2018).

Even more insightful for this review than studies on the effects of music listening are studies that examined the stress-regulative effects of music while dancing. Although a whole line of research investigates the effects of music listening on exercise-related outcomes (e.g., Ghaderi et al., 2009; Karageorghis & Priest, 2012; Patania et al., 2020; see the Supplementary Online Material for more details), we identified only two relevant studies that specifically examined dance.

The first study investigated the influence of music on emotional and hormonal responses in partnered dance (Murcia et al., 2009; see also the *Partnering and social contact* section below). The authors used four different experimental conditions, of which two were dancing with a partner with music, and dancing with a partner without music. They found that dancing with a partner and music had more positive effects on positive affect than dancing with a partner without music. Furthermore, the music condition also led to higher reductions in salivary cortisol. The contrast to earlier findings from Rohleder et al. (2007), who found increases in cortisol concentrations in ballroom dancers, can very likely be explained by differences in the setting: while Murcia et al. (2009) investigated the effects of dancing for the purpose of enjoyment, Rohleder and colleagues (2007) investigated a high social evaluative threat situation in a competitive dance setting.

The second study that examined stress-related effects of music while

dancing was conducted by Bernardi et al. (2018). They found that dancing to “groovy”⁴ music (e.g., *Superstition* from Steve Wonder, see Bernardi et al., 2018) “produced a distinct state of heightened flow, which was not present when the same music was listened to without engaging the body” (p. 421). Regarding the experience of feelings of joy and power, it did not matter whether participants were dancing or only listening to groovy music. Nongroovy music (e.g., *What a wonderful world* from The Innocent Mission, see Bernardi et al., 2018) also had positive effects on the sense of flow, irrespective of whether participants were listening or dancing to it. Interestingly, copying groovy dance moves without music led to some feelings of joy and power, but participants did not experience any flow, while the copying of non-groovy dance moves without music did not have any positive effects (Bernardi et al., 2018). That the different study conditions led to such different outcomes nicely illustrates that dance influences music perception and that music influences dance perception (Orgs & Howlin, 2020). Bernardi and colleagues (2018) conclude that types of movement and types of music which are perceived as groovy have positive effects on individuals’ feelings, and that only the combination of these two in the form of dancing can also create a feeling of flow; they define flow as a unique and strongly rewarding experience of deep absorption and focused attention (Bernardi et al., 2018). The ability of dance and certain (groovy) rhythms to evoke feelings of flow possibly represents another way to foster resilience given that flow has been found to be positively associated with eudaimonic well-being and life satisfaction, and negatively associated with anxiety (Mao et al., 2020).

3.2. Physiological and neurobiological findings

The previous section showed that music listening supports positive emotion regulation, and that it evokes states related to pleasure and reward. Neurobiological studies demonstrate how neural systems, such as the brain’s reward pathway, contribute to these psychological effects (Salimpoor et al., 2011; Yehuda, 2011; Zatorre & Salimpoor, 2013). The reward pathway implicated in the processing of reward and pleasure, includes the mesolimbic and mesocortical structures with the nucleus accumbens (NAc), the ventral tegmental area (VTA) and the prefrontal cortices; they use dopamine as the main neurotransmitter. Brain research by means of positron emission tomography (PET) has demonstrated that dopamine is released in response to pleasurable music (Salimpoor et al., 2011). The observed dopamine release within the reward pathway is associated with strong emotional responses to music. This is interpreted as evidence of a neural mechanism underpinning the pleasurable and rewarding effects of music and could be seen as a physiological incentive to dance (Salimpoor et al., 2011). Functional connectivity analysis conducted by Menon and Levitin (2005) has furthermore demonstrated that listening to music modulates the activity within the dopaminergic network involved in reward processing, and specifically the NAc and the VTA, but also the hypothalamus that is involved in the regulation of body homeostasis and the response to stress.

The fact that music stimulates the brain’s reward system is of relevance to stress when considering the neural mediators implicated in both music perception and stress responses. Among those, there are β -endorphins from the group of endogenous opioids that, together with the neurotransmitter dopamine, play a role in the regulation of behaviours generated by the brain’s reward system related to pleasure, reward and motivational states. Those effects can reduce stress and result in an enhanced state of well-being associated with β -endorphins (Veening &

⁴ Levitin et al. (2018) characterise groovy music as music that compels somebody to move along with it. When moving to groovy music, people “become aware of its rhythmic flow, and groove is manifested as the kinematic feeling arising from one’s embodied experience of entrainment to the music” (Levitin et al., 2018, p. 64).

Barendregt, 2015). Such behavioural effects are consistent with the fact that β -endorphins are closely linked with the HPA as briefly addressed in the section on *Stress regulation*. The understanding that music and rhythmic stimulation can activate the brain’s reward system and, as a result, reduce stress, informs and justifies the use of rhythmic music in neurorehabilitation (Kotchoubey et al., 2015).

Noteworthy, music perception is a complex task for the brain as it implicates not only the brain’s reward systems but also other separate and overlapping cortical networks necessary for the integration of melody, harmony, pitch, rhythm, and timbre (e.g., Schmithorst, 2005). Rhythm is a very important element of music and dance. It is appropriate to recall that rhythms are ubiquitous in the natural environment and that they are important innate elements of life. Hence, it is plausible to expect cross-species responses to musical rhythms or music with a beat. An earlier neuroimaging study on the neural basis of human dance demonstrated a synchronised interaction of the brain network during spatially patterned rhythmic movements of dance (Brown et al., 2006). Beat perception and synchronisation are common in humans; innate beat synchronisation has even been observed in human newborn infants (Winkler et al., 2009). But beat synchronisation is also displayed by nonhuman animals, including rats; the latter recently studied in depth by the Takahashi group (Ito et al., 2022). Their well-publicised study reports that both the rat and human participants had optimal beat synchronicity based on the head movements and neural recordings, which suggests similar neural mechanisms for beat synchronisation in rats and humans (Ito et al., 2022). In line with these findings, theories state that the perception of and synchronisation with external and internal rhythms are vital for the survival of organisms. Hence, music and dance evoke rhythm-related rewards and emotions that have both biological and social functions (Wang, 2015). Further research is needed to understand the role of dance rhythm in stress regulation from the neurobiology perspective.

Yehuda (2011), while broadly reviewing the role of music in stress, draws attention to the fact that electrical activity in the brain is affected by listening to music. Studies found that relaxation techniques as well as relaxation music can increase alpha waves (6–12 Hz) appearing during relaxation and theta waves (4–7 Hz) that are observed during deep relaxation (Yehuda, 2011). It is also of relevance that most of the limbic brain subregions that are involved in responses to music, such as the cingulate cortex, hippocampus, and amygdala (Harvey, 2020), have a pronounced presence of oxytocin fibres and high levels of oxytocin receptors (cited after Harvey, 2020, also Landgraf & Neumann, 2004). Although there is a scarcity of studies directly addressing the role of oxytocin in responses to music, it has been demonstrated that listening to slow-tempo and fast-tempo music was associated with an increase in salivary oxytocin levels and a decrease in cortisol, respectively (Ooishi et al., 2017). The authors interpret that changes in oxytocin and cortisol linked to music listening play a role in physiological relaxation and emotional excitation, respectively (Ooishi et al., 2017). Such findings provide important neurobiological explanations why music interventions and music therapy can be successful in stress-related health conditions (de Witte et al., 2020, 2022). Of broad relevance, frequently published measurements of heart rate (HR) and heart rate variability (HRV) as the physiological indicators of the activity of the peripheral autonomous nervous system confirm that various genres of music reduce or increase those parameters of which HRV is used as an indirect indicator of stress.

