Affective Wearable Haptic Interventions: A Systematic Literature Review

JUEUN LEE*, Karlsruhe Institute of Technology, Germany
TOBIAS RÖDDIGER, Karlsruhe Institute of Technology, Germany
SARAH MAKAREM, Karlsruhe Institute of Technology, Germany
TILL RIEDEL, Karlsruhe Institute of Technology, Germany
KAI KUNZE, Keio University, Japan
MICHAEL BEIGL, Karlsruhe Institute of Technology, Germany

The rise of haptic technology in wearable devices presents new opportunities for affective interventions, promoting mental well-being with minimal effort and immediate relief in everyday situations. This review analyzes 83 relevant articles from 1098 identified, outlining research trends and key dimensions of intervention design and evaluation. Through thematic and descriptive analysis, the studies are organized by affective goals, haptic modalities, body locations, and contextual mechanisms. Three major affective orientations were identified—valence-arousal, social, and embodied affect—revealing a dominant focus on calming and stress-related interventions. Vibrotactile feedback on wearable-friendly areas such as the wrist and forearm was most common, while thermal, pressure, and stroking-based modalities are emerging. Cross-dimensional mapping shows that haptic modality, body placement, and intervention mechanism jointly shape affective outcomes, emphasizing embodied physiological regulation and interpersonal connection as key pathways for affective modulation, as well as future directions involving multi-user interactions. By synthesizing current findings, this work offers a structured framework to guide the design, implementation, and evaluation of affective wearable haptic interventions across diverse application contexts.

CCS Concepts: • **Human-centered computing → HCI design and evaluation methods**; • **General and reference → Surveys and overviews**.

Additional Key Words and Phrases: Touch, Haptics, Wearable Technology, Affective Haptics, Affective Health, Mental Well-Being, Interventions, Emotion, Affective Computing, Meta-Analysis, Systematic Literature Review, Content Analysis

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1 INTRODUCTION

Touch is one of the earliest forms of interpersonal communication [1] and serves as a primary channel for affective interaction [2, 3, 4]. Specialized receptors in human skin, such as C-tactile (CT) afferents, process gentle, affective touch, which plays a key role in the development of the social brain [5, 6, 7, 8]. As a means of communication,

*Corresponding author.

Authors' Contact Information: Jueun Lee (corresponding author), Karlsruhe Institute of Technology, Karlsruhe, Germany, jueun.lee@kit.edu; Tobias Röddiger, Karlsruhe Institute of Technology, Karlsruhe, Germany, tobias.roeddiger@kit.edu; Sarah Makarem, Karlsruhe Institute of Technology, Karlsruhe, Germany, sarah.makarem@kit.edu; Till Riedel, Karlsruhe Institute of Technology, Karlsruhe, Germany, riedel@teco.edu; Kai Kunze, Keio University, Tokyo, Japan, kai.kunze@keio.jp; Michael Beigl, Karlsruhe Institute of Technology, Karlsruhe, Germany, michael.beigl@kit.edu.

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touch effectively conveys emotions and regulates physiological states related to emotional experiences [9, 10], often bypassing cognitive interpretation [4, 11, 12], unlike verbal and visual methods. Research shows that touch is beneficial for physical and emotional well-being, such as reducing heart rate (HR), blood pressure [13, 14, 15], and cortisol levels [16], while increasing oxytocin, improving mood [1, 17], and providing comfort [18, 19].

Wearable haptic technology, which leverages the fundamental mechanisms of touch and the ubiquity of devices such as vibrotactile actuators, offers a promising way to evoke positive or regulated emotions in everyday users. Its potential lies in passive health interventions [20], which provide an advantage over other sensory inputs. Unlike traditional visual and auditory interventions that require significant user engagement, passive haptic feedback can provide immediate relief with minimal participation [21]. Studies indicate that touch can reduce stress more effectively than verbal support [22, 23], alleviate visual strain [24], and maintain emotional privacy [25]. With haptic feedback already integral to devices such as smartphones and smartwatches [26, 27], wearables are well positioned as platforms for personalized interventions. In particular, our focus is driven by the advantages of body-worn haptic systems, emphasizing their potential for mobile interventions that facilitate self-management of mental well-being [20, 28, 29]. The size dimensions of haptic devices can vary due to their hardware specifications, frequently rendering them impractical for users to carry, whereas wearable devices are purposely designed to be lightweight and remain in contact with the skin.

Concurrently, the post-COVID shift toward remote interaction and digital health has accelerated the digitization of everyday interventions [29, 30]. While mobile and screen-based tools have increased accessibility, they often under-serve embodied regulation and social connection. Wearable haptics can bridge this gap by harnessing the physicality of touch for mind-body approaches (e.g., bodily awareness) [31] and by operating unobtrusively in-situ [20, 21]. Moreover, haptics hold promise as part of an integrative system supported by wearable biosignal sensing for affect and stress, a direction that has been explored in more depth in previous work [32, 33, 34]. However, the design of such interactions, haptic feedback, and body-specific effects of wearables, along with other potential key dimensions, has not yet been systematically investigated in affective intervention research.

Research on affective haptic interventions integrates insights from various fields in Human-Computer Interaction (HCI), including psychology, haptics, and affective computing, to inform design choices. Studies such as Vyas et al. [20] provide extensive summaries of affective haptics designs in HCI, emphasizing emotion regulation based on Gross's process model [35, 36] as a growing area, distinct from emotion communication and body awareness. In the domain of affective health, Sanches et al. [37] identified "adult sufferers" and researchers as primary stakeholders, revealing that interventions and self-management emerged as frequent topics. Eid and Osman [25] established an overview of affective haptics, highlighting their ability to communicate emotions and applications, e.g., in social interaction, healthcare, and entertainment. Building on the core mechanisms of human perception and behavior, Huisman [17] explored the potential of advanced haptic technology in social robots and virtual reality (VR) to mediate social and affective touch. However, existing work has primarily focused on haptic design and technology [17, 20, 25, 38, 39] or broader computer-aided interventions [29, 30, 37]. The unique potential of haptic interventions through wearable technology remains an underexplored area. Therefore, we propose the following research questions:

RQ1. What affective phenomena are targeted in wearable haptic interventions?
RQ2. What haptic modalities are employed?
RQ3. Which body locations are selected for wearable haptic devices?
RQ4. What are the key design dimensions for affective wearable haptic interventions?
RQ5. How can future research improve the methodological rigor and effectiveness of interventions?

Driven by these questions, we conducted a systematic literature review to examine the current state and emerging directions of affective wearable haptic interventions. Using keyword-based searches in major digital libraries, supplemented by backward citation chaining, we identified and selected 83 articles according to predefined inclusion and exclusion criteria (Section 3). We then conducted a thematic analysis (Section 4), refining the conceptual structure of interventions across three key dimensions: affective goals, intervention methods (including haptic modalities), and associated contexts (e.g., social and application setting, body placement). These dimensions were further analyzed through descriptive and cross-dimensional mapping (Section 5, Section 6.1) to reveal patterns linking affective targets, haptic feedback types, and bodily or contextual factors. The analysis highlights dominant trends—such as the prevalence of vibrotactile and calming-focused interventions—alongside emerging modalities (thermal, pressure) and opportunities for socially or physiologically integrated designs. Finally, we synthesize these findings into conceptual and design implications for future affective wearable haptic research, identifying challenges and opportunities toward more coherent, and contextually grounded affective intervention frameworks (Section 6).

2 RELATED WORK

2.1 Defining Affective Wearable Haptic Intervention

Psychological interventions are complex and cannot be easily defined; they should be characterized according to their content, underlying mechanisms, intended outcomes, and methodological approaches [40]. Thus, we first defined an "affective wearable haptic intervention" based on existing reviews related to this topic, specifying its interpretation within this study. *Affect* is defined as the objective and observable description of a state of feeling [41], generally referring to valence, arousal, and dominance framed in dimensional models of emotions [42]. This encompasses *emotions*, which are specific conscious responses, such as joy, anger, or sadness, and can vary in valence [43]. In contrast, *mood* refers to a consistent, sustained feeling state, which is typically expressed more subjectively by individuals over a prolonged period of time. In particular, the terms *affect* and *emotion* have often been used interchangeably in haptic research [8, 44]. In this review, we focus on broader affective phenomena, including both implicit and explicit intervention effects [29]. In addition, *interventions* are understood as actions or activities aimed at modifying affective states or behaviors related to well-being, supported by computer technology in HCI [45]. Moreover, we identified affective health and affective haptics as the primary subfields relevant to affective wearable haptic interventions. Affective health research focuses on mental health, addressing affective disorders such as anxiety and depression, as well as related affective states, including feelings, emotions, and stress responses [20, 25, 37]. It explores various intervention approaches, such as emotion regulation, traditional psychological interventions, self-tracking, and biofeedback training [37]. Meanwhile, affective haptics research is centered on mediated touch, designing computational systems capable of displaying, eliciting, and communicating emotional states [46] through haptic user interfaces [25]. Based on these perspectives, we formulate the following definition.

> **Affective Wearable Haptic Intervention** refers to the design and application of haptic input in wearable systems to elicit and regulate affective phenomena and mental well-being.

2.2 Intervention Design Factors

Psychological interventions can be designed with two primary objectives: to address mental distress or to enhance subjective well-being [47]. In particular, the latter represents a distinct aspect of mental health that interventions aim to improve by promoting positive changes in affect and adaptive states, an approach that is increasingly emphasized along with traditional diagnosis-based goals [48]. A meta-review of mental health models indicates that mental well-being can exist independently of the presence or diagnosis of mental disorders. Therefore, the scope of psychological interventions encompasses both experiential mental well-being and affective indicators, collectively or individually [49]. In the needs analysis for intervention design, the target outcome can be identified at different interpersonal levels. Initially, at the individual level, this could involve enhancing mental well-being, improving personal resilience to stress or adversity, or addressing sub-clinical mental distress, such as depression, anxiety, and stress [48]. At the interpersonal level, support from relationships represents another key environmental outcome to target, as recent trends in mental health interventions emphasize the integration of both individual symptoms and the broader interpersonal and social contexts [48, 50]. For example, fostering small positive dynamics within social environments enhances mental health [51, 52], while experiences of isolation and loneliness can have a significant detrimental impact on well-being and mental health [53, 54]. In intervention evaluation, affective measurement encompasses both subjective and physiological changes that can define specific emotional states, whether directly triggered or influenced by a process of cognitive appraisal [43, 55]. While individuals may or may not be able to verbally express their emotional states [43], related physiological measures can serve as indirect indicators of these states [56, 57].

2.3 Haptic Perception

Touch perception is mediated by the somatosensory system, which includes mechanoreceptors that detect mechanical forces on the skin [8] and thermoceptors responsible for temperature sensing [58, 59]. In particular, low-threshold mechanoreceptors (LTMRs) that are responsible for detecting non-painful mechanical stimuli or touch are classified into four types of skin sensory receptors and afferent neurons in glabrous skin based on their distinct sensitivities, conduction speeds, and responses to mechanical pressure [60, 61, 62]. Slowly-adapting (SA) receptors respond to indentation: SA1 receptors, innervating Merkel cells in the basal epidermis, provide information on the static characteristics of pressure, while SA2 receptors found in Ruffini corpuscles within the dermis are highly responsive to skin stretching. Conversely, rapidly-adapting (RA) touch receptors act as velocity sensors, responding to vibration and movement. RA1 receptors, found in Meissner corpuscles located in dermal papillae, detect slow and light 'fluttering' movement across the skin, whereas RA2 receptors, which end in Pacinian corpuscles in the deeper dermis, are tuned to high-frequency vibrations. In hairy skin, specific nerve endings link hair follicles, similar to how RA1 innervates Meissner corpuscles in hairless skin, detecting hair movement and gentle skin contact. CT afferents, innervated by unmyelinated and slow-conducting C fibers, are particularly sensitive to skin stroking at the lowest rate that is considered pleasant, known as 'emotional touch', which is associated with comfort and social bonding [6, 8, 60, 63, 64]. In the context of haptic technology, haptic feedback is defined as any physical sensation perceived through the sense of touch, encompassing stimuli such as "vibrations, force, temperature, pressure, or other tactile sensations" [65].

3 METHODS

We conducted a systematic literature review through a keyword search in relevant databases, followed by article screening, eligibility assessment, and backward citation chaining, culminating in analysis (Figure 1). The literature was collected from the ACM Digital Library (ACM-DL) and IEEE Xplore (IEEE-X), which are believed to cover most publications on wearables and affective haptics. A set of inclusion and exclusion criteria was established, and the four-eyes principle was applied throughout the selection process, along with backward chaining using the same criteria. The final selection of articles was coded and thematically analyzed, providing dimensional criteria for a subsequent quantitative and descriptive summary.