3.3. Socio-cultural findings

The psychological findings reviewed above provide evidence that music and rhythm have unique beneficial stress-regulative effects, and the neurobiological findings give important insight into potentially underlying physiological mechanisms (see also Fig. 1). However, it remains unknown why music has these unique effects. A review of socio-cultural findings within the realm of music, rhythm, and stress can

provide important answers to this question to advance the understanding of the socio-cultural importance of music and rhythm.

Anthropological considerations present a diversity of disciplinary positions on this subject, ranging from socio-cultural to more evolutionary perspectives. Contemporary psychologists and biolinguistics specialists note that hominids have a propensity and predisposition for sound pattern recognition and production – a "preparedness of our neural system" (Ravignani & Madison, 2017, p. 3) whether trait by evolutionary adaptation or by-product by evolutionary exaptation. The anthropologist and discipline-founding ethnomusicologist John Blacking, in his groundbreaking work in the 1970s that predates this new field of biomusicology (Ravignani et al., 2014), states that music is "humanly organized sound" (Blacking, 1973, p. 32). The ability to produce and understand sounds that are considered as standard "physiological and cognitive processes" (1973, p. 7) presumed by Blacking to be genetically inherited faculties: structured sounds are perceived through instances of structured listening such as ritual performances amongst the Venda of South Africa or England's English Symphony Orchestra. Similarly, humanly organised sound leads to "soundly organised humanity", so Blacking (1973, p. 89) concludes, arguing that the relationship between the production and interpretation of sound is akin to that of the production and regulation of society. Bond (2008) makes similar assumptions in her study of sensory impaired infants. Working to disentangle the relations between dance and biology, she suggests that sound and movement relate to the formation of "aesthetic community". They are the building blocks of society, Bond (2008) postulates: ritualised vocalisations, and sounds and movements that externalise private experiences and feelings into a public world of shared meanings and understandings. The habitual, regulated self-expression of somaesthetic knowledge – body receptivity as *aisthesis* – can be found cross-culturally as well as across the lifespan. It is typically tied to music, but not necessarily, with some movement systems such as site-specific dance focusing upon the external place of movement rather than a connection between sound and movement (Hunter, 2011). Mime would be a similar example of physical expression and aesthetic non-verbal communication less closely tied to sound, or the more rhythmic movements of Japanese *butoh* (Fraleigh, 1999). However, while the above positions can all be argued for, most of them remain speculative in the end.

Adopting an evolutionary perspective, Ravignani (2019) proposes rhythmic cognition as a function of evolution, for example via sexual selection. Synchrony by sound and movement could offer evolutionary adaptational advantage and group stressor-prevention, or the potential to uncover what Ravignani (2019, p. 78) refers to as "rhythmic phylogenies" in classifications of animals from the songs of the zebra finch to the staccato hooting of the bonobo. Distinctions between communication and music in non-human animals are notoriously difficult to maintain, especially with music's design features such as isochrony (regular pulse or beat), instrumentality ("sound tools"; Nettl, 1983), intentionality, and performative contexts. The difficulty of the evolutionary perspective is that it leaves out the arts-based aesthetic (Fink et al., 2021, p. 351) and potentially produces "untestable just-so" stories of the past (Fitch, 2006, p. 207) with its "rhythmic complexity" (Morley, 2012). Ravignani requests future research still isolate "the genetic and neuro-hormonal biological substrates responsible for perception and production of isochronous behaviour in humans as well as other animals" (Ravignani & Madison, 2017, p. 9); yet, while this will undoubtedly give clarity in the social understanding of stress systems and stressor relief, it also reflects that the scientific quest upon which the above community-related propositions rest is still unfound.

Ethnographically, and from a social constructionist perspective, both music and dance are "nonverbal communication" systems (Hanna, 1979b). They are "performative modes of thought" as bodily intelligence exercises an exteriority of the self and group (cf. (Grau, 1999, p. 166). Hagen and Bryant (2003) press for an approach to dance as functional in terms of a socio-cultural explanation for the role of music – and dance – in society. The authors explain that music and dance can be seen as

aesthetic, non-utilitarian and sometimes pre- or proto-linguistic communication systems that derive from the need for alliance formation between non-group members. For Hagen and Bryant (2003), music and dance are coalition signalling systems that developed during activities such as war and politics. Thus, music serves to establish wider alliances and to subsequently maintain social cohesion and internal stability that ultimately give onto a group protection from environmental stressors. Complex rehearsals and performances necessitate close group interaction as rhythm is articulated, such as the "social rhythm" found in Brazilian Candomblé (Sjørølev, 2013); the "communitas" (Turner, 1969) of traditional and modern dance events; and the hyper-density and solidarity of togetherness, collaboration or intimacy between artist and audience (Chrysagis & Karampampas, 2017, p. 9). Moreover, music – and dance – can easily be appreciated and decoded by even wider audiences (Hagen & Bryant, 2003, p. 30) (an additional example is provided in the Supplementary Online Material).

4. Partnering and social contact

Dance provides not only physical activity, motor coordination, and sensory and emotional responses to music and rhythm. Many types of dance also involve forms of physical or social contact and partnering: touch, social interactions, group entrainment, or movement in synchrony – all leading to a perception of togetherness, i.e. joint agency as a social unit (Cross et al., 2024; Phillips-Silver & Keller, 2012). The broad attractiveness, sense of social cohesion, and significance of social contact in human lives motivate people across various ages to dance with others (Coogan et al., 2023; Qu et al., 2023). This section is focused on partnering and social contact in dance as those key aspects uniquely add to the constellation of dance features as a form of complex activity that extends well beyond physical exercise or expression of movement tuned to music and rhythm.

4.1. Psychological findings

The presence of and connection with others in leisure time dance activities, from line dancing to nightclub clubbing, is considered to be an important factor for the stress regulatory effects attributed to dance (Garcia-Mispireta, 2023; Nadasen, 2008; Tarr et al., 2015). Yet, there is not a lot of evidence on stress-related psychological effects of partnering and social contact in dance. One of the few experimental studies that examined the effects of social contact in dance more systematically is the one by Murcia et al. (2009) that has already been described above. The authors found that dancing tango without a partner but with music did not have the same beneficial effects on affect as dancing with a partner and music. On a descriptive level, having no partner resulted in even lower positive affect levels than having no music, yet, the difference between the two conditions was not statistically significant. Cortisol levels also decreased when participants were dancing without a partner, yet not as much as in the partner-tango condition (Murcia et al., 2009). However, it can of course be argued that dancing tango without a partner is quite unusual and that it is thus no surprise that not the same beneficial effects as in normal tango dance emerge.

Instead of looking at the losses when a partner is removed, it is therefore also interesting to look at the gains when a partner or social contact is added. Unfortunately, we do not know of a study that systematically examined such gains in a dancing context, but several studies found benefits of exercising together with a partner for other exercise types. Sackett-Fox et al. (2021), for instance, found that participants experienced higher positive affect when exercising with their romantic partner than when exercising alone. Stress levels were not examined, yet higher positive affect levels are regarded to strengthen well-being and thus also play an important stress regulatory role, possibly fostering resilience levels (Lyubomirsky et al., 2005). Other studies likewise found exercise to have more beneficial health effects when performed together with others (Kanamori et al., 2016) or as part

of a sports team (Eime et al., 2013). It is hypothesised that strengthened social factors cause these additional health benefits, for instance an increase in levels of social connectedness or social support. Remarkably, these social factors have received only little attention in studies examining the stress regulatory effects of exercise (Plante et al., 2001), and a distinction of exercise or group exercise is usually not made in experimental studies (e.g., Klaperski & Fuchs, 2021), impeding meaningful inferences.

In addition to studies examining the effects of social contact while exercising, studies investigating the effects of social/partner support on the acute stress response can provide insights into the importance of social contact and/or touch for stress regulation. While several studies in this area found that social support by a partner and/or stranger decreased the acute physiological stress response, they found no differences regarding the acute subjective stress response (Ditzen et al., 2007; Kirschbaum et al., 1995) or state anxiety levels (Ditzen et al., 2007). The findings by Kirschbaum et al. (1995) furthermore point towards sex-specific patterns of the effects of social support, as only men showed reduced physiological stress responses when supported by their partners (stranger support did not have this effect). Ditzen and colleagues (2007) did find positive effects on the physiological stress response in female participants, yet only in the case of physical contact, not when male participants provided their female partners with verbal social support (all examined participant dyads were heterosexual couples). Thus overall, the evidence in this field is still unclear and studies examining the effects of touch of non-romantic friends or dance partners are lacking. An interesting piece of evidence, that actually supports the idea that positive effects can also be initiated by the presence of non-romantic partners stems from Linnemann et al. (2016). They examined real-life stress levels and the effects of music listening in an ambulatory assessment study over seven days. Results indicated that listening to music in the presence of others led to more profound reductions in subjective stress levels; this effect occurred independently of the familiarity of the others present. The authors explained their findings with a potential increased feeling of social cohesion (Linnemann et al., 2016).

In addition to the stress-reductive effects of physical contact, the synchronisation with somebody else, especially when moving to music, is considered to cause positive feelings toward a partner, trust, and social bonding (de Witte et al., 2020; Horwitz et al., 2022). Lang et al. (2017) found that participants who showed high levels of synchronous arm movements were rated as more likeable than participants who synchronised their movements less. Another study investigating the effects of music on interpersonal coordination showed that participants who were asked to engage in chair rocking synchronised their chair rocking more strongly when listening to music and furthermore reported to feel more connected to their fellow chair rocking participant in the study (Demos et al., 2012). This corresponds with another study's findings showing that participants who listened (via headphones) to the same music and danced in synchrony felt closer to each other than participants who listened to the same music but who performed different movements (Tarr et al., 2015). Findings by von Zimmermann et al. (2018) furthermore highlight that in a larger group not unitary synchrony but distributed coordination, i.e., echoing others movement, predicted liking of others. Considering that the feeling of social connectedness is an important resilience factor (Richards, 2016), these findings provide support for the unique stress-regulative effects of movement in synchrony and movement as coordinated action.

4.2. Neurobiological and physiological findings

Social behaviours are universal across the animal kingdom; they underpin reproduction, species success and survival. This also applies to humans who evolved as a social and highly affiliative species. Human social behaviour plays a significant role in the complexity of individual well-being and mental health, as highlighted by the psychological effects

reviewed above. A large number of studies in the area of social neuroscience have been published and it is beyond the remit of the present review to explore them all here in detail. As a summary, it can be stated that social experience can be a source of comfort or anxiety, thus affecting the perception of stress and its physiological manifestations (Insel, 2002). The brain networks involved in social behaviours and social cognition have been researched in depth together with their molecular, cellular, and computational mechanisms (Chen & Hong, 2018). The neurobiology of social behaviour points at the involvement of the neuropeptides oxytocin and vasopressin, which are distributed within the limbic system as mentioned above (e.g., Landgraf & Neumann, 2004). As already stated in the section *Stress regulation*, oxytocin supports positive social interactions and attachment (Insel & Young, 2001); it also plays a role as a protective factor against stress, including psychosocial stress in humans (Heinrichs et al., 2003). Social touch as an element of social contact can in particular act as a stress buffer through engaging the brain pathways and networks that regulate social attachment via oxytocin and endorphin signalling (Morrison, 2016).

The present focus is maintained on the aspects of social behaviours associated with dance. To our knowledge, there is a striking paucity of research on the links between dance as a social experience and oxytocin as a prosocial hormone/neuromodulator. A study of relevance in this context is the one that assessed the role of intranasally administered oxytocin in modulating synchrony during dance (Josef et al., 2019). Interestingly, administration of oxytocin (vs. placebo) increased movement synchrony in dancing pairs, thus leading the authors to the conclusion that central oxytocin is implicated in synchronised interpersonal movement during dance (Josef et al., 2019). This interpretation remains consistent with the role of oxytocin in the regulation of social behaviour (e.g., Heinrichs et al., 2009). It is fair to assume that the aspect of social contact and synchrony in dance, both an attractive and important element of people's motivation to dance socially, is regulated by the brain's oxytocin system. Future research needs to bring more evidence in support of this hypothesis.

Regarding the topic of partnering in dance, a novel two-person fMRI study observed the brain activity in trained couple dancers who alternated between being the leader and the follower (Chauvigné et al., 2018). The leading dancer's brain displayed a pattern of self-orientation, in association with activation of the brain areas involved in motor planning and monitoring, navigation, and error correction. In contrast, the brain of the dancer who was following showed a more sensory, externally-oriented pattern (Chauvigné et al., 2018). Studies of this kind demonstrate the intricate neural controls implicated in dance not only as a movement exercise but also as social interaction.

4.3. Socio-cultural findings

The preceding sections highlighted how partnering - or even mirroring/synchronising with another person - can positively impact stress reduction. The neurobiological position appears to extend the socio-cultural suggestion made by Blacking who proposed that humans have "species-specific characteristics" (Blacking, 1977, p. 8). In his view, humans are biologically programmed to come together and cooperate, and that in that interaction and coherence, humans evince sensibilities that allow them to appreciate and respond to others. In the shared somatic experience of a partner dance there is a synchrony that is elicited expressly by shared music-making and dancing: two people typically come together, engage and share understandings of each other's physicality. This capacity to become entrained with another person is seen as important facilitator of coordinated activities (Phillips-Silver et al., 2010).