3.1 Article Retrieval

The first article retrieval process involved generating search keywords for use in digital libraries. Using the aforementioned definition, two authors conducted an exploratory search in ACM-DL and IEEE-X. From the initial results, they extracted and analyzed the author keywords, identifying the most frequently occurring terms to determine common research topics and structure a search query. Additionally, the keyword query was refined

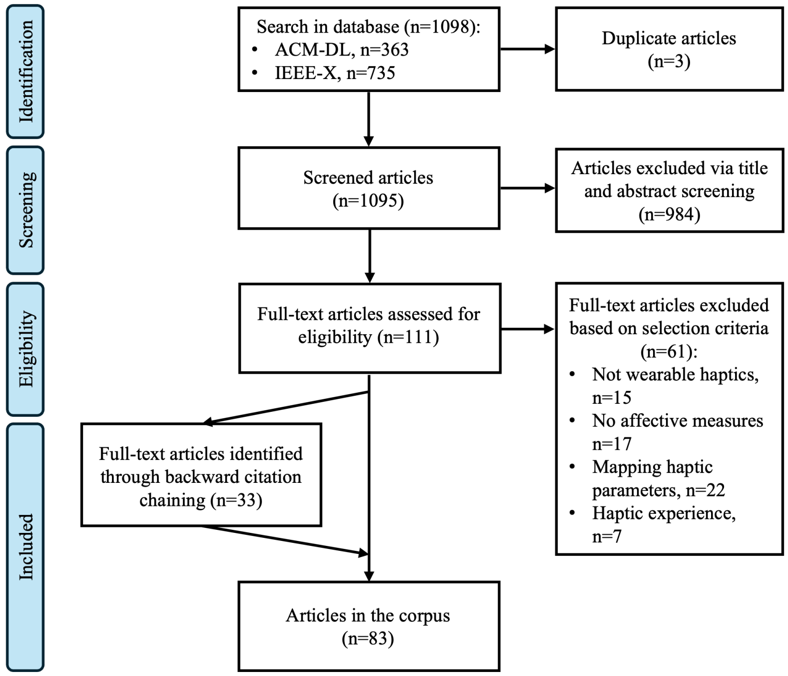

Figure 1. Article selection procedure illustrated in a PRISMA flowchart for the final collection of 83 articles.