From an evolutionary anthropology perspective, research in the last two decades has developed from descriptive ethnographic studies of music-making, marching, and dancing - what McNeill (1995) had described as the "muscular bonding" rituals. Wiltermuth and Heath (2009) experimented with synchronous movement and singing to

discover that synchrony facilitates future cooperation in group activities. Evolutionary psychologist Dunbar (2004) (see also Liebenberg, 2017) proposed the more formative position that the endorphins given off from rituals of primate grooming, collective music-making, dance, and religious worship are an adaptive strategy to promote group bonding and prosocial behaviour. In effect, attention to music and rhythm are a critical aspect of the continued evolution of primates. This social advantage hypothesis has since been tested by Cohen and colleagues (Cohen et al., 2009, 2014; Tarr et al., 2015). They demonstrated that synchrony in drumming, dancing, and rowing led to the release of opioids and elevated pain thresholds (a proxy for endorphins). The assumed direct connection between neurohormones and prosocial behaviour was, however, not borne out in drumming experiments in Brazil (Cohen et al., 2014), for all the resilience to pain.

In addition to these processes mainly focused on others, dancing with others also influences subjective states. In her early work, Hanna covers a range of sociocultural examples on affect, what she defines as "the conscious subjective aspect of emotion" (Hanna, 1987, p. 67). Pleasure in dancing with another, satisfaction in learning and executing moves in unison, excitement and a sense of novelty at significant meaningful practices, altered states of consciousness from dance highs to ecstatic trance possessions: these can all be the effects of partner social dancing that, in their catharsis, share a reduction in stress levels. Whether ritual dance (for war, for celebration, for commemoration, for possession) or social dance (for physical enjoyment, for social company, for exotic difference, for feminist independence [cf. Skinner, 2007; Skinner & Neveu Kringelbach, 2012]), Hanna (2006, p. 51) refers to the various dances as formative "stress management programmes". They are the precursors to dance as therapy whether informally as in the counter to conditions associated with Parkinson's (Houston, 2019), PTSD (Dieterich-Hartwell, 2017), depression and schizophrenia, or formally as dance movement therapy (DMT) (Chaiklin & Wengrower, 2015).

DMT is not the focus of this review. We thus recognise its importance and cover a few more aspects of it in the Supplementary Online Material. Here, we only briefly note the distinct variation of DMT in the wider form of Contact Improvisation. This dance-art developed in the United States in the early 1970s as a social experiment is what dance anthropologist Novack (1990, p. 3) refers to as "egalitarianism and communality". It is a non-compositional movement of its time that demonstrates American cultural values, such as utilitarian individualism. It develops by stimulus and response whereby the flow of energy between dancers is key. It promotes responsiveness in the body and is sensual rather than sexual. Bodies move together independently "with no set moves other than an awareness of their dynamic exchange of touch" (Pallant, 2017, p. 9). Novack (1990, p. 185) promotes this folk dance "for fostering 'both calm peacefulness and wild disorientation' as dancers become comfortable following the laws of nature with their bodies (friction, gravity, momentum, inertia) even should it lead to disorientation.

This ability to assume and relinquish agency, to also demonstrate attunement within the self and between the self and the other (inter- and intra-kinaesthetic attunement) is a pathway to de-stressing. It is examined more recently by Deans and Pini (2022) as they bring the sociology of the body work of Bourdieu and Wacquant with, respectively, their habitus and cathectic schemata (Deans & Pini, 2022, pp. 138–139) - the underlying habits and dispositions of human practice. The kinaesthetic awareness of the body, refined and honed through practice, is an "attunement" within the self and without the self. Traversing this interface is more than artistic in that it necessitates a body confidence alongside the self-consciousness. The ability to interact constitutes a high degree of emotional development in the dance partners according to the authors as developmental attunement takes place on the dance floor rather like the developmental parenting of an infant through repeated expressions and surprising faces and gentle throws in the air (Deans & Pini, 2022, p. 8). This capacity to surrender and let go in the adult is a capacity with uncertainty in life. Between dancers, an interpersonal resonance can develop, an embodied togetherness for Himberg

et al. (2018). It translates into a resilience in the face of what the poet John Keats referred to as a "negative capability" (cf. Bion, 1970, p. 125). Bion (1970) elaborates that this is effectively - or perhaps affectively - a guard against the interminable.

Touch can be both object and subject: being toucher and touched is simultaneous in this non-localised of senses. The act of touching and the sense of touching take place at the same time. One might refer to touch as a rebuttal to the buffetings of social stress upon the individual. Following Aristotle, it is, for Paterson, the primary sense: it is the first sense developed in the embryo, and it is at the core of our "sensory facility" (Paterson, 2007, p. 7). In detail, this tactile cutaneous sense of pressure, of physical resistance, stems from the stimulation of mechanoreceptors. It aligns the body-self through a learned perception of position (proprioception), and in the context of dance betrays an aesthetic quality and affective reaction in the dancer/s and audience. If the mechanisms are universal, their interpretation and understanding are socio-cultural, metaphysical and can be affected by neuro-diversity (whether desexualised intimacy of New York "cuddle parties" [Mayr, 2023], moral stance to prohibitions of Untouchable caste groups in India (Guru & Sarukkai, 2018), or sensory differences in autistic horse riders [Fitzgerald, 2013]). This "haptic aesthetics", Paterson (2007, p. 9) suggests, has an immediacy about it that is comforting, self-affirming and verifying.

With another, the social dancer thus perceives "a mutual complication" (Paterson, 2007, p. 3); this is "indistinction" for Bollen (2001, p. 291) writing about queer kinaesthesia as dancers' out themselves in the social and dancefloor lives in his study of Mardi Gras in Sydney, Australia. On nightclub dancefloors, Garcia (2013) identified a "slippery togetherness", a feeling of connection that creates a space of belonging and social cohesion while preserving anonymity. In clubs, tactile gestures that would be regarded as inappropriate otherwise, offer moments of intimacy (Garcia-Mispireta, 2023). Bodies merge and the self emerges from the dancing with the other. Anthropology of the senses scholar Le Breton (2017, p. 97) opines similarly that "Touch is the sense par excellence of closeness". Touching another orientates the person as the boundary between self and other is established and felt. It calms and reassures with its "predictable reference points" for Le Breton (2017, p. 100). The traces of the touch are tangible and also leave an intangible residue. To return to Aristotle (2017, pp. 41–43; 419a12, 423b6-424a12), there is a "something in between" about the object touch and the flesh organ of the body where it is perceived and how it affects us. It is intermediate and both tangible and intangible as a core perceptual capacity. Without this, resilience is not even feasible. There is no, what Dagnino-Subiabre (2022) expressed more recently, "social buffering": behavioural patterns or abilities to mitigate the dangers of the human environment.