according to the body of research known to the authors and existing survey articles in adjacent domains, such as affective haptics [20, 25] and mediated social touch [4, 17]. The final search query consisted of two sets of keywords: terms associated with wearable haptics and those related to mental and affective health.

```
query target: Title, Keywords (ACM-DL) / Document Title, Author Keywords (IEEE-X)
keywords: haptic, tactile, vibrotactile, touch, "force feedback", thermal, temperature,
electrotactile AND mental, anxiety, affective, emotion, psych*, social, wellbeing, well(-)being,
health
filter: Research Article OR Short Paper (ACM-DL) / Conferences, Journals (IEEE-X)
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A keyword-based search of the final query was performed again in the ACM and IEEE digital libraries. We matched the queries against titles and author keywords, while omitting abstracts as they introduced excessive noise into search results. The search yielded 363 ACM-DL and 735 IEEE-X publications. The last query for both libraries was executed on September 5, 2025.

3.2 Selection Criteria, Backward Chaining, and Filtering

To refine the results retrieved, we applied inclusion and exclusion criteria, as keyword-based searches often produce articles with unclear boundaries. Broader affective haptic agendas, including emotion communication and on- and off-body applications (e.g., in robotics, virtual reality, and rehabilitation), were excluded from the analysis as they have been addressed in existing surveys [20, 25, 44, 66, 67, 68, 69]. Studies that did not address affective state modulation were also excluded, including those that investigated haptic feedback mainly as a

means of processing non-affective information (e.g., notifications, guiding cues), or mapping haptic parameters to predefined affective labels (e.g., [25]). Likewise, studies that focused more on the usability and user experience (UX) of haptic-integrated systems [65] than on affective outcomes, were excluded.
In summary, selected studies were required to:

(1) include haptic devices that are worn on the body, as well as haptic actuation units that can potentially be adapted into wearable forms; and
(2) utilize haptic systems to influence affective states, assessed through empirical measures.

In particular, we excluded articles that:

(1) focused on mapping haptic parameters to non-affective functions or predefined emotive labels;
(2) focused on haptic user experience;
(3) lacked peer-review, such as workshop proposals, theses, patents, and technical reports; or
(4) were not written in English.

Since our goal is to capture the extensive scope of research contributions on wearable haptic interventions to date, we did not filter articles based on the number of citations or participants.

Two authors independently reviewed initial retrievals (n=1098), first removing three duplicate articles and then examining the titles and abstracts based on the criteria mentioned above. This process resulted in a preliminary selection of 111 articles. The initial screening yielded a raw inter-rater agreement of 93.5% and a Cohen's Kappa (κ) of 0.50, indicating moderate agreement [70]. Discrepancies were resolved through a consensus-based approach [71], in which the two authors—and, when necessary, a third author—discussed the cases until consensus was reached. This resulted in a final selection of 50 articles. We then engaged in backward citation chaining of the references of the initially selected articles to incorporate works not found in ACM-DL and IEEE-X, or those overlooked by the query search. Two authors reviewed the references using the same criteria, each author verifying the selections of the other authors. This process added 33 articles. The entire article selection process is outlined in Figure 1.

In summary, 83 articles were included in the analysis, spanning seven publication venues: ACM-DL (n=42), IEEE-X (n=31), Elsevier (n=2), SpringerLink (n=5), Frontiers (n=1), Nature (n=1), and MDPI (n=1), published between 2010 and 2025 (Figure 2).

3.3 Analysis

The 83 selected articles were first coded deductively through content analysis [71], using broad topics predefined from prior literature (see Section 2) and research questions (RQ1-RQ3) as analytic dimensions. Textual excerpts from the articles were coded into these dimensions to enable data reduction and sorting. For low-subjective

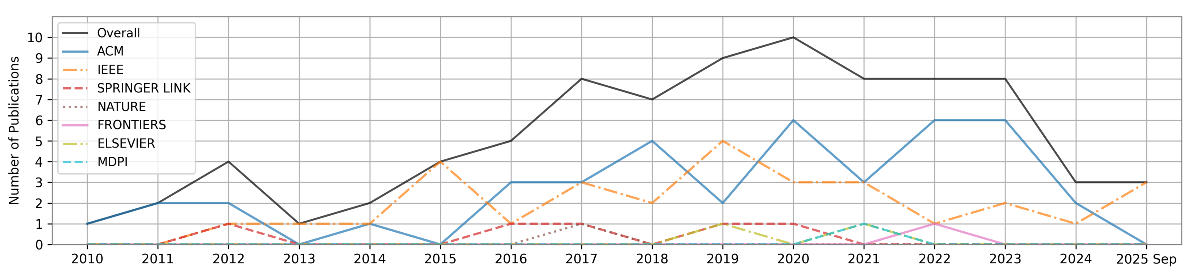

Figure 2. Total number of articles included in the literature review, overall and by publication venue, ranging from 2010 to September 2025.

dimensions in RQ2 and RQ3, haptic modalities were classified according to the perception properties of touch, distinguished by the mechanisms of LTMRs and thermoceptors, including pressure, vibration, stretch, gentle touch or movement on the skin, and temperature. On-body locations of haptic wearables were classified according to human anatomy and the corresponding wearable forms. For RQ4, intervention design aspects, including affective goals, mechanisms of intervention, and interpersonal context, were used as higher-level dimensions for coding. Two authors independently reviewed the coding categories and results, with conceptual ambiguities addressed through iterative updates of categories and recoding as needed. Following coding, the data were inductively analyzed both within and across descriptive categories. Affinity diagramming was used as a visual step within thematic analysis to cluster related insights and identify overarching themes that recur across articles [72]. Final themes were established through the same consensus procedure as in the previous screening (Section 4). Finally, a descriptive summary of each dimension was provided, along with a cross-dimensional mapping (Section 6.1).

4 RESULTS OF THEMATIC ANALYSIS

We report recurring themes identified across the selected articles, following the analysis procedure described in Section 3.3. The findings group into three overarching categories: (i) *affective goals* that interventions aim to influence, (ii) *intervention mechanisms* through which methods elicit or regulate affect, and (iii) *intervention context* describing the social and experimental settings in which these systems are evaluated.

Affective goals are clustered into three complementary types: *valence–arousal affect*, which targets emotional states along a positive/negative or high/low arousal axis (e.g., calm or excitement and mitigating stress or anxiety); *social affect* such as co-presence and closeness in dyadic or group interaction; and *embodied affect* emphasizing body-based sensations and associated affects (e.g., biofeedback, breathing, and frisson).

Intervention mechanisms are organized around four principal approaches: *sensory-modality effects*, which rely on sensory properties of haptic stimulation (e.g., vibration, pressure, thermal cues) to evoke affective responses; *physiological regulation*, which modulates affect through biofeedback or entrainment cues (e.g., guided breathing); *multimodal media communication*, which integrates haptic feedback with audio-visual media to shape emotional experience; and *mediated social touch*, which simulates affective touch or interpersonal gestures (e.g., stroking effects or squeezing patterns).

Intervention context includes three subthemes: *interpersonal dynamics*, which distinguishes between individual, dyadic, group, and audience-based interaction configurations; *application context*, which characterizes the intended usage domain, such as everyday self-regulation, mediated communication, or external stressor protocols; and contextual and technology-specific *wearable placement*. These themes provide the conceptual foundation for the dimensional analysis presented in Section 5.

4.1 Affective Goal

4.1.1 Valence–Arousal Affect. Across the reviewed studies, several interventions were designed to influence affective states positioned within the valence–arousal space. In the Positive Activation–Negative Activation (PANA) model [73], affect is represented along a continuum from positive to negative activation, while the circumplex model of affect [42] extends this representation by introducing arousal as a second dimension and locating affective states within a two-dimensional space. Emotions can thus be characterized by combinations of valence (pleasant–unpleasant) and arousal (activation–deactivation). For example, excitement reflects high valence and high arousal, relaxation reflects high valence and low arousal, and tension reflects low valence and high arousal. These states were often measured using the Positive and Negative Affect Schedule (PANAS) and the Self-Assessment Manikin (SAM) [74]. Within this dimensional framing, three recurrent affective goals were identified in the corpus: increasing pleasant low-arousal states (e.g., calmness, relaxation), increasing pleasant high-arousal states (e.g., excitement, engagement), and reducing negative-valence states (e.g., perceived stress,

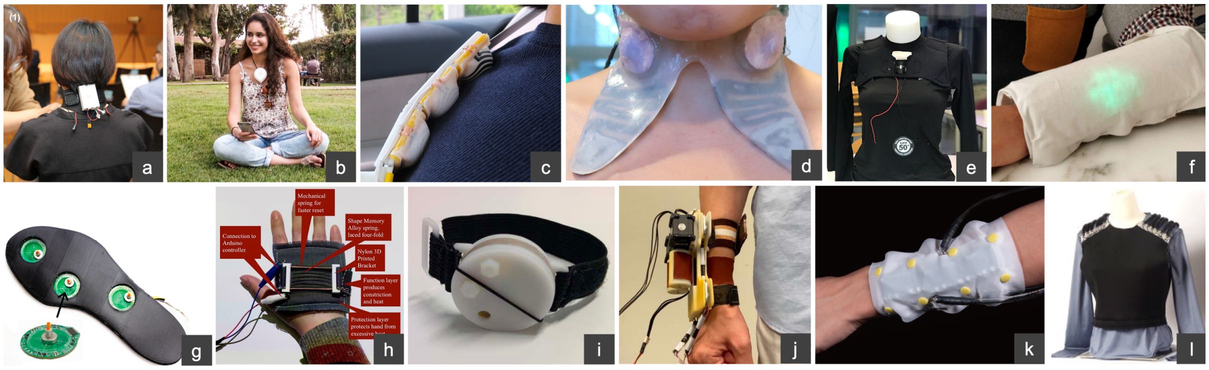

Figure 3. Custom-built wearable haptic systems from the included literature. (a) Frisson Waves [76], (b) Breeze [77], (c) aSpire [78], (d) a pneumatic interoception device [79], (e) ThermalWear [80], (f) VisualTouch [81], (g) TickleFoot [82], (h) SqueezeBands [83], (i) EmotionCheck [84], (j) Emoband [85], (k) ThermoCaress [86], and (l) a compression garment prototype [87]. Images reproduced from the cited works; © respective rights holders.

state anxiety). These goals were typically stated through valence-related descriptors provided by the authors. However, the level of arousal was not always explicitly defined and was often inferred from electrodermal activity (EDA), which comprises a tonic component—such as skin conductance level (SCL)—reflecting baseline autonomic activity responsive to external stimuli, and a phasic component—measured through electrodermal responses (EDR) or skin conductance responses (SCR)—capturing transient sympathetic fluctuations [75].

Low-arousal positive affect referred to goals concerned with calmness, relaxation, and pleasant low-activation states. Many studies in this group examined the perceived affective quality of haptic feedback itself, particularly when generated by social touch-inspired actuation such as gentle stroking [88], soft pressure [87], or warmth [86]. In other cases, interventions combined calming affective intent with situational demands, applying haptic feedback during foreground tasks [89] or everyday use [90] to support in-the-moment emotional regulation. *High-arousal positive affect* involved enhancing positive activation, such as enjoyment [91], alertness [92], or emotional engagement [93]. These studies frequently embedded haptic feedback into audiovisual [91] or interactive experiences [94]. Rather than reducing arousal, these interventions used dynamic or event-driven haptic patterns to reinforce stimulation and increase emotional intensity. *Stress and anxiety-related affect* was targeted in studies addressing negatively valenced emotional states associated with tension or situational strain, as characterized in the circumplex model [42, 95] and in stress models [32, 96]. These interventions were often evaluated under conditions intended to elicit elevated stress or anxiety, such as socially evaluative tasks (e.g., [97]) or cognitively demanding activities (e.g., [98]). Haptic feedback in this category frequently adapted methods from existing self-regulation techniques redesigned for wearable delivery. Correlated physiological indicators such as EDA, HR, and heart rate variability (HRV)—particularly the root mean square of successive differences (RMSSD), standard deviation of NN intervals (SDNN)—were used to capture autonomic nervous system (ANS) responses[99, 100, 101].

4.1.2 Embodied Affect. Several studies focused on affective experiences grounded in bodily perception [31], referred to here as *embodied affect*. These interventions emphasized the physical nature of haptic stimulation and targeted affect through bodily engagement rather than through emotional categories alone. Affective influence in this theme was linked to awareness of internal states (e.g., biofeedback and interoception) [102] or sensory phenomena such as frisson [76] and often involved sensing cardiac activity [84], skin conductance [76], or breathing rate [103] as part of the feedback design. Interventions used these bodily sensations to facilitate physiological entrainment and regulate anxiety or stress, while others explored cognitively mixed, aesthetic, or pleasurable bodily experiences elicited through haptic feedback. Haptic stimuli in this group often produced naturalistic or body-congruent sensations, such as heartbeat-like feedback synchronized with the user's physiological signals [104] or thermal cues corresponding to situational states [105].

4.1.3 Social Affect. Several interventions aimed to evoke affective experiences grounded in social interaction [106]. These *social affect* goals focused on feelings that arise in relation to others, such as social presence [83], emotional closeness [107], or interpersonal warmth [108]. Included interventions frequently appeared in remote or hybrid communication contexts, where haptic feedback served as an additional interpersonal channel to complement audio or visual cues. In such settings, haptic signals were used to convey affective intentions, maintain a sense of mutual awareness, or reinforce the feeling of being with another person despite physical distance. Some systems synchronized physiological signals between paired users, for example, by sharing thermal stimulation to create a sense of connectedness [109]. Others simulated affective touch gestures such as holding hands [83], stroking [107], gentle squeezing [110], or rubbing the forehead [111]. These gestures were applied in scenarios that emphasized relational meaning, such as comfort or emotional support.

4.2 Intervention Mechanism

4.2.1 Sensory Modality Effects. In the following, we detail how different haptic modalities such as vibration, pressure, warmth, and caress-like stimulation and their design parameters have been investigated.

Optimizing vibration parameters. Studies have calibrated various parameters of vibration, including intensity, frequency, duration, patterns, materials, and spatial placement. For example, Zheng et al. [112] investigated the impact of comprehensive actuator parameters on valence, hypothesizing the attention-capturing effect of positive haptic feedback. Key findings showed that switching stimulus locations (arm to back), actuation types (vibration to pressure), materials (plastic to rubber), and shapes (flat to small radius) increased positive valence, while increasing intensity or switching profiles (step to ramp) decreased it. In a more application-specific study, Korres et al. [92] designed an adaptive haptic alarm aimed at facilitating a pleasant awakening experience, thereby mitigating the stress and fatigue typically associated with abrupt arousal from sleep. They utilized an armband integrated with vibrotactile motors to deliver continuous, simultaneous, and successive vibrotactile patterns, with varying features and attributes controlled by Pulse-Width Modulation (PWM). The results revealed that continuous stimulation (burst duration 300 ms, overlap 120 ms) achieved the highest ratings for both valence and arousal. In contrast, modifications in the attributes of intensity, velocity, and direction did not result in significant differences.

Pressure for therapeutic touch. Investigating pressure stimuli through wearable haptics has been likened to a gentle, human social touch with potential health advantages, e.g., massage therapy has been shown to significantly influence pain perception, mood, and anxiety levels [113]. In particular, pressure feedback was often designed in its association with Deep Pressure Therapy (DPT) and social touch such as squeezing, while its ambient nature, compared to vibration, has been applied as haptic nudges in contexts involving other foreground tasks (particularly by Choi et al. [78, 89, 114]). DPT is mainly researched for its ability to reduce physical anxiety responses [115]. Common DPT devices include weighted blankets [116], weighted [117] or inflatable vests [118]. Brown et al. [119] designed the Automatic Inflatable DPT vest (AID) to deliver lateral compression through inflatable actuators integrated into a commercial fleece vest, creating a hug-like sensation by reducing the girth of the vest. Bontula et al. [120] further explored the effects of the AID vest on the level of anxiety, with the result that participants who were comfortable with social contact experienced a greater reduction in anxiety in the intervention condition with the AID vest. Similarly, in the development of a haptic garment that features gentle pressure on the shoulder [87], torso and upper arm [121], the soothing properties of compression and warmth were incorporated to offer emotional grounding, alleviating the effects of negative thoughts and emotions [122, 123, 124]. Zhu et al. [125] further explored the parameters of common social touch, such as squeezing, poking, patting, massaging, and stroking, applied to the forearm using a sensor and actuator-integrated sleeve, and evaluated its valence, realism, and comfort.

Complexities of haptic warmth. The presence of warmth has been identified as beneficial for health, such as through the neural pathways that are responsible for mood regulation and cognitive processes, potentially influencing stress-related disorders [126]. Moreover, both neutral physical warmth and social warmth, as exemplified by a hug, are governed by a shared neural mechanism [127]. As a key modality of human touch, thermal feedback has been studied in wearable haptics, though research findings remain mixed. While several studies demonstrated thermal effects on arousal, findings regarding valence were inconsistent when examining the sensation of mediated warmth alone. Investigations of body heat-like temperatures (32–35 °C) within the context of Computer Mediated Communication (CMC) [108] indicated no impact on perceived social presence and closeness, suggesting the need for future research to incorporate a wider range of temperature and interaction variables. Salminen et al. [128] examined the effects of mediated warmth in the palm and found that warm stimuli (either dynamically changing or the first static +4 °C of hand temperature) influenced levels of arousal and emotional dominance, compared to neutral or cold stimuli, while no effect on valence was observed. In conjunction with vibrotactile stimuli, findings suggest that thermal stimulation should be applied with caution to avoid causing adverse valence. For example, a temperature shift from cold to hot (28–36 °C) [129] and warmer stimuli (35–40 °C) [130] were found to decrease valence.

MacDonald et al. [131] designed emotionally resonant thermotactile feedback combining varying vibration frequencies, amplitudes, and temperatures applied to the palm. The stimuli simulated real-world sensations such as raindrops, a cat's purring, and breathing, with results showing that temperature (24–34 °C) significantly influenced the arousal. When presented with media stimuli, the emotional perception of news was not affected by thermal vibration [132], whereas valence and arousal responses to images were enhanced by associated temperature cues [133]. Moreover, Umair et al. [134] emphasized the importance of personalizing vibrotactile or thermal patterns. In an applied context, thermal cues delivered through the Embr Wave, a commercial thermal bracelet, enhanced presenters' awareness of the audience and perceived social connectedness, as personalized temperature feedback (±8 °C) reflected group engagement during presentations [109].

Caress-like stimulation. Research into affective touch simulation has focused on replicating the gentle stimulation of CT afferents on hairy skin through soft materials such as fabric, feathers, and fur, mimicking the pleasant sensations associated with natural social touch. Fabric-mediated CT touch and its features have been the subject of extensive investigation by the same research group, led by Bianchi et al. [135, 136, 137], Greco et al. [138, 139, 140], and Valenza et al. [141]. Building upon the system established by Bianchi et al. [135], the researchers investigated caress-like sensations through an elastic fabric layer on the forearm, wherein the fabric's edges are affixed to two rollers actuated by motors. By modulating the positions and rotational velocities of the motors, the system regulates both the velocity (9.4-65 mm/s) and intensity (2-20 N) of the synthetic caress applied to the user's arm. The main effect on emotional responses elicited by this stimulation was found in valence and arousal levels, along with changes in power spectral density (PSD) in the frequency bands α, β, and γ of the electroencephalogram (EEG) [141, 142, 143], EDA [138], and HRV [136, 144]. Similarly, a recent study by Yang et al. [85] found that textile materials (e.g., wool, silk, cotton) significantly influenced valence ratings for stroking stimuli, while movement-related factors, such as velocity (78-206 mm/s) and duration (1-2 s), significantly enhanced both valence and arousal. For squeezing stimuli, the type of material also significantly affected valence ratings, while increased pressure (0-15 N) and longer duration (2 s) led to more negative valence and higher arousal ratings.

4.2.2 Physiological Regulation. In the following, we review how wearable haptic systems have been designed to regulate affect by influencing physiological processes.

Interoception and biofeedback. Interoception, the perception of internal bodily signals, is closely linked to affective experience [145, 146]. Interoceptive awareness (IAc), defined as the ability to perceive and respond to interoceptive cues, has been associated with changes in affective and physiological states [147, 148], and can be modified through targeted interventions [149, 150]. In the reviewed studies, interoception and biofeedback were used as mechanisms to modulate affect by coupling haptic feedback with physiological signals such as heart rate or breathing rhythm. Prior work suggests that interoceptive training can be achieved through both mindful attention [47, 151, 152] and implicit feedback cues that require minimal cognitive effort [153]. Consistent with this, wearable haptic systems frequently delivered biofeedback through subtle, continuous feedback loops that were aimed at supporting automatic regulation rather than explicit emotional control. Unlike traditional biofeedback techniques used in interactive systems [29], haptic affective biofeedback emphasized implicit down-regulation and physiological synchrony [29, 154]. Several studies specifically investigated heart rate feedback, using slow, augmented, or "false" heartbeat signals [84] to influence perceived emotional state [155, 156] and reduce stress in demanding conditions [157, 158, 159].

Costa et al. [84] evaluated a vibrotactile wristband, EmotionCheck, that provided slow heartbeat-like feedback (60 BPM). Participants who were falsely led to believe that the feedback matched their actual heart rate exhibited significantly lower anxiety scores than those in control conditions. In real-world applications, Choi et al. [114] evaluated ambienBeat, a wristband that delivers heartbeat-like pressure feedback for heart rate regulation, against auditory and visual biofeedback. In passive tasks, boosting tactile feedback (120 BPM) increased HR, whereas in active tasks, calming tactile stimuli (60 BPM) resulted in a greater HR reduction compared to auditory input. Other studies personalized the frequency of haptic heartbeat feedback based on individuals' resting heart rates, showing that feedback adjusted by 20-30% successfully influenced state anxiety levels. Expanding on the previous study [84], Costa et al. [26] investigated the effects of customized heart rate vibrations (±30% from baseline) via Apple Watch during a cognitive task. Slow feedback reduced anxiety, improved HRV, and enhanced performance, while fast feedback had the opposite effect. Similarly, Azevedo et al. [160] examined the calming effects of Doppel, a vibrotactile wristband, during public speaking preparation. Slow biofeedback (20% below baseline) significantly lowered perceived anxiety and skin conductance responses, though it did not affect average HR. In contrast, Wang et al. [161] recently examined the impact of fast heartbeat signals (30% above baseline or fixed 120 BPM) delivered via tactile or auditory means. These signals significantly increased HR and anxiety scores under both calm and stress conditions, reinforcing the need for careful biofeedback design to avoid unintended stress responses. Furthermore, Xu et al. [104] specifically investigated IAc as a moderator of biofeedback efficacy, showing that individuals with higher IAc exhibited a smaller HR increase and greater HRV improvements when exposed to slow heartbeat vibrations (80% of baseline). This suggests that the perception of biofeedback varies based on an individual's interoceptive sensitivity.

Guided breathing. Conscious or voluntary breathing is widely recognized as an effective method for alleviating mental distress, often incorporated into mindfulness and meditation practices [162, 163]. Specifically, slow breathing has been shown to reduce psychological stress and modulate the autonomic nervous system (ANS) [162, 164, 165]. In light of this, research on wearable haptic interventions has focused on designing haptic signals that facilitate slow and mindful breathing. This is achieved through respiratory metrics, such as the breathing rate [78, 166], and parameters derived from breathing waveforms for evaluation [103, 167].

Frey et al. [77] further investigated breathing biofeedback using a wearable chest pendant that combined visual, audio, and haptic cues. Haptic feedback was rated as more pleasant than other modalities, and longer exhalation was correlated with increased valence, while breathing variability and pacing influenced arousal. These findings highlight the potential of haptic biofeedback to support interoceptive engagement and affect regulation.

Nevertheless, studies indicated that breathing techniques may not consistently translate changes in breathing rate into broader reductions in stress or arousal, especially when measured through more indirect physiological markers. Papadopoulou et al. [105] developed the Affective Sleeve, a wearable that provides warm rhythmic pressure to modulate breathing during a time-constrained cognitive task. Both slower (relaxed baseline) and faster haptic pacing (25% above baseline) accordingly influenced the breathing rate, although no significant effects were observed on EDA as a stress indicator. In commuting contexts, Paredes et al. [166] compared vibrotactile and voice-guided breathing support during simulated driving and reported stage-dependent effects on heart rate and root mean square of successive differences (RMSSD), with voice feedback producing greater increases in RMSSD, although no reduction in perceived stress was potentially found due to the absence of induced stressors. Balters et al. [168] addressed this by introducing acute stress in a driving simulation and found that haptic guidance significantly increased RMSSD under both calm and stressed conditions, although heart rate was not affected. Furthermore, individual differences in breathing mechanisms, user awareness of the intervention purpose, and varying design factors can further complicate the consistency of results. Miri et al. [103] introduced the PIV, personalizable and inconspicuous, breathing pacer that generated haptic feedback based on participants' respiratory data (breaths per minute and inhale–exhale ratio) during an audio-guided slow-breathing session. The study examined the effects of feedback placement (chest, abdomen, lower back), waveform shape (vertical, horizontal, diagonal), and order (inhale-first vs. exhale-first), and found a small but significant decrease in tonic EDA when vertical waveforms were used, indicating reduced arousal. Choi et al. [78] evaluated aSpire, a seatbelt-integrated haptic system designed to promote paced breathing during car commutes. Although no significant effects were found on stress or arousal, the breathing rate decreased when the participants were informed of the purpose of the device. In general, breathing-focused haptic interventions have examined both interaction design parameters and application contexts; however, the findings remain inconclusive due to complex physiological interactions during breathing [169] and variable psychophysiological outcomes [163]. Detailed, context-sensitive intervention and study designs are suggested to leverage the known relaxation effects of guided breathing [162, 164, 165].

4.2.3 Multimodal Media Communication. As digital media, including music, video, social and mobile platforms, become increasingly prevalent and influential in mental health and psychology [170], wearable haptic technologies have been introduced to enhance these media experiences. In interpersonal communication, haptic devices have supported emotional expression and intimacy in remote contexts. The Feel Glove system [107], pairing a vibrotactile glove with a sensing counterpart, allowed couples to exchange touch during calls, significantly enhancing perceived intimacy compared to non-haptic modes. Similarly, RingU [171] used vibration and color cues to prime the affective tone of text messages, with positive haptic feedback shifting perceptions of neutral and negative messages toward higher valence. Additionally, ThermalWear [80] showed that chest-worn thermal displays could convey affect in voice messages, with warm and cool stimuli increasing and decreasing the valence of the message, respectively, without causing discomfort.