5. Movement and physical activity

Above, we reviewed the evidence on the stress regulatory role of music and rhythm, and partnering and social contact, as dance often involves these characteristics. This might give dance a particularly important stress regulatory role. A characteristic that is always present in dance is physical movement. We will therefore provide a separate albeit brief overview of the evidence on the relationship between dance-based movement/physical activity, stress, and outcomes related to coping and resilience. Noteworthy, while all types of exercise involve, per definition (see footnote 1), physical movement, dance movements still differ from other exercise movements: in contrast to most other types of exercise (like running or playing football), dance can be engaged in as a type of planned and repetitive exercise or sport. Yet, it can also be a purely aesthetic and non-utilitarian physical activity/movement without any exercise-related goals (e.g., dancing at a party or as part of a cultural practice) (Christensen et al., 2021).

5.1. Psychological findings

The manifold stress-regulative effects of movement or physical activity in general have been the topic of numerous empirical studies and reviews (Gerber & Colledge, 2023; Gerber & Pühse, 2009; Klaperski, 2017). Findings for different activity types, like for instance running or dance aerobics, are usually not differentiated between when examining the stress regulatory effects of physical activity or exercise (Arvidson et al., 2020; Klaperski & Fuchs, 2021) – a potential shortcoming we have highlighted above. In this subsection, we therefore want to review the evidence on the specific stress regulatory effects of dance (movements). In doing so, it is important to acknowledge that it is very hard to distinguish the effects of natural dance movement from other dance factors such as music or touch. Reviewing the evidence nonetheless provides an important overview of the evidence that looked at the stress regulatory effects of dance in general. Previous publications that examined the stress regulatory effects of physical activity have used the well-known Transactional model of stress to explore how physical activity can impact stress regulation (Fuchs et al., 2020; Lazarus & Folkman, 1984). In line with these publications, we will briefly summarise the influence of dance on the four main stress regulatory pathways relating to this model: 1) direct reductions of stressors; 2) increases of psycho-social resources; 3) reductions of the stress reaction; and 4) direct improvements of health and well-being levels (Fuchs et al., 2020).

Much of the evidence reviewed above already shows that stress-regulative effects of dance can also be attributed to these four pathways. Firstly, the subsection on *Partnering and social contact* showed that dance facilitates social contact and connection. This means that loneliness and social disconnection can be reduced, i.e., stressors that have been found to bear greater mortality risk than physical inactivity (Holt-Lunstad et al., 2017; Liu et al., 2023; Nadasen, 2008; Wu et al., 2023). Dance is however not expected to affect the extent of individual stressful life experience in general. Thus, findings by Bass et al. (2002) showing that aerobic dance classes did not reduce stressful life experiences are not surprising (Fong Yan et al., 2024). In addition to the reduction of certain stressors, dancing can, secondly, improve important psycho-social resources and thus appraisal processes. Dance has for instance been found to positively impact self-esteem, one's self-concept, or social support perceptions, as well as coping strategies (Burkhardt & Brennan, 2012; Quiroga Murcia et al., 2010). Looking at the third pathway, several studies found music listening to reduce the acute stress response, making it very likely that regular dancing reduces the acute stress response just like it has been found for other types of exercise (Gerber & Fuchs, 2020; Klaperski et al., 2014). However, in contrast to studies showing that dance *competitions* increase acute stress levels (de las Heras-Fernández et al., 2023; Rohleder et al., 2007) to-date no study has examined the effects of non-competitive dance on the acute psychological and physiological stress response. Evidence showing that dancing in particular reduces the stress response is thus currently lacking. Fourth, several studies reviewed above showed that dance can help to regulate stress by directly improving health and well-being outcomes, thus increasing resilience (Buck & Snook, 2020; Fuchs et al., 2020). In addition to the studies related to music and social contact described above, evidence for this health-strengthening pathway also comes from a multitude of dance intervention studies that have not yet been considered in our synthesis. In the following, we will therefore briefly review their main findings.

Direct positive effects on mood, affect, distress, and well-being have been found in studies looking at the effects of a single dance session (Kim & Kim, 2007; West et al., 2004; Zajenkowski et al., 2015), as well as in studies examining the effects of longer dance programmes or interventions (Burkhardt & Brennan, 2012; Duberg et al., 2020; Liu et al., 2023; Pinniger et al., 2013; Sheppard & Broughton, 2020). In a recent review on the topic, Sheppard and Broughton (2020) concluded that dance participation contributes positively to individuals' health and well-being across different cultures and age groups. Interesting results

from a mixed-methods study with leisure time dancers furthermore show that such dance benefits relate to a variety of factors, for example to emotions, well-being and meaningfulness, creativity, and physical abilities (Quiroga Murcia et al., 2010). The previously mentioned study by Bernardi et al. (2018; see also the section *Music and rhythm*) furthermore highlights that rhythmic or groovy moments, as seen in dance activities, cause particularly positive effects: participants who copied groovy dance moves without music experienced some feelings of joy and power, while participants copying non-groovy dance moves without music did not report any positive emotional effects (Bernardi et al., 2018).

As physical activity is known to generally promote health and well-being (Gerber & Colledge, 2023), studies comparing the health-strengthening effects of dance with the effects of other exercise activities are of particular interest. A recent meta-analysis on the effectiveness of dance interventions on improving psychological and cognitive health concluded that while dance was not generally found to be more beneficial than other physical activity interventions, there was "preliminary evidence to suggest that dance may be superior to other physical activity interventions for the psychological outcomes of motivation [...], distress (hostility and somatisation) [...], depression [...], emotional wellbeing [...] and cognitive outcomes" (Fong Yan et al., 2024, p. 20). The authors also highlighted that dance interventions tended to have higher retention rates; yet due to a huge methodological variability and an overall low-to-moderate quality of the included studies the findings need to be interpreted with caution (Fong Yan et al., 2024). All in all, existing evidence provides support for the assumption that movement does not equal exercise and that exercise does not equal dance. In particular rhythmical dance movements seem to result in more beneficial psychological and health-strengthening effects. However, further research in this area is needed to draw more robust conclusions.

5.2. Neurobiological and physiological findings

The neurobiological and physiological bases of movement have a remarkable presence in the academic literature. There are many comprehensive reviews that provide in depth insights in the neural mechanisms of exercise playing a role in health and disease, and across the life span, for example Nicolini et al. (2021), Won et al. (2021), and Nowacka-Chmielewska et al. (2022) – a review that is also concerned with stress. A recent literature review that focused on changes in stress pathways as a possible mechanism of aerobic exercise effects on brain health argues that physical activity in the form of aerobic exercise improves neurocognitive health, although no original studies have been found in support of the long-term effects of exercise on stress pathways implicated in this process (Molina-Hidalgo et al., 2023). To provide a similarly comprehensive overview of the role of physical activity as part of dance effects is beyond the scope of the present article, instead we will briefly summarise the most important neurobiological and physiological stress-regulative effects physical activity is known to have.