Building on these communication studies, several works examined how haptics modulate affective experience in music and audiovisual media. Chan et al. [172] found that paired participants exchanging squeezes on the forearm while listening to happy or sad songs experienced emotional alignment influenced by both song valence and partner familiarity. Mazzoni et al. [173] demonstrated that vibrotactile patterns encoded arousal and valence dimensions of music—high intensity and frequency conveying high-arousal, positive states, and low values mapping to calmer, negative tones—consistent with the circumplex model of emotion. At a collective level, Frisson Waves [76] targeted shared aesthetic chills during musical performances, detecting physiological frisson and reproducing it as cold thermal stimuli (24 °C) via a neck-worn interface. The system enhanced frisson sensations and fostered audience connectedness, illustrating how haptics can mediate collective affective experiences. In the multisensory domain, FeelTheNews [132] combined vibrotactile and thermal feedback with news videos, finding that engagement and perceived agency moderated emotional impact, as haptic cues did not significantly alter perceived valence or intensity. Timing was further explored by Tara et al. [91], reporting increased skin conductance and self-reported emotional intensity when vibration was synchronized with visual events.

From an accessibility perspective, haptic systems have provided alternative affective channels for the deaf and hard-of-hearing community. Lucía et al. [174] showed that vibrotactile feedback could simulate the emotional qualities of music, activating the auditory and emotional regions of the brain in participants with hearing impairment. Similarly, López et al. [175] found that vibrotactile stimulation during emotional video scenes increased neural activation in areas linked to affective processing, suggesting that tactile cues can enrich audiovisual experiences and emotional engagement for users with hearing loss.

4.2.4 Mediated Social Touch. In the following, we examine how wearable haptic systems convey affect through mediated social touch.

Stroking illusion. Studies have explored sensory illusions to generate stroking sensations by sequentially activating fixed arrays of vibrotactile actuators, as an alternative to custom kinesthetic haptic systems [44, 176]. This method builds on the cutaneous "rabbit" illusion [177] or "apparent movement" [178] that occurs when sequential taps at separate points on the skin create the perception of continuous phantom sensations between them. Affective mechanisms underlying stroking illusions have been linked to neurophysiological and perceptual processes associated with pleasant touch. The perceived pleasantness of caress-like stroking follows an inverted U-shaped function of velocity, reflecting optimal activation of CT afferents in the hairy skin [6]. The social touch hypothesis further proposes that these CT afferents act as filters for socially relevant tactile signals, mediating emotional comfort and bonding [2]. Although vibrotactile stroking illusions likely engage other mechanoreceptors, they can nonetheless evoke comparable affective interpretations through learned associations with natural stroking experiences [63]. Several included studies designed haptic sleeves to simulate gentle stroking on the forearm by optimizing actuation parameters to enhance naturalness, continuity, and emotional impact. They illustrated that achieving an effective stroking illusion requires tuning of spatial, temporal, and intensity parameters, with evidence supporting lower frequencies, moderate amplitudes, and optimal timing overlaps. Specifically, studies investigated how sequential activation and pulse timing influence perceived smoothness and pleasantness. Raisamo et al. [179] compared vibrotactile patterns on the forearm, showing that smoothly modulated amplitudes were rated as more continuous and pleasant than discrete saltation pulses, with perceived continuity positively correlating with pleasantness and negatively with arousal. Culbertson et al. [180] and Nunez et al. [181] further demonstrated that precise inter-actuator delays are critical: shorter delays (12.5-50% of pulse width) produced the most pleasant stroking sensations, whereas longer delays caused discomfort resembling crawling. A subsequent comparison of indentation and skin-slip actuation confirmed that skin-slip produced a more effective and continuous stroking illusion [182]. Zhu et al. [125] extended these findings, showing that overlapping actuator signals (25% motion duration) and amplifying mid-stroke intensity enhanced the perceived realism of motion. Other studies examined how actuation strength and speed modulate affective valence. Israr et al. [183] found that low-frequency (<40 Hz), low-amplitude strokes were rated as more pleasant than high-frequency vibrations. Similarly, Huisman et al. [88] reported that low-intensity (140 Hz, ±0.9 g) and slower stroking velocities (6.4 cm/s) elicited higher pleasantness than stronger, faster vibrations.

Mediated social gestures. Zhu et al. [125] advanced the design of mediated social touch by reproducing a range of familiar social gestures—including poking, patting, massaging, squeezing, and stroking—using a wearable array of voice coil actuators. Their system captured and replayed recorded human touch gestures through sensor-based encoding and gesture-based signal processing. In a user study examining how gesture speed influenced perceived valence, arousal, realism, and comfort, faster gesture playback was associated with greater negative affect and reduced realism. Yarosh et al. [83] investigated mediated social gestures such as handshakes and high-fives to improve remote cooperation using SqueezeBands, which provided squeezing sensations on the hand and upper arm to mimic the feeling of a hug or a reassuring pat on the shoulder. Although the study did not find a significant effect on social presence, as hypothesized, haptic support reduced task load in emotionally salient tasks during video chats. Similarly, Wang et al. [110] showed that squeezing pressure on the upper arm during emotional story peaks significantly enhanced the listeners' sense of connection with the storyteller. Mostofa et al. [111] extended this line of work by enabling family members to convey touch remotely through vibrotactile stimulation on the forehead of participants acting as isolated patients. Their results indicated increased positive emotions and decreased negative emotions after the tactile telepresence intervention, consistent with prior findings on the comforting effects of touch [1, 19]. Zhang et al. [81] examined mediated social gestures through multimodal integration in VisualTouch, a visuo-tactile sleeve that combines low-frequency vibration (<5 Hz) with dynamic visual cues representing gestures such as rubbing, patting, and stroking. When visual and tactile cues were temporally congruent, participants rated the interaction as more natural and affectively positive, demonstrating that congruent visual motion can enhance the interpretation of mediated social gestures.

4.3 Intervention Context

4.3.1 Interpersonal Dynamics. Interpersonal configuration substantially shaped how wearable haptic interventions addressed affective experience and regulation. Most studies involved individual or dyadic contexts, while a smaller number engaged group-level interaction. Dyadic interventions often centered on familiar relationships, such as romantic partners or friends, where haptic cues mediated emotional connection and mutual regulation through shared physiological feedback [184] or comforting touch [185]. In contrast, neutral or remote pairings were employed to examine communicative and empathic potential in the absence of direct physical contact, highlighting how relational familiarity influences the interpretation of haptic meaning [186]. Mediated settings frequently explored how haptic communication could foster social presence and emotional closeness despite physical separation. For instance, mediated gestures were designed to convey warmth [108], care [111], and cooperation [83]. While some systems did not significantly alter perceived social presence [83], haptic cues nonetheless reduced task load or increased positive affect in emotionally salient contexts [111].

Several individual-focused interventions incorporated social evaluation as an experimental factor to study anxiety and stress regulation. Social anxiety arises from individuals' negative assumptions about the likelihood and social consequences of displaying physiological arousal [187]. Specifically, social-evaluative threat (SET) occurs when an aspect of the self is judged by others, triggering cognitive, affective, and physiological responses, including acute psychophysiological stress reactions and potential long-term health implications [188]. The Trier Social Stress Test (TSST) [97], including public speaking tasks, was commonly used to simulate SET, while perceived anxiety was universally measured using the State-Trait Anxiety Inventory (STAI) [189]. For example, Bontula et al. [120] evaluated deep pressure stimulation using an inflatable vest during TSST procedures, showing that comfort with social touch moderated anxiety reduction, while Raether et al. [190] tested vibrotactile wrist feedback in a virtual public-speaking scenario, finding that timing relative to physiological arousal influenced heart rate responses.

4.3.2 Application Context. Experimental and applied contexts varied widely across studies, reflecting distinct goals in affective evaluation and intervention design. We identified three overarching study contexts: controlled laboratory protocols, applied laboratory environments, and real-world field deployments, following the emotion elicitation framework described by Schmidt et al. [32]. Most studies were conducted in laboratory settings, where affective responses could be systematically elicited and measured. Emotional stimuli included standardized affective media (e.g., images, videos, or music), cognitive and attention tasks (e.g., mental arithmetic [97], verbal association [98], Stroop Color and Word Test or SCWT [191]), and physical activities such as walking or jumping. Several studies implemented validated anxiety-inducing protocols, such as TSST [97], or other evaluative tasks—e.g., the Sing-a-Song Stress Test (SSST), an alternative to the TSST in which participants are unexpectedly asked to sing in front of confederates—to examine anxiety, stress, and physiological regulation under controlled stressors. These designs emphasized experimental rigor and reproducibility. Beyond controlled settings, a growing number of interventions adopted contextual scenarios that balanced experimental control with ecological realism. For example, virtual reality environments simulated stress-inducing [190] or emotion-embedded scenarios [94] to evoke affective responses. Other studies embedded wearable haptics into everyday or mobile activities, including simulated driving, working [89], or commuting [166], to explore how affect regulation operates alongside routine or naturally stressful situations. Remote collaboration [83] and telepresence scenarios, such as those simulating hospital stays [111], were also simulated. A smaller but notable subset of studies evaluated wearable haptic interventions in field settings, where environmental and situational context played a crucial role. These included scenarios such as waking up after regular sleep [92], attending live performances [76], or driving in real city environments [78].

4.3.3 Wearable Placement. The strategic positioning of haptic devices on the body is primarily guided by practical considerations of wearability and comfort. For instance, usability during sleep [92], affective furniture such as chairs [192], jackets [193, 194], vests [195], and integration into existing environmental devices [112, 129] are all considerations, along with the size of the actuator and ease of placement [130, 131, 196, 197]. Some designs take into account skin sensitivity and the incorporation of wearable technology. For example, the integration potential of the pinna (earlobe) with earphones [198], and hand stimulation technologies incorporated into glove designs [173]. Focusing on a task-oriented system design, Miri et al. [103] evaluated the effectiveness of a breathing pacer applied to the abdomen, chest, and lower back, the areas most relevant to breathing training. Additionally, vibrotactile actuator arrays were developed to mimic the area of social touch, such as the forearm [88, 183], to promote gentle and affective tactile sensations on regions of non-glabrous skin. In particular, the forearm, classified as a hairy skin area with CT afferents [6, 60, 64], is a key site for caress-like stimulation and the stroking illusion due to its role in affective touch [3, 199], being socially acceptable for wearable haptics [200, 201]. This makes it a focus for studies on mechanical stroking [125] and the design of wearable devices such as arm sleeves equipped with actuators on the dorsal [81, 125, 183], ventral [88], or lateral side [202]. Overall, notable wearable forms identified include arm sleeves [81, 125, 180, 202], gloves [107, 173, 174, 175], inflatable [119] or compression vests [121], neckbands [76, 203], a pendant worn on the chest [77], a clip-on device that can be attached to a seat belt or backpack strap [78], an insole [82], and a shirt [87]. Examples of custom-built wearable haptic systems found in our review are presented in Figure 3.

5 DESCRIPTIVE TRENDS ACROSS INTERVENTION DIMENSIONS

This section reports the descriptive trends across the core dimensions of affective wearable haptic interventions: *affective goal* (RQ1), *haptic modality* (RQ2), and *body location* (RQ3). These dimensions provide an overview of what affective phenomena are examined, how haptic feedback is designed and implemented, and where it is applied on the body (Figure 4). In addition, we include the *intervention mechanism* and *interpersonal context* (RQ4) as thematic dimensions identified in Section 4, i.e., how interaction through wearable haptic systems is designed to influence targeted affective experiences and what interpersonal dynamics are assumed. As the application contexts are diverse, we describe them in relation to their associated affective goals in Table 1. We later discuss this analysis through cross-dimensional integration in Section 6.1, examining how these key dimensions interact in current design practice.

5.1 RQ1: Affective Goal

We classified intervention goals into six categories based on the intended affective outcomes specified by authors (Figure 4). A summary of concrete measurements and their associated application contexts, along with the

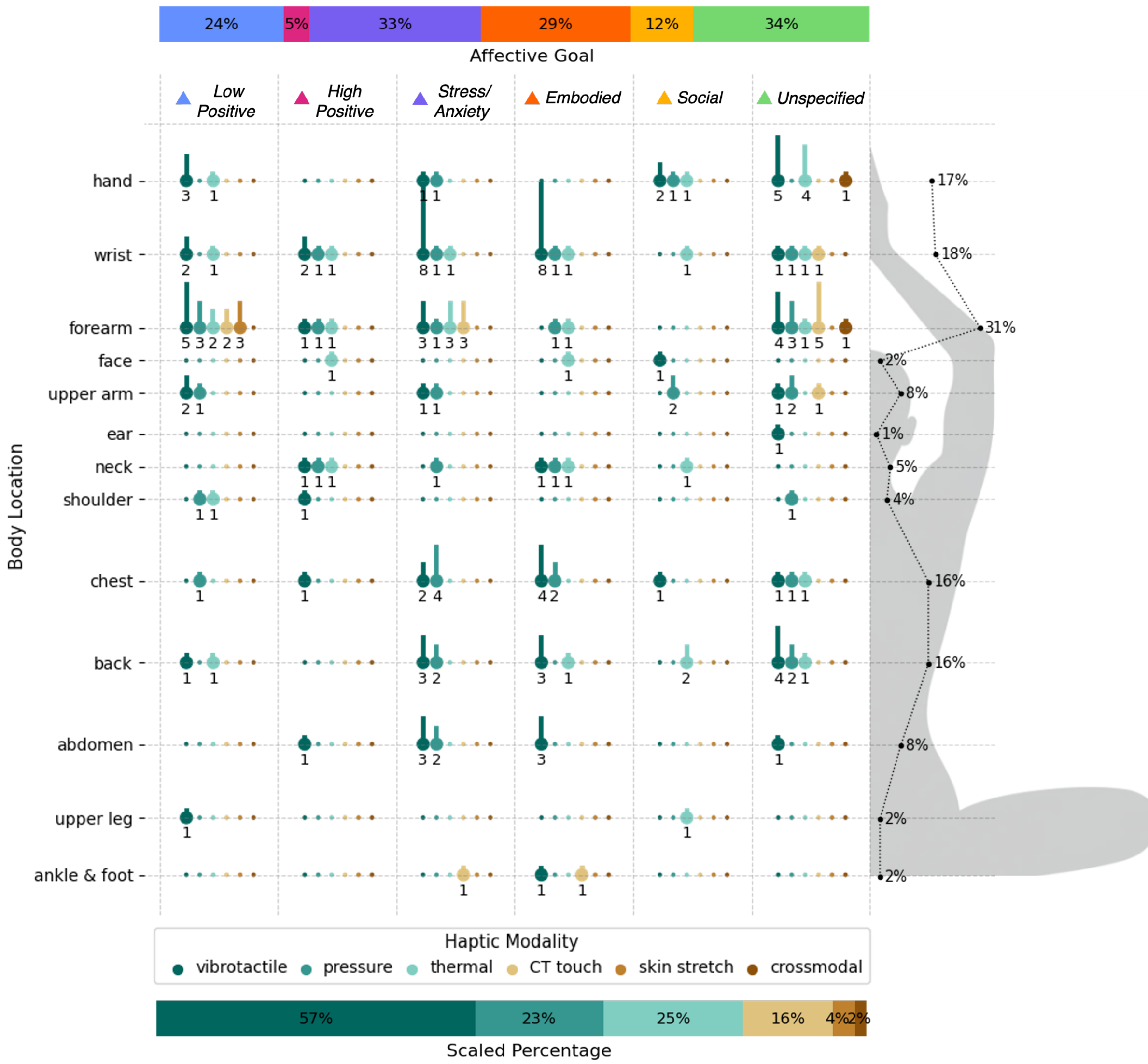

Figure 4. An overview map of the dimensions of affective wearable haptic interventions, including affective goals, haptic modalities, and body locations. The full corpus of included articles and their corresponding dimensional classifications are provided in Appendix A. In the figure, intersections where affective goals (described in Table 1) meet body locations are categorized by haptic modality, which is represented in different colors corresponding to the legend. The line heights extending from each haptic modality point and the numbers below indicate the number of corresponding articles. Bar graphs at the edges display the distribution of affective targets (top) and haptic modalities (bottom). Additionally, a line graph on the human torso figure (right) represents the relative percentages of dimensional categories. The ankle and foot are grouped together due to their limited representation, coupled with vibration and CT touch modalities, respectively. Since articles may cover multiple categories across the dimensions, the bar and line plots use a 'scaled percentage' approach.

Table 1. Overview of affective goal categories, including their descriptions, identified affective measures, and associated application contexts of the respective intervention studies.

Affective Goal	Measures	Application Context
Low positive affect Relaxed, restorative states; positive valence and low arousal in the circumplex model.	*Physiological:* EDA [105, 138, 160], HR [160, 202], HRV (RMSSD [134]), EEG (PSD in α, β, γ) [140], breath parameters [89, 105] *Subjective:* pleasantness [86, 87, 88, 148, 180, 181, 182, 183], valence and arousal [90, 131, 138, 140, 192, 197], calmness [87, 105], positive/negative affect, relaxation and mindfulness [87]	Real-world sensations [131], meditation [87], attentional task [90]
High positive affect Engaging, uplifting positive states; positive valence and high arousal in the circumplex model.	*Physiological:* HR, HRV (SDNN, RMSSD) [93], EDA [91] *Subjective:* valence and arousal [92], excitement [91, 93], awe [94]	VR scene [94], kinesthetic video [91], sport viewing [93], waking up [92]
Stress/anxiety Negative valence states associated with external stressors; conceptually aligned with tension or distress in the circumplex model.	*Physiological:* HR [79, 104, 114, 119, 131, 160, 161, 166, 168, 190, 202, 204, 205], HRV (RMSSD [21, 26, 134, 166, 168]; SDNN [114]; the number/percentage of successive heartbeat intervals differing by more than 50 ms, NN50/pNN50 [26]; frequency domain [21, 26, 104]; sample entropy [21]), EDA [78, 105, 166] (or SCR [82, 103, 160, 167, 190, 196], SCL [160]), breath parameters [78, 89, 103, 105, 166, 167, 168] *Subjective:* anxiety (e.g., STAI) [21, 26, 79, 84, 89, 134, 160, 161, 167, 190, 196, 206], stress [82, 114, 166, 205], positive/negative affect (e.g., PANAS) [103, 206], valence and arousal [78, 79, 82], perceived workload (e.g., NASA Task Load Index) [83]	Public speech [190], job interview (e.g., TSST) [21, 84, 104, 119, 120, 202], singing (SSST) [202], cognitive task (e.g., SCWT, spatial reasoning, math test) [105, 134, 168, 205], emotional content [184, 204], remote collaboration [83], driving [78, 166, 168], daily foreground tasks [89], socially anxious participants [196]
Embodied affect Physiological modulation through bodily sensations (e.g., interoception) and associated affects.	*Physiological:* HR [79, 104, 114, 160, 161, 166, 168, 190, 203], HRV (RMSSD [26, 134, 166, 168, 203], SDNN [114], NN50/pNN50 [26], frequency domain [26, 104]), EDA [76, 78, 105, 166] (or SCR [82, 103, 160, 167, 190], SCL [160]), breath parameters [77, 78, 89, 103, 105, 166, 167, 168] *Subjective:* valence and arousal [77, 78, 79, 82], frisson/chill [76, 94, 148], ticklishness [82]	HR biofeedback [84, 104, 114, 134, 150, 160, 161, 190, 203], breathing [77, 78, 103, 105, 166, 167, 168, 206], (physical) foreground task [114], aesthetic experience [76]
Social affect Concerned with affective states shared in interaction or embedded in a social context.	*Physiological:* EDA [76] *Subjective:* closeness/intimacy (e.g., Inclusion of Other in the Self, IOS; Social Closeness Index, SCI) [107, 207], connectedness [76, 107, 109, 110], social presence [83, 111, 207, 208], friendliness [208], attractiveness [150], empathy [148], positive/negative affect (e.g., PANAS) [110, 111], qualitative data [111]	Hospital isolation [111], storytelling [110, 148], remote collaboration [83, 109], long distance relationship [107], performance audience [76], virtual agent [208]
Unspecified goal Represents affect in the valence–arousal space or via physiological correlates rather than discrete affective states.	*Physiological:* EEG (PSD in α, β, γ [139, 141, 209], activation peaks [174, 175]), EDA (EDR [135, 136], SCR [128]), HRV (SDNN, RMSSD, pNN50) [136], facial electromyography [210] *Subjective*: valence and arousal [80, 81, 85, 125, 128, 129, 130, 132, 133, 135, 136, 137, 139, 141, 171, 173, 179, 209, 211, 212, 213] with Wundt's items [198] or dominance (e.g., SAM) [128, 133, 213], positive/negative affect (e.g., PANAS) [112, 172], attention [112]	Text message [171], music experience [172, 173, 174, 175], hearing-impaired participants [174, 175], video watching (news [132], movie [209]), voice perception [80, 198], image perception [133, 213]

corresponding publications, is presented in Table 1. The most frequent category was *unspecified* or neutral goal (n=28, 34%), which included studies that evaluated wearable haptic systems without articulating a specific affective intervention goal. These studies typically measured affective responses such as valence or arousal but treated affect as an outcome of interaction rather than the primary target of intervention. The second largest category was *stress or anxiety* reduction (n=27, 33%), comprising interventions explicitly designed to reduce stress, anxiety, or emotional tension. These systems commonly supported self-regulation in everyday contexts involving external stressors through down-regulating effects. *Embodied affect* interventions (n=24, 29%) focused on body–mind engagement and interoceptive awareness, often synchronizing haptic feedback with physiological signals such as breath or heart rate to support emotional grounding. *Low positive affect* as intervention goals (n=20, 24%) targeted positively valenced, low-arousal states such as calm, relaxation, and pleasantness. These interventions frequently used gentle or affective tactile cues (e.g., caress-like motion, gentle stroking). *Social affect* interventions (n=10, 12%) aimed to convey or enhance interpersonal emotions such as connectedness, empathy, or remote social presence through mediated touch or shared nonverbal context. Finally, *high positive* goals (n=4, 5%) sought to elicit high-arousal positive states such as excitement or awe. This category was the least represented in the corpus.

5.2 RQ2: Haptic Modality

Six types of haptic modalities were identified in the reviewed interventions (Figure 4). A summary of their perceptual characteristics and applied actuation technologies is presented in Table 2. *Vibrotactile* stimulation was the most prevalent modality (n=47, 57%), typically delivered via eccentric rotating mass (ERM) motors, linear resonant actuators (LRA), or voice coil actuators. Vibrotactile feedback was widely used due to its compact form factor, flexible signal modulation, and established integration in consumer wearables. It was most commonly configured using variations in frequency, amplitude, or temporal patterning. *Thermal* stimulation (n=21, 25%) conveyed temperature changes or gradients and was primarily implemented using Peltier elements. Warmth was often used to produce comforting tactile experiences, while cooling effects were investigated less frequently. *Pressure* stimulation (n=19, 23%) involved force applied to the skin surface and was implemented using servo motors, shape memory alloys (SMAs), or pneumatic actuation. This category encompassed both direct normal force (e.g., pressing or squeezing) and distributed compression around a body region (e.g., inflatable straps or bands). Pressure-based haptics were frequently used to emulate touch-like sensations. *C-tactile (CT) touch* stimulation (n=13, 16%) reproduced slow, gentle stroking optimized for CT afferent activation. These systems used soft materials such as fabric pads, motor-driven brushes, or feather-like components to deliver affective touch characterized by low-force, continuous motion. *Skin stretch* (n=3, 4%) involved lateral deformation of the skin surface through shear forces. This modality was implemented using robotic actuation mechanisms that apply tangential movement to the skin [39, 214]. Finally, *crossmodal* stimulation designs (n=2, 2%) integrated haptic feedback with additional sensory channels such as auditory or visual stimuli to shape multisensory affective experiences. Only studies in which haptic stimulation functioned as an active affective component were included in this category; works that used other sensory modalities solely as control variables were excluded.

5.3 RQ3: Body Location

Thirteen on-body locations were identified across the reviewed interventions (Figure 4). The most common placements were on the *forearm* (n=26, 31%), *wrist* (n=15, 18%), and *hand* (n=14, 17%), together accounting for over half of all studies. These regions align with established trends in wearable design [201] and are frequent sites for socially acceptable and unobtrusive interaction [215]. The *forearm* and *upper arm* are also relevant to affective haptics due to the presence of C-tactile (CT) afferents in hairy skin areas, making them suitable for mediating affective touch. *Hand*-based implementations often used glove or palm-worn designs and leveraged the high mechanoreceptor density of glabrous skin for precise tactile perception. The *chest* (n=13, 16%) and *back* (n=13, 16%) were also frequently targeted, particularly in interventions related to breathing guidance, cardiac awareness, or deep pressure stimulation. These locations were commonly implemented through garment-like devices such as vests, harnesses, or seat-integrated systems. Less frequently explored sites included the *abdomen* (n=7, 8%), *neck*

Table 2. Overview of haptic modalities identified, including descriptions of their perception properties and the actuation technologies used.

Haptic Modality	Perception	Actuation Technology
Vibration	Vibrations of varying frequencies that are delivered by vibrotactile actuators and processed by mechanoreceptors in the skin.	Single, array or grid of vibrotactile motors, e.g., eccentric rotating mass (ERM) [81, 111, 112, 129, 174, 175], voice coil actuator [82, 84, 88, 91, 92, 93, 125, 131, 132, 161, 179, 180, 182, 183, 190, 192, 196, 197], linear resonant actuator (LRA) [103, 107, 130, 166, 167, 168, 184, 202, 206], piezo actuator [173], audio transducer [150, 203, 212]; non-specified [77, 171, 198, 204, 205], off-the-shelf products, e.g., *Doppel* [134, 160], *Apple Watch* [26, 104], *bHaptics* vest [209]
Pressure	Force applied to the skin, from gentle to deep pressure, including sensations such as compression, squeezing, and pneumatic pressure.	Servo motor tightening a fabric layer [85, 110, 172] or controlling cam arms [112]; shape memory alloy (SMA) [83, 87, 105, 119, 121, 210], pneumatic actuator [78, 79, 86, 89, 93, 120], voice coil actuator [114, 125, 180]
Temperature	Warmth, coolness, and temperature change relative to the human body's temperature homeostasis.	Peltier modules [76, 80, 93, 94, 128, 130, 131, 132, 133, 148, 208, 213], shape memory alloy (SMA) [87, 105, 210], polyimide heating element [184], water pouch connected to a low-temperature cooker with tubes [86], non-specified [204], off-the-shelf products, e.g., *Embr Wave* [109, 129, 134], Waeco Magic Heat [207]
CT touch	A pleasant sensation of slow, gentle touch, such as soft stroking, or tickling, processed by CT afferents and typically associated with social and affective contexts.	DC motor moving an attached feather [184, 204] or a furry object [21]; DC servo motor connected through cylinders moving a fabric layer [85, 135, 136, 137, 138, 139, 140, 141], PCB module with voice coil actuators driving magnets to activate a mounted brush [82], non-specified motors sliding a fabric layer [211]
Skin stretch	Lateral force movement across skin, including skin slip, and skin stretch.	DC motors designed to drive a tactor array [181, 182], shape memory alloy (SMA) [90]
Crossmodality	The interaction of multiple sensory modalities, such as tactile stimulation combined with visual or auditory stimuli.	RGB LED for visual input [81, 171], all applied with vibrotactile systems

(n=4, 5%), *shoulder* (n=3, 4%), *upper leg* (n=2, 2%), *ankle* and *foot* (n=2, 2%)—counted together in Figure 4—and the *ear* (n=1, 1%). These regions were primarily associated with specialized applications such as respiratory training (*abdomen*), pulse-based entrainment (*neck*, *ankle*), affective social cues (*shoulder*), or experimental tactile exploration (*foot*). Although *face*-based stimulation was rare (n=2, 2%), it appeared in caregiving and emotive touch scenarios despite being uncommon in public wearable use due to social acceptability constraints [215]. The *ear* was explored as a site combining sensing and actuation due to its compatibility with audio devices and everyday wearables.

Table 3. Overview of intervention mechanisms, their core processes, and representative stimulus examples identified across the reviewed studies.

Mechanism	Core Process	Stimulus Examples
Sensory modality	Direct tactile perception shaping affective experience.	Vibration, pressure, warmth
Physiological regulation	Modulating physiology through interoceptive processes.	Heart rate biofeedback, breathing
Media-mediated experience	Affective experience in multisensory media contexts.	Video, voice, image
Mediated social touch	Affective touch sensation or interpersonal gestures.	Illusory stroking, squeezing patterns

5.4 RQ4-1: Intervention Mechanism

Through thematic analysis, we identified four distinct mechanisms describing *how* wearable haptic systems attempted to influence affective experience (Table 3). The most common mechanism was *sensory modality effects* (n=31, 37%), where affect was shaped through tactile pleasantness or stimulus qualities such as intensity, frequency, or direction. These interventions typically leveraged vibrotactile or affective touch parameters to evoke low-arousal positive states or reduce emotional discomfort through soothing sensations. The second most frequent category was *physiological regulation* (n=21, 25%), in which haptic feedback was used to entrain or guide bodily rhythms such as breathing or heart rate. These interventions often combined rhythmic feedback with biofeedback strategies to support emotional self-regulation and grounding, aligning with embodied cognition and interoceptive awareness. *Media-mediated experience* (n=16, 19%) used haptics to enhance emotional engagement with external media sources such as storytelling, music, and visual narratives. In this category, affect modulation emerged indirectly by synchronizing tactile cues with multisensory content. Finally, *mediated social touch* (n=15, 18%) conveyed affect through social interaction, often encoding gestures such as squeezing, stroking, or hugging to simulate interpersonal touch. These systems emphasized emotional communication and relational bonding rather than self-regulation.