Physical activity famously boosts endorphins in the brain which enhances the perception of well-being (e.g., Veening & Barendregt, 2015). In addition, and as already mentioned above, endorphins are closely linked with the HPA axis that is directly implicated in the physiological response to stress (e.g., Takai et al., 2007). There is also ample evidence of dopamine involvement in neurobiological responses to physical exercise (Gorrell et al., 2022; Matta Mello Portugal et al., 2013). This neurotransmitter is implicated in movement control within the subcortical part of the brain - the basal ganglia - and also the reward pathway as already discussed above in the section about music and rhythm. Experimental studies in rats show that physical exercise enhances dopamine release in both the dorsal striatum as part of the basal ganglia, and its ventral part, the nucleus accumbens (NAc) which is an important region of the reward system (Bastioli et al., 2022). The brain derived neurotrophic factor (BDNF) plays a role in exercise-increased

dopamine release in the dorsal striatum and NAc (Bastioli et al., 2022; Nicolini et al., 2021). Dopamine release is also enhanced in patients with Parkinson's disease (PD, a movement disorder with drastically reduced dopamine availability in the basal ganglia) who exercise (Mak et al., 2017). The link between physical exercise and dopamine can also help interpret the long-term positive effects of dance movement in PD, and the clinical benefits observed in PD patients who dance (de Natale et al., 2017; McGill et al., 2018). This is due to the fact that dance incorporates physical activity, and movement, and rhythm - all of which together improve body movement initiation, and gait and balance that are typically impaired in PD. Of relevance, reports suggest that the best improvements in movement initiation and body balance can be observed in patients with PD participating in dance groups when compared with those in exercise only groups (Earhart, 2009).

More broadly, movement and physical exercise improve one's health, mood, and sense of well-being in the longer term, as discussed above from the psychology perspective. These effects can increase resilience and improve a person's ability to cope with stress. Of note, and significance with respect to our socio-cultural findings below, dance/movement training appears to improve cortisol regulation in older adults better than aerobic exercise (without dance). Vranceanu et al. (2019) for example showed that after three months of 3hrs training per week, a dance movement training group had lower salivary cortisol values post-training compared with an aerobic exercise and a waitlist group, even though fitness improved only in the aerobic exercise group (Vranceanu et al., 2019). Similarly, Ho et al. (2018) found that dance movement training led to steeper diurnal cortisol slopes in highly stressed breast cancer patients. Such findings that dance could offer a preventive measure against negative effects of HPA axis hyperactivity (Vranceanu et al., 2019) are important because elevated cortisol levels are associated with ageing, and preventive interventions that can moderate cortisol levels can potentially limit the adverse impact of HPA axis hyperactivity on physiological ageing. These findings that support the beneficial link between dance movement training and healthy hormonal stress regulation complement earlier research showing a similar link with perceived stress both in healthy older adults and in clinical populations (Bräuninger, 2012; Ho et al., 2018; Kluge et al., 2012). Overall, the evidence suggests that dance movement training can beneficially affect the hormonal regulation of stress independently of perceived psychological effects - a finding that also aligns with mismatches between physiological and psychological stress responses reviewed above.

To conclude this aspect, engagement in physical activity that involves music and rhythm, like dancing, can be considered as beneficial to health through multiple physiological mechanisms. These mechanisms also include those that reduce stress and increase resilience.

5.3. Socio-cultural findings

Throughout the world, physical movement in the form of social dance can be seen to be a powerful source and resource for health and healing. Cross-culturally it is a buttress against the buffetings of socio-cultural forces acting on or against the individual and community. We thus suggest that it is a mechanism for not just resolving external difficulties but for salvaging internal factors such as stress. Social dance is more than an important source of meaning - "meaning in motion" as it is coined by dance anthropologist Desmond (1997, p. 3) in her collection examining "the public display of bodily motion". Movement is, in itself, transformative as a potent change agent: physical movement is dynamic and diverse in its impact, particularly so in a socio-cultural context in the fields of sport and physical education, and health. Whilst sport and dance are closely related (cf. Dyck & Archetti, 2003, pp. 10–11), these disciplined and entrained practices differ in that the dance is less competitive but more choreographed and aesthetic. Both can be, nevertheless, drivers for energy allocation and intrasexual selection (Longman et al., 2020), factors that are of particular importance during

times of insecurity, scarcity and difficulty - each of these being potentially stressogenic.

Energy deficit during times of famine, for example, necessitates a response such as migration, but such "energetic stress" can, if prolonged, lead to dysfunctional stress responses within the body according to Harrell et al. (2016). In her study of Tamil refugees in Arctic Norway, Grønseth (2010) found that migrants of conflict can become "hyper-consumers" of health services in the post-malaise of war trauma and physical dissociation. Dance in the Diaspora can hence be considered a restorative activity; this is demonstrated by Irish dancing events and the annual St Patrick's Day parades and festivals in urban areas of high Irish immigration in the US such as Chicago, Boston, and New York (cf. Conrad, 2015; Nagle, 2012).

More sociologically, Gotfrit (1988) presents social dancing in modern clubs and discos as physical movements that instil a tension between resistance and self-regulation as middle-aged women temporarily dance back to their youth, to their more liberated times, to their younger bodies, to their pre-marital or family independence. Their "boogie night" evenings are nights back in time, when ideologies of social reproduction are played with, challenged and transgressed before being restored when everyone goes back home. This is the pleasure of desire for and with the body played with without consummation - a public expression of sexuality without the sex. These are feminist contradictions about corporeal resistance that serve a cathartic function as "safety valve", as partial liberation and temporary de-stressing activity regardless of the social dance (cf. Skinner, 2008).

In a health and healing context, Carapellotti et al. (2023) note how because the social dance physical movement has a recursive dimension to it - is patterned and repetitive - participants are able to expand and grow in confidence from the patterns. This is important in a health setting where diagnoses sometimes feature movement limiting, confining conditions. For Carapellotti et al. (2023), sufferers of multiple sclerosis or Parkinson's Disease are able to develop confidence in the predictability of dance steps and the freedom of access to space around them. Their worlds open outwards and expand through their experiences on the social dance floor. Nadasen (2008) makes a similar point writing about elderly female line dancers in Cape Town, South Africa: her research revealed that physical activity serves as a buffer against stress and trauma. It prevented social isolation and depression for dancers who had lost their life partners. Yet, the physical movement promotes more than an individual self-expression. This support structure fostered a new social consciousness and engagement in the community, even, in the dancers. This cuts across racial divides in a post-apartheid environment, just as salsa dancing could breach the ethno-national in Northern Ireland (Skinner, 2007) and, for the dancers, was considered to be "better than [pharmacological] medication" (Nadasen, 2008, p. 338) in the sense that the moving together had become a panacea for many of their ills, "a buffer for trauma and stress" (Nadasen, 2008, p. 331).