5.5 RQ4-2: Interpersonal Context

We classified each intervention according to its interpersonal configuration, indicating whether affective influence was designed for an individual or distributed across multiple people. Most studies targeted *single*-person use (n=58, 70%), operating in controlled settings without explicit social interaction. These interventions largely focused on self-directed affect regulation, relaxation, or emotional self-awareness. *Dyadic* configurations (n=14, 17%) represented systems designed for two users, often enabling remote emotional communication or synchronized emotional states between partners, friends, or caregivers. An *audience*-based configuration (n=9, 11%) directed affective influence toward a single user in the presence of observers (e.g., social stress tasks). Only a few studies (n=2, 2%) explored shared affective experiences in *group*-based settings, such as synchronized group physiology or collaborative team experience. Overall, the distribution indicates that affective haptic design remains predominantly centered on the individual, with comparatively limited exploration of interpersonal affect dynamics.

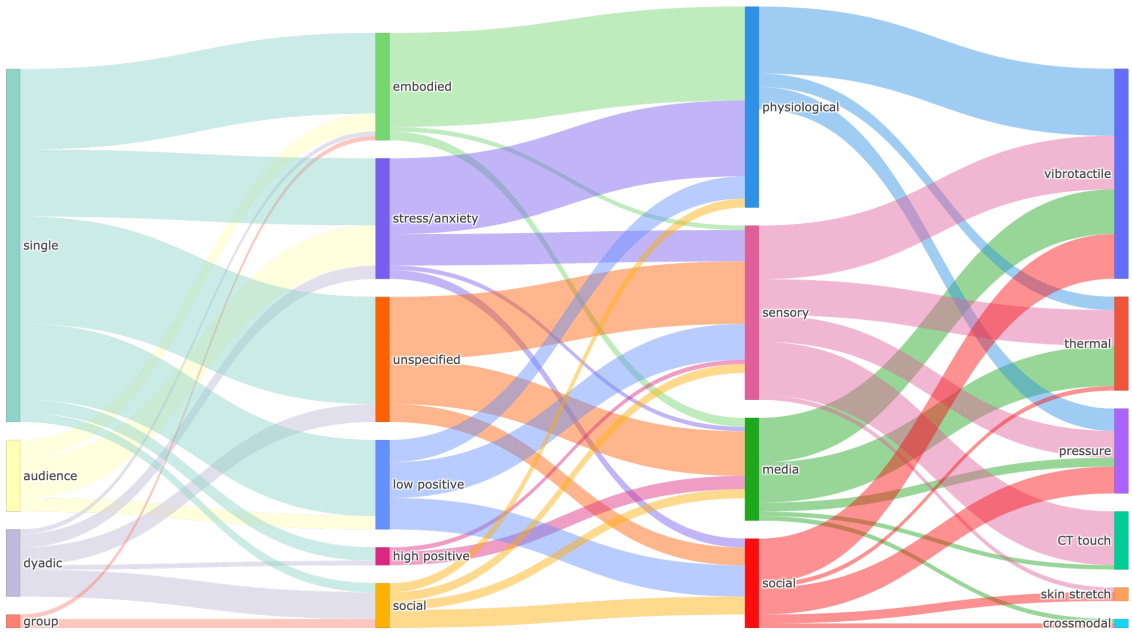

Figure 5. Sankey diagram illustrating the relational structure between *interpersonal*, *affective goal*, *mechanism*, and *haptic modality* dimensions across the reviewed studies. Nodes are color-coded for categories within each dimension, with their width reflecting the number of articles. The semi-transparent flows represent overlapping connections between dimensions, with flow width corresponding to the number of articles.

6 DISCUSSION

In recent years, research on mediated social and affective touch has expanded significantly within HCI, exploring how advanced wearable technologies can deliver haptic stimulation for widespread mobile interventions [37]. However, there have been limited systematic efforts to bridge the gap between formative research in HCI and the evaluative focus in health research [216, 217]. To address this, we conducted a systematic literature review of wearable haptic interventions, examining how affective goals, haptic modalities, body locations, and contextual mechanisms are comprised and interrelated. Based on these findings, we developed an integrative framework that organizes these dimensions within a coherent analytical structure to guide future research and design of affective wearable haptic systems. In the following sections, Section 6.1 presents the findings and implications of cross-dimensional mapping, while Section 6.2 outlines the overarching opportunities and challenges for future research on wearable haptic interventions.

6.1 RQ5-1: Insights from Cross-dimensional Mapping

Wearable haptic interventions for affective support are shaped by multiple interrelated design choices spanning affective goals, haptic modalities, intervention mechanisms, and interpersonal contexts (Figure 5). In this section, we synthesize cross-dimensional patterns observed in the literature and derive implications for future design.

6.1.1 Implicit Affective Goals. Although many studies measured valence or arousal, a substantial portion did not articulate explicit affective intervention goals (*unspecified*). These studies were commonly exploratory, focusing on perceptual responses to haptic parameters or proof-of-concept prototypes supported by *sensory*-based (e.g., direct haptic modality effects) or *media-based* mechanisms, where media content provided baseline affects that were enhanced or augmented by haptics. While valuable for foundational understanding, the lack of clearly stated affective goals limits interpretability and comparison across studies. For example, several studies investigated whether and how vibrotactile stroking illusions can induce effects similar to human stroking, which is associated with neural pathways underlying socially related pleasant experiences, focusing on proof-of-concept using wearable haptics rather than clearly positioning the system in the context of an intervention. Explicit articulation of affective intent would support theory-driven and reproducible intervention design.

6.1.2 Calming-oriented Intervention Focus. Most interventions targeted the induction of low-arousal positive states (*low positive*), such as calmness and relaxation, or the reduction of *stress/anxiety*, which also frequently encompassed *embodied affect* goals. This indicates a therapeutic orientation, emphasizing down-regulation over emotional activation. While these are associated with the commonly discussed intervention objective of addressing mental distress (see Section 2.2), another primary objective of promoting positive affective change can be further explored, as shown in the included studies targeting high-arousal positive states (e.g., excitement, happiness). Future studies can expand the expressive potential of affective haptic technology to explore richer emotional engagement beyond comfort and stress relief.

6.1.3 Physiological Regulation in Stress and Embodiment. Stress/anxiety reduction and *embodied affect* were frequently studied together (the largest cluster among combined goals), often under simulated distress and mediated through *physiological regulation* mechanisms. These systems synchronized haptic feedback with breathing or cardiac rhythms to guide bodily regulation, directing attention to specific bodily sensations [31]. This pattern highlights a strong link between wearable haptics and bodily self-awareness, suggesting a trend toward embodied and interoceptive approaches to affective modulation. However, in particular, the results of subjective and physiological metrics did not always align (e.g., [21, 160, 190]). This discrepancy underscores the importance of integrating both self-reported experiences and physiological data to interpret and discuss the affective outcomes of interventions. In addition, bodily mechanisms underlying these effects are grounded in insula-based interoceptive processes that connect body sensations, emotion, and awareness [31]. Future research should expand beyond stress-based protocols to explore alternative interoceptive techniques, such as body scan or open monitoring, while ensuring mindful, regulated attention rather than hyperawareness or anxiety-driven monitoring [31]. Moreover, while this survey focused on pervasive wearable interventions, interoceptive haptic approaches could also be examined in clinical mental health contexts using refined and explicit measurement frameworks [31, 102].

6.1.4 Interpersonal Context and Affective Intent. Most interventions focused on *single*-person use, typically conducted in laboratory settings without social interaction. These studies predominantly targeted *unspecified affect*, reflecting a laboratory-based or self-managed regulation approach. *Audience*-based dynamics, representing a contextualized form of individual use characterized by evaluative social presence as a stressor rather than an interaction partner, appeared mainly in *stress/anxiety* reduction interventions. In contrast, *dyadic* configurations were strongly associated with *social affect* goals, mediating emotional connection, empathy, or support between remote partners through affective haptic cues. Interestingly, *mediated social touch* mechanisms were often studied in *single*-user contexts for *low positive* affect, demonstrating that haptic feedback designed to evoke socially associated pleasantness can elicit affiliative affect even without a communication partner. This shift suggests that wearable haptics are evolving beyond direct social mediation toward enabling solitary yet socially resonant affective experiences.

6.1.5 Modality–Mechanism Affordances. Distinct patterns emerged between intervention mechanisms and haptic modalities. *Vibrotactile* feedback was the most prevalent across all mechanisms, followed by *thermal* and *pressure* stimuli, while *skin stretch* and *crossmodal* feedback remained underexplored. Studies employing *sensory modulation* mechanisms frequently investigated both *vibrotactile* and *CT touch* stimulation, focusing on how continuous or gentle stimulation could mediate pleasant, socially associated touch, e.g., stroking sensations, through wearable haptics. *Thermal* and *pressure* modalities showed emerging interest as naturalistic alternatives to vibration [20], aiming to evoke social touch qualities through temperature or compression cues. *Media-based* interventions often used *thermal feedback* to align perceived temperature with emotional tone in music, video, or mediated communication, while *vibration* was commonly embedded in everyday digital contexts to enhance affective expressivity. *Physiological regulation* mechanisms predominantly relied on *vibrotactile* feedback to convey biofeedback parameters such as heart rate, accompanied by *pressure*-based breathing feedback using pneumatic systems that mimic bodily rhythms. In *mediated social touch*, *vibration* and *pressure* were again most common, where continuous vibration conveyed stroking-like illusions and pressure feedback mediated socially meaningful gestures such as hugging or squeezing. Although some intersections were sparsely represented, these trends suggest that different haptic modalities carry implicit affective affordances shaped by their physical characteristics and by the social or physiological metaphors they embody.

6.1.6 Affective and Functional Logics of Body Placement. Overall, the *forearm*, *wrist*, and *hand* placements dominated affective haptic research due to their accessibility, familiarity in wearable interaction, and relevance to affective touch. For example, the *forearm*—the most frequently targeted site—was associated with both *unspecified* and *low positive* goals, as its dorsal hairy skin populated with CT afferents and its suitability for wearable forms such as sleeves make it an ideal site for diverse haptic modalities. Regarding specific modalities, *CT touch* appeared predominantly in forearm-based feedback, while *skin stretch* was also used on the forearm for similar reasons, typically targeting *low positive* affect to evoke pleasant sensations. The *wrist* was most commonly paired with *vibrotactile* stimulation in interventions addressing *stress/anxiety* and *embodied affect*, where integration into everyday stress scenarios was a key motivation, benefiting from the ubiquity of haptic-enabled form factors such as wristbands and smartwatches. Torso-based placements, including the *chest* and *back*, enabled physiological targeting and were primarily associated with *vibrotactile* and *pressure* feedback, often used in heart rate biofeedback and pneumatic breathing guidance for *stress/anxiety*, *embodied*, and *unspecified* goals. Peripheral locations such as the *face*, *ear*, *neck*, *leg*, and *foot* were chosen for specific technological or bodily requirements and represent emerging yet underexplored opportunities for future inquiry.

6.2 RQ5-2: Design Implications and Challenges

Based on our findings, we recognize the opportunities and challenges that need to be addressed for future research to further investigate wearable haptic interventions.

6.2.1 Personalizing Interaction Design. To include more diverse design perspectives, the varying user needs and characteristics of customizable technologies should be investigated [218, 219, 220]. Personalized intervention approaches have been shown to improve engagement and outcomes, while they should be balanced to achieve scalable intervention designs that can target broader populations [48]. Future research can identify extensive intervention contexts by detailing the preference and individual differences in the need for interaction with a wearable haptic system. For instance, the timing of haptic feedback, such as those based on real-time sensing, can be informed and adjusted to users, as this has been shown to influence the experience of interventions [78, 84, 190]. Haptic intervention systems should allow users to have control over how and when the system detects emotional states and delivers specific types of haptic feedback [221, 222], taking into account individual factors such as IAc [104], different age groups or clinical contexts, sensitivity [137], as well as accessibility considerations for neurodivergent individuals [223, 224]. In addition, ethical aspects should be considered when conveying effective yet potentially false or missing information to users (e.g., [84]). Furthermore, the sensation of haptic feedback may be influenced by perception and cognitive processes that vary between individuals [44]. Future research could examine whether the implicit level of acceptance of haptic input actually mediates affective outcomes, thereby separating the intervention effects.

6.2.2 Haptic-supported Group Dynamic. In our observation, most of the reviewed research focused on personal affective regulation, typically within individual or dyadic contexts. Wearable haptic interventions involving group dynamics can be more complex to design, given the various individual responses and technical challenges, such as device implementation and logistical difficulties in coordinating multiple participants and measuring collective outcomes. Nonetheless, as demonstrated by He et al. with Frisson Wave [76], group coordination can be non-verbal and implicit (e.g., [225]), using physiological data with integrated sensing technology to reduce the complexity of multi-user interaction in intervention design. This highlights how wearable sensing and haptics can augment physical and social presence—key factors in increasing feelings of connection [226, 227, 228]—particularly in contexts where in-person contact is limited, such as remote interactions, health-related constraints, or government restrictions, as recently observed during the COVID-19 pandemic [227, 229]. In fact, Oh et al. [106] identified physical proximity as a central contextual feature of social presence and found that haptic feedback contributed most positively to this sense of immersion compared to visual or auditory modalities. Given the lack of identified articles on group dynamics, future research may focus on integrating existing wearable haptics prototypes that were investigated for more common affective targets into specific situational contexts, such as concerts, team-based work or school environments, and traditional group therapy. In addition, theoretical frameworks or guidelines tailored to collective affective well-being can be developed that also address ethical concerns about privacy and emotional safety in group settings.

6.2.3 Body as an Affective Design Space. Body locations convey distinct emotional affordances that can shape the effectiveness and meaning of haptic interventions. Various body sites were identified in connection with wearable formats such as gloves, vests, jackets, and pendants; however, their selection was often driven by technological or product-related decisions. We observed a lack of comprehensive models that specifically address body placement for affective haptic interventions. While foundational work on human factors in wearable haptics [230], dating back more than two decades, and research on wearability [201, 231] remain relevant, further investigation is needed to address the unique requirements of affective haptic technologies (e.g., [203, 232]). In addition, insights from interdisciplinary fields, such as psychophysical factors in wearables [233, 234], affective haptics [20, 25], and social touch [4, 235], can provide valuable guidelines to help establish a comprehensive framework for haptic body placement.

6.2.4 Wearable Haptics for Everyday Usage. Although most of the reviewed studies, particularly those specifying intervention contexts, focused on the benefits of mobile passive interventions, there is still a limited systematic approach to body locations and wearable forms that can be integrated into users' daily lives, as well as in-the-wild studies. In the reviewed articles, designs inspired by garments and accessories have been explored, such as vests, gloves, and rings, in addition to standard wristband forms or smartwatches. Body areas that were rarely or not addressed, such as the head, lower leg, or foot, can also be considered for affective haptic interventions with wearable forms such as hats [236, 237], or footwear [238]. Furthermore, wearable forms need not be restricted to conventional designs, but can be developed with a focus on functionality and feedback modality, ensuring minimal social acceptability and comfort. Examples include prostheses attached to the back [148] or forearm sleeves (e.g., [105, 202]). In addition, it will be necessary to ensure that custom-built devices are robust, scalable, and affordable for a wider application to off-the-shelf wearable devices. Furthermore, the acceptance of devices worn in less common wearable locations for everyday use remains uncertain. To encourage acceptance and potential usage, it is important to understand people's willingness to wear dedicated intervention devices, which can vary according to individual and sociocultural factors, such as the potential stigma associated with device visibility [239, 240, 241].

6.2.5 Integrating Real-time Sensing. We observed that sensor data were used for real-time detection of quantified affective responses or encoding touch input, allowing immediate haptic feedback as needed. For example, several studies used biofeedback to provide personalized haptic stimulation based on the current heart rate of the user [26, 104, 160] or the breathing state [77], and others rendered the sender's state as haptic feedback for the receiver in telecommunications [83, 107, 172, 184]. Yet, there are opportunities to utilize a wider variety of biosignal parameters for haptic feedback design and potential emotion recognition [32, 33]. For example, haptic adaptive biofeedback has mostly relied on heart rate signals, but it could also be explored using HRV and neurosignals [242, 243]. Recent reviews of wearable-based affect recognition emphasize that most existing systems rely on a limited subset of physiological measures, predominantly heart rate, electrodermal activity, and respiration, to infer arousal or stress-related states [32]. However, the physiological basis of affect extends beyond these metrics: multimodal sensing approaches integrating heart rate variability, skin temperature, muscle activity, and motion data can better capture both arousal and valence dimensions of affective experience. In particular, sensor-integrated wearable haptic devices offer three advantages that have been lacking in previous research: (1) Mobile systems enable evaluations in real-life situations, enhancing the ecological validity of interventions, which is still needed, as most studies in our literature dataset rely on lab-based causation results. (2) Continuous monitoring of physiological responses can help assess the progression of interventions, providing insight into whether immediate effects persist over time, and ultimately supporting independent emotion management [244]. (3) In addition, such integration of sensing and feedback mechanisms points toward closed-loop affective modulation, where wearable systems dynamically adjust feedback to users' changing psychophysiological states. Thus, future studies should explore more integrative sensing for passive, in situ interventions that adaptively respond to users' physiological and emotional states.

6.2.6 Establishing an Evaluation Framework. The wide variation in system setups and research methods of affective haptic interventions has complicated systematic comparison of findings and replication. Thus, our descriptive analysis of psychophysiological measures and study procedures addressing intervention context aimed to support the evaluation of the future intervention design and their replication in the affective haptics domain. In fact, although there has been an increasing focus on affective health in the field of HCI in recent times [37], throughout our article selection process, numerous studies with wearable haptic prototypes for intervention purposes were excluded from the analysis due to missing evaluation. Thus, we call for sustained research efforts that encompass all phases from design to evaluation, from preliminary proof-of-concept to extensive summative evaluations, with consideration for potential replications. In particular, evaluation should include both psychological self-assessments and physiological measures, as these can yield incongruent results across affective contexts. Physiological data can capture a broader range of emotions beyond stress and arousal, but should be complemented by self-reports to ensure valid interpretation of affective responses [33]. Moreover, the long-lasting effects of interventions should be further investigated, including the frequency and duration of intervention participation, and whether affective outcomes can influence longer-term cognitive and behavioral changes [48]. Based on identified affective targets and intervention contexts, scenario-specific in-the-wild studies can be conducted to provide insights for real-world applications. These evaluation considerations will support the development of future intervention designs grounded in accumulated evidence in the long term [217].

6.2.7 Underexplored Haptic Modalities for Affect. Despite growing diversification, several modalities remain underexplored. Skin stretch and crossmodal combinations appear in only a few studies, often as technical demonstrations rather than evaluated interventions. Electrotactile stimulation, though emerging in recent years, has been investigated mainly for discriminative perception rather than affective modulation [245, 246, 247]. Yet its compact form factor and controllable sensation range position it as a promising candidate for future affective wearable systems, particularly where fine-grained expressivity or low-profile form factors are required. In addition, while haptic interventions generally emphasize subtlety and unobtrusiveness, multimodal integration remains an open challenge and opportunity. Only a small number of reviewed studies combined haptic with visual or auditory cues, likely to avoid cognitive overload and preserve the passive nature of affective wearables. Future work could examine how combining sensory channels—or simply contextualizing tactile feedback within visual or auditory information—enhances emotional meaning and intervention efficacy [78, 84, 248].

7 CONCLUSION

This work examined the current state of affective wearable haptic interventions through a systematic literature review of 83 articles. Our findings systematically mapped affective wearable haptic interventions across affective, mechanistic, and contextual dimensions. The results reveal clear trends: a predominant focus on stress and calmness regulation, widespread reliance on vibrotactile feedback, and recurring use of forearm and wrist placements for accessibility and social acceptability. Physiological synchronization—such as heart rate and breathing feedback—emerged as a central mechanism for embodied stress and anxiety modulation, while new modalities such as thermal and pressure cues indicate growing interest in more naturalistic haptic forms. This work contributes a structured analytical model that links key dimensions of affective wearable haptic interventions, advancing a more integrative understanding that can guide future design. The discussion highlights both the potential and the gaps in current intervention research, calling for greater attention to interpersonal contexts, particularly in multi-user interactions, clearer articulation of affective goals, and improved methodological rigor.

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A Included Articles in the Review

Table 4. The corpus of reviewed studies, including their publication year, venue, and corresponding dimensional categories, sorted by body location, haptic modality, and affective goal.

Article	Year	Venue	Body Loc.	Haptic Modality	Affective Goal
Shim and Tan [197]	2020	Springer Link	hand	vibrotactile	low positive
MacDonald et al. [196]	2024	ACM	hand	vibrotactile	low positive, stress/anxiety
Singhal et al. [107]	2017	ACM	hand	vibrotactile	social
López et al. [175]	2023	IEEE	hand	vibrotactile	unspecified
Lucía et al. [174]	2020	IEEE	hand	vibrotactile	unspecified
Mazzoni et al. [173]	2015	IEEE	hand	vibrotactile	unspecified
Macdonald et al. [131]	2022	ACM	hand	vibrotactile, thermal	low positive
Hecquard et al. [208]	2024	IEEE	hand	vibrotactile, thermal	social
Yoo et al. [130]	2017	IEEE	hand	vibrotactile, thermal	unspecified
Pradana et al. [171]	2014	ACM	hand	vibrotactile, crossmodal	unspecified
Akazue et al. [133]	2016	ACM	hand	thermal	unspecified
Akazue et al. [213]	2017	ACM	hand	thermal	unspecified
Salminen et al. [128]	2011	ACM	hand	thermal	unspecified
Yarosh et al. [83]	2017	ACM	hand, upper arm	pressure	stress/anxiety, social
Azevedo et al. [160]	2017	Nature	wrist	vibrotactile	low positive, stress/anxiety, embodied
Korres et al. [92]	2018	IEEE	wrist	vibrotactile	high positive
Costa et al. [84]	2016	ACM	wrist	vibrotactile	stress/anxiety, embodied
Costa et al. [26]	2019	ACM	wrist	vibrotactile	stress/anxiety, embodied
Raether et al. [190]	2022	ACM	wrist	vibrotactile	stress/anxiety, embodied
Wang et al. [161]	2023	ACM	wrist	vibrotactile	stress/anxiety, embodied
Xu et al. [104]	2021	Elsevier	wrist	vibrotactile	stress/anxiety, embodied
Umair et al. [134]	2021	ACM	wrist	vibrotactile, thermal	low positive, stress/anxiety, embodied
Choi et al. [114]	2020	ACM	wrist	pressure	stress/anxiety, embodied
Yang et al. [85]	2023	ACM	wrist	pressure, CT touch	unspecified
Haliburton et al. [109]	2023	ACM	wrist	thermal	social
Peng et al. [93]	2022	ACM	wrist, forearm, neck	vibrotactile, pressure, thermal	high positive
Paredes et al. [205]	2011	ACM	wrist, chest	vibrotactile	stress/anxiety
Valente et al. [203]	2024	ACM	wrist, chest, neck, ankle, foot	vibrotactile	embodied
Shetty et al. [129]	2021	MDPI	wrist, back	vibrotactile, thermal	unspecified
Israr et al. [183]	2018	ACM	forearm	vibrotactile	low positive

Table 4 – Continued from previous page

Article	Year	Venue	Body Loc.	Haptic Modality	Affective Goal
Huisman et al. [88]	2016	Springer Link	forearm	vibrotactile	low positive
Raisamo et al. [179]	2013	IEEE	forearm	vibrotactile	unspecified
Zhu et al. [125]	2022	Frontiers	forearm	vibrotactile, pressure	unspecified
Ooms et al. [132]	2023	ACM	forearm	vibrotactile, thermal	unspecified
Cabibihan et al. [204]	2012	Springer Link	forearm	vibrotactile, thermal, CT touch	stress/anxiety
Cabibihan et al. [184]	2017	IEEE	forearm	vibrotactile, thermal, CT touch	stress/anxiety
Nunez et al. [182]	2020	IEEE	forearm	vibrotactile, skin stretch	low positive
Zhang et al. [81]	2019	ACM	forearm	vibrotactile, crossmodal	unspecified
Sousa et al. [210]	2025	IEEE	forearm	pressure	unspecified
Liu et al. [86]	2021	ACM	forearm	pressure, thermal	low positive
Papadopoulou et al. [105]	2019	Springer Link	forearm	pressure, thermal	low positive, stress/anxiety, embodied
Chandra et al. [192]	2020	IEEE	forearm	CT touch	low positive
Greco et al. [138]	2015	IEEE	forearm	CT touch	low positive
Greco et al. [140]	2019	IEEE	forearm	CT touch	low positive
Bianchi et al. [137]	2017	Springer Link	forearm	CT touch	stress/anxiety
Zhao et al. [21]	2023	ACM	forearm	CT touch	stress/anxiety
Bianchi et al. [135]	2014	IEEE	forearm	CT touch	unspecified
Bianchi et al. [136]	2016	IEEE	forearm	CT touch	unspecified
Greco et al. [139]	2017	IEEE	forearm	CT touch	unspecified
Valenza et al. [141]	2015	IEEE	forearm	CT touch	unspecified
Haynes et al. [90]	2019	IEEE	forearm	skin stretch	low positive
Nunez et al. [181]	2019	IEEE	forearm	skin stretch	low positive
Kelling et al. [202]	2016	ACM	forearm, upper arm	vibrotactile	low positive, stress/anxiety
Culbertson et al. [180]	2018	IEEE	forearm, upper arm	vibrotactile, pressure	low positive
Mostofa et al. [111]	2021	IEEE	face	vibrotactile	social
Marquardt et al. [94]	2025	IEEE	face	thermal	high positive, embodied
Wang et al. [110]	2012	ACM	upper arm	pressure	social
Ghiasi et al. [211]	2019	IEEE	upper arm	CT touch	unspecified
Foo et al. [121]	2018	ACM	upper arm, shoulder, chest, back	pressure	unspecified
Zheng et al. [112]	2012	IEEE	upper arm, back	vibrotactile, pressure	unspecified
Aou et al. [198]	2010	ACM	ear	vibrotactile	unspecified
Jain et al. [79]	2023	ACM	neck	pressure	stress/anxiety, embodied

Table 4 – Continued from previous page

Article	**Year**	**Venue**	**Body Loc.**	**Haptic Modality**	**Affective Goal**
He et al. [76]	2022	ACM	neck	thermal	social embodied
Foo et al. [87]	2020	ACM	shoulder	pressure, thermal	low positive
Tara et al. [91]	2021	IEEE	shoulder, chest, abdomen	vibrotactile	high positive
Frey et al. [77]	2018	ACM	chest	vibrotactile	embodied
Nishimura et al. [150]	2012	ACM	chest	vibrotactile	embodied, social
Choi et al. [89]	2022	ACM	chest	pressure	low positive, stress/anxiety, embodied
Choi et al. [78]	2021	ACM	chest	pressure	stress/anxiety, embodied
El et al. [80]	2020	ACM	chest	thermal	unspecified
Miri et al. [103]	2020	ACM	chest, back, abdomen	vibrotactile	stress/anxiety, embodied
Wang et al. [209]	2025	IEEE	chest, back, abdomen	vibrotactile	unspecified
Bontula et al. [120]	2023	IEEE	chest, back, abdomen	pressure	stress/anxiety
Brown et al. [119]	2021	IEEE	chest, back, abdomen	pressure	stress/anxiety
Balters et al. [168]	2020	ACM	back	vibrotactile	stress/anxiety, embodied
Paredes et al. [166]	2018	ACM	back	vibrotactile	stress/anxiety, embodied
Chandra et al. [212]	2018	ACM	back	vibrotactile	social
Schoeller et al. [148]	2019	Elsevier	back	thermal	low positive, embodied, social
Chan et al. [172]	2020	IEEE	back, upper leg	vibrotactile	unspecified
Willemse et al. [207]	2015	IEEE	back, upper leg	thermal	social
Miri et al. [206]	2020	ACM	abdomen	vibrotactile	stress/anxiety, embodied
Miri et al. [167]	2022	IEEE	abdomen	vibrotactile	stress/anxiety, embodied
Elvitigala et al. [82]	2022	ACM	foot	CT touch	stress/anxiety, embodied