Finally, in a comprehensive review of cultural dance and physical education, Olvera (2008) associates ethnic world dances with the potential to promote the health of young and old beyond quality of life measures. Folklorico, salsa, African dance programmes can contribute to weight loss, improved resting heart rates, cortisol reduction, the management of hypertension (Guidetti et al., 2015). Olvera cites the work of Harris (2007) in Sierra Leone: significantly, post-traumatic stress was blunted in former child-soldiers interacting with each other and engaging with their stories of atrocities - flash dances to resolve painful flashbacks. The dancing promotes a locus of control within the body; self-reliance that chips away at the distress of violence. It involves deep engaged breathing that dampens the erratic arousal of the nervous system; yawning and shrugging to relax and recover a new assertiveness; and balance experiments with a partner to re-calibrate posture *contra* repression and helplessness (Harris, 2007). While not being the focus of this review, these examples highlight how dancing solo or in partnership or in groups, social in orientation or psychologically and emotionally

driven can all help healing by integrating the senses: learning how to regulate breathing whilst moving directly influences the vagal system and hence its regulation of emotions. This self-awareness, or interoception, is as much about stress prevention as it is stress management (see Kiepe et al., 2012). Alpert (2011, p. 156) makes similar points about dancing "in the moment" as a counter to stress and high blood pressure and how this can impact at a more fundamental level through the autonomic nervous system.

6. Discussion

This review presents multidisciplinary insights into the core elements of dance that include music and rhythm, partnering and social contact, as well as movement and physical activity (see also Fig. 1). It is the first of its kind to simultaneously review neurobiological, psychological, and anthropological findings. The evidence we summarised is diverse and in places the reasoning is new to the field of sport and exercise psychology. We thus want to highlight and integrate the main conclusions that can be drawn from each of the three sections above.

Music and rhythm: Although very few studies looked at the effects that music exerts when dancing, the existing evidence suggests that certain positive effects, like the feeling of flow (a state deep absorption and focused attention), only emerge when movement and music are combined while dancing (Bernardi et al., 2018). This finding is also in line with exercise psychological evidence highlighting that music which accompanies dance can result in a more positive activity experience and a longer engagement in the activity (Patania et al., 2020).

In comparison with evidence on dance and music, much more is known about the effects of sole music listening that has been found to promote coping and resilience in different ways. We summarised evidence showing that music stimulates the brain's reward system and that the same neural mediators, like β -endorphins, are involved in both music perception and stress responses (Salimpoor et al., 2011; Veening & Barendregt, 2015). Furthermore, music listening has been found to be linked to increases in oxytocin levels and decreases in cortisol levels (Ooishi et al., 2017). These neurobiological mechanisms can explain why psychological studies find that music listening firstly reduces negative psychological states caused by acute stressors, and secondly, why it increases general health and well-being factors (de Witte et al., 2020; Labbé et al., 2007; Pelletier, 2004). That such effects were observed in particular for music that individuals experience as relaxing (Ghaderi et al., 2009; Linnemann et al., 2015, 2016) is in line with the empirical finding that this type of music increases electrical brain waves that are associated with the state of relaxation (Yehuda, 2011). Furthermore, studies demonstrating particularly positive psychological effects for certain types of rhythmic music (Bernardi et al., 2018; Kim et al., 2018) are in line with the unique and innate importance of beat perception and synchronisation shown in neurobiological studies as well as anthropological considerations (Blacking, 1973; Ito et al., 2022). Hominids are considered to have a propensity and predisposition for sound pattern recognition and production, and music might cause distinct positive psychological and social effects due to an important societal and evolutionary function music bears (Blacking, 1973; Cohen et al., 2014; Ravnani & Madison, 2017). Anthropological scholars argue that, especially in times of stress, music and acting in synchrony might play fundamental roles in expressing and reinforcing innate characteristics that predispose humans towards cooperation and social interaction (Ravnani, 2019; Wiltermuth & Heath, 2009). Music and dance are regarded as aesthetic, non-utilitarian communication systems that allow for group bonding as well as for self-expression (Bond, 2008; Hagen & Bryant, 2003).

These interdisciplinary considerations show that, for the field of sport and exercise psychology, it is key to not regard music purely as a form of exercise bi-product, entertainment, or cultural phenomenon, but to understand that music is deeply ingrained in human biology and psychology and can thus trigger manifold beneficial neurobiological,

physiological, psychological, and social responses.

Partnering and social contact: Several sport and exercise psychological studies found that dancing with a partner as well as exercising with a partner resulted in even more positive psychological effects than doing these activities alone (Kanamori et al., 2016; Murcia et al., 2009; Sackett-Fox et al., 2021). Likewise, listening to music in the presence of others also seems to have beneficial stress regulatory effects (Linnemann et al., 2016). Considering that humans evolved as social and highly affiliative species, these findings do not come as a surprise; correspondingly, the ability to demonstrate attunement within the self and between the self and the other in dance has been characterised as a pathway to de-stressing (Deans & Pini, 2022). Still, the role of social factors has up to the present received surprisingly little attention in psychological studies examining dance or the stress regulatory effects of exercise in general.

When turning towards the field of stress research for further insights, it becomes apparent that social support by a partner and/or stranger can decrease acute physiological stress responses to an artificial stressor (Ditzen et al., 2007; Kirschbaum et al., 1995). That this effect seems to be in particular linked to physical contact (Ditzen et al., 2007) aligns with the conclusion that social touch acts as a stress buffer through engaging the brain pathways and networks that regulate social attachment via oxytocin and endorphin signalling (Morrison, 2016). Reviewing the socio-cultural meaning of touch, it becomes clear that touch is intermediate and both tangible and intangible as a core perceptual capacity - it can be seen as a rebuttal to the buffetings of social stress upon the individual (Le Breton, 2017; Paterson, 2007). The social dancer thus connects with the other, bodies merge, and the self emerges from dancing with another. Facilitating spontaneous somatic rhythmical and interpersonal synchronisation, dance is regarded to support emotional release and social or cultural synchronisation (Bollen, 2001; Samaritter, 2019). In line with these and previously summarised socio-cultural considerations relating to music, psychological studies have shown that the synchronisation with somebody else, especially when moving to music, can give rise to positive feelings and social bonding (Demos et al., 2012; Tarr et al., 2015). Interestingly, neurobiological investigations furthermore showed that oxytocin increased movement synchrony in dancing pairs, highlighting the importance of oxytocin as the prosocial hormone in social dance and corroborating the importance of social/partner dance for resilience and coping (Josef et al., 2019).

Movement and physical activity: Just like many other exercise activities, engaging in dance movement has been found to impact stress regulation in different ways, namely by reducing stressors and their perceptions, by improving psycho-social resources, and by increasing health and well-being levels (e.g., Burkhardt & Brennan, 2012; Holt-Lunstad et al., 2017; Liu et al., 2023; Zajenkowski et al., 2015). These psychological findings align with neuro-biological and physiological evidence showing that physical exercise enhances endorphins and dopamine release, modulating the activity of reward-related neural networks and the HPA axis (Gorrell et al., 2022; Molina-Hidalgo et al., 2023; Takai et al., 2007; Veening & Barendregt, 2015). Benefits related to engagement in dance have been found to relate to a variety of factors, e.g., meaningfulness, creativity, and physical abilities (Quiroga Murcia et al., 2010); looking at the importance of movement from a socio-cultural perspective, it becomes likewise clear that social dance is a powerful resource for health and healing. Dance movement is transformative and restorative as it allows for self-expression as well as for confidence-building when movement patterns are repetitive and predictable (Carapellotti et al., 2023; Desmond, 1997; Nadasen, 2008). Dancing enables the dancer to self-regulate, to connect with their past and cultural roots, and to foster social connection, even across social divides, by moving together (Goffrit, 1988; McGoldrick, 2018; Nadasen, 2008; Skinner, 2007).

In sport and exercise psychological studies, this broader, socio-cultural meaning of movement has received only very little attention. Considering that several studies show that stress regulatory effects differ

for different types of movements and exercise (Bernardi et al., 2018; Gerber et al., 2014), and that beneficial changes are not automatically linked to changes in fitness levels (Vranceanu et al., 2019), a narrow focus on typical exercise characteristics, such as the intensity level, might hinder new insights. Current meta-analyses on the superior effects of dance as well as research comparing effects of exercise and dance interventions in patients with Parkinson's disease highlight the importance of rhythmical dance movements for stress regulation (Earhart, 2009; Fong Yan et al., 2024). Yet when drawing this conclusion, it needs to be acknowledged that many of the reviewed studies that investigated the stress regulatory role of dance movement also involved music/rhythm and/or partnering/social contact.

6.1. Future research recommendations

At the beginning of this review, we emphasised the importance of gaining better insights into the stress-regulative effects of *specific types* of exercise, especially given the significance of exercise and resilience and coping for health. The sport and exercise psychological evidence in the field of stress regulation is generally limited by a shortage of studies that compare dance activities with other types of physical activities; and by a mostly undifferentiated, generalised use of the term "exercise". Most studies examine specific aerobic activities like running, or use exercise categories like aerobic vs anaerobic or moderate vs. vigorous physical activity (Klaperski & Fuchs, 2021; Meyer et al., 2021). Other characteristics, e.g., whether activities have a social component, involve touch, or whether they involve music, are being neglected. This narrow focus on the characteristics relevant for movement science, e.g., the intensity of an activity, likely hinders researchers in understanding what characteristics of an activity cause an observed effect.

Our review on the specific stress-regulative effects of dance has highlighted numerous insights that provide support for dance as a unique stress regulatory activity. However, it also revealed points for which currently only limited evidence regarding the effects of dance on resilience and coping is available. The theme of resilience, as spanning across the fields of psychology and neuroscience, is clearly among the areas warranting further original research to build a body of data and evidence available for translation into interventions in healthcare (the aspect exceeding the remit of this review but systematically dealt with by Fong Yan et al., 2024). Other areas that call for further investigations include the exploration of the role of music within the realm of dance, with a focus on its enduring impacts over time. Furthermore, delving into the intricacies of rhythm and its relationship with dance, independent of musical accompaniment, presents a promising avenue for future scholarly inquiry. Generally, a more specific investigation of stress-regulative effects of different movement types, if possible also dissecting movement from other characteristics like music or social contact, is very warranted to gain more meaningful insights.

There is likewise a need for more emphasis on the gender effects on stress responses in the context of social dance, and for better understanding the influence of dance on individual characteristics, like for example pessimism/a sense of helplessness and optimism/proficiency in adaptive coping. Lastly, we agree with Fong Yan et al. (2024) who highlighted several methodological issues, such as the short follow up periods and low quality of study designs. Those limitations also apply to many of the studies that were reviewed in the present paper.

6.2. Strengths and limitations of the current review

The present review has strengths as well as limitations. Its main strengths are its interdisciplinarity and its sole focus on dance as a specific form of exercise. This allowed us to, for the first time, explore several characteristics of dance and their links to stress regulation in depth, leading to new insights. At the same time, we must acknowledge that it was not possible to review all relevant dance characteristics (Christensen et al., 2021) considering the length of the present review.

Themes that this review has not dealt with in depth are for example: communication (Hanna, 2006), the role of body awareness and somatic practice (Deans & Pini, 2022), creative learning and inner personal change (Buck & Snook, 2020; Horwitz et al., 2022), the development of emotional competencies (Borowski, 2023), the role of posture, and the expression of emotions that have been positively or negatively modified by recreational dance (Alfredsson Olsson & Heikkinen, 2019).

Another important limitation regards the methodology of the review. We initially aimed to use a systematic literature search strategy, yet, most of the identified publications were not of direct relevance (see *Method* above and the Supplementary Online Material). At the same time the systematic review criteria and a sole focus on "dance" as keyword led us to missing many discipline-specific literature sources. We resolved this problem by using an iterative and purposeful subjective literature search approach; however, its breadth meant that a systematic examination of all sources was not viable. Using this iterative search process and the author team's existing literature collections allowed us to provide a rich and meaningful summary of the evidence. It is however important to acknowledge that no comprehensive literature screening and review was conducted and that the search cannot easily be replicated. This means that the current narrative review bears a risk for bias, as relevant publications might have not been included and other researchers might have considered other sources and interpretations, coming to different conclusions⁵ (Sukhera, 2022).

7. Conclusion

In conclusion, this multidisciplinary narrative review of the beneficial effects of dance on coping, resilience, and stress offers unique insights from a psychological, neurobiological, and anthropological perspective. We hope our interdisciplinary approach has not only enhanced the understanding of the beneficial effects of dance but also underscored the richness of integrating diverse perspectives to explore complex phenomena in the realm of human health and well-being. By examining the intricate interplay between mind, body and brain, and culture, this narrative review widened disciplinary horizons and shed light on the diverse mechanisms through which dance positively impacts individuals' abilities to cope with stress. Various empirical psychological studies showed that dance and music can promote coping and foster resilience. Neurobiological research highlighted the rewarding and stress-reducing effects of dance and its unique characteristics, demonstrating its ability to modulate brain regions involved in the stress response. Anthropological insights underscored the cultural significance of dance as a universal form of human expression, offering a communal space for bonding, healing, and collective coping strategies. Together, these perspectives emphasise the profound potential of dance as an embodied practice that addresses coping, resilience, and stress at multiple levels of the human experience. So get up and dance your stress away.

CRediT authorship contribution statement

Sandra Klaperski-van der Wal (Psychology): Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Conceptualization. **Jonathan Skinner** (Social

⁵ Considering the flagged risk for bias and the collaboration as an interdisciplinary team, it would have been beneficial to, notwithstanding the adoption of an iterative, purposeful review approach, create notes of all searches and to keep short discussion records; regrettably, we have not made use of this opportunity that was brought to our attention in the peer review process. Following recommendations for narrative reviews, we did however describe all key components of our review as transparently as possible, hoping that this enables the reader to critically appraise the overall quality of our review (Baethge et al., 2019; Sukhera, 2022).

Anthropology): Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Jolanta Opacka-Juffry** (Neuroscience/Physiology): Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Kristina Pfeffer**: Writing – review & editing, Writing – original draft, Resources, Methodology, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.psychsport.2025.102823>.

Data availability

No data was used for the research described in the article.

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