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Deep touch pressure for calming and comfort therapy from the perspective of contact mechanics: A review

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3 GOOD HEALTH AND WELL-BEING
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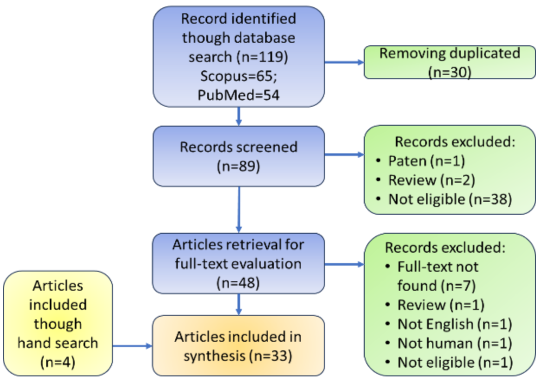

Highlights:

- The role of mechanical contact on deep touch pressure (DTP) has been studied
- Contact area and the determination of pressure magnitude affect the success of deep touch pressure (DTP) therapy
- Contact mechanics aspects need to be considered in order to enhance deep touch pressure (DTP) therapy effectiveness

Abstract

The art of touch therapy has been around for centuries and has evolved into various models and styles throughout the years. In addition to reducing muscle pain, relieving stress, and providing relaxation, this therapy has worked and has been useful for many people. Methods such as touch or pressure stimulate the parasympathetic nervous system, which plays a role in a person's emotional well-being. Knowing its effects, the interaction between therapeutic devices used on the body needs to be studied further. The contact area provided by the deep touch pressure (DTP) tool will also play an important role in the therapeutic outcome. In addition, levels of comfort in pressure treatment should also be explored further to ensure compliance. This paper describes in extensive the potential of DTP in providing a comfort effect from a contact mechanics perspective. Interactions of various DTP types and pressure distribution on body area have been further investigated to minimize contact mechanics research gap in DTP and providing the bridge between sensory therapy and mechanical engineering domain.

Keywords: Deep touch pressure; Calming; Comfort therapy; Contact mechanics; Mechanical contact

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1. Introduction

Deep touch pressure (DTP) is a therapeutic technique that falls under the umbrella of touch therapy. It is gaining recognition as a promising intervention for individuals with sensory processing deficits. The primary aim of this practice is to generate a soothing and reassuring impact by evoking somatosensory perceptions through actions such as embracing, applying pressure, caressing, or providing gentle support [1]–[3]. DTP therapy has garnered significant attention and interest from a wide range of individuals, encompassing healthcare professionals, therapists, and individuals seeking personal relief. The perceived advantages of this phenomenon are thought to surpass limitations in sensory processing. According to available reports, DTP therapy has demonstrated efficacy in the reduction of muscle pain, mitigation of stress, and facilitation of general relaxation [4]. The sensory system is thought to experience a reduction in stress and anxiety levels through the application of DTP, leading to an enhanced state of tranquility and overall well-being for individuals. The predominant focus of recent research endeavors has been directed towards the assessment of the therapeutic intervention's impact on both physiological and behavioral aspects [5]–[8].

Contact mechanics, a branch of mechanics studying solid behavior upon contact [9], is integral to understanding the surface interactions involved in DTP which is reliant on touch and pressure stimulation and encompasses factors such as material properties, pressure distribution, and duration of treatment. In the context highlighted by Van Kuilenburg [10], products in daily life, like clothing, are profoundly influenced by touch-contact behavior with the skin, emphasizing the importance of considering contact mechanics in design. This discipline offers insights into optimizing the comfort and functionality of products that interact with the body, ensuring the applied touch and pressure align with desired effects on the human sensory system. A diverse range of DTP tools have been developed, including non-wearable options such as large V or U-shaped beds, chair-shaped devices with several straps, and weighted blankets [11]–[15]. Additionally, there are wearable alternatives like compression garments, which include various approaches such as weighted vests, inflated vests, and stretched vests [16]–[18]. Illustrations of DTP tools are shown in **Figure 1**.

With many types of DTP tools that combine the type of material and touch/pressure mechanism, the approach of DTP in contact mechanics and tribology research still has many gaps to investigate. This provides exciting opportunities for future studies to explore and understand the potential applications of DTP principles in enhancing surface interactions and improving material design. Exploring the potential applications of DTP in contact mechanics and tribology research is significant as it paves the way for collaboration between the fields of health sciences and engineering. Integrating knowledge about therapeutic effects at the levels of human physiology and behavior with mechanical interactions between material surfaces can lead to innovative solutions that enhance comfort and improve the efficiency of mechanical systems. Nevertheless, despite the inherent connection between these actions and the disciplines of contact mechanics and tribology, there is a scarcity of research investigating these approaches within these fields.

Overall, bridging the gap between sensory therapy domains and engineering mechanics can yield significant benefits, not only for individuals needing sensory therapy but also for the development of technologies and design improvements affecting various aspects of our lives. Therefore, this study aims to gather previous studies and discuss the influence of differences in contact area in providing comfort, while also providing new insights into DTP therapy from the perspective of contact mechanics.

Figure 1. Deep Touch Pressure (DTP) tools

2. Methods

2.1. Search Strategy

This study was conducted based on PRISMA 2020 guidelines using systematic searches in Scopus and PubMed databases to identify relevant articles in the field of interest. The meticulous approach aimed to ensure unbiased retrieval of valuable literature and create a strong foundation for research and analysis. The search strategy included various keywords following Boolean phrase: ("deep pressure therapy" OR "deep pressure touch" OR "deep touch pressure" OR "weighted blanket" OR "weighted vest" OR "inflatable vest" OR "snug vest" OR "hug machine") AND ("therapy") NOT ("review").

2.2. Inclusion and Exclusion Criteria

The process of establishing inclusion and exclusion criteria in a research study is of utmost importance as it determines the characteristics of subjects or objects that will be included or excluded from the investigation. The inclusion criteria used in this study were as follows: (1) the study was written in English, (2) involved human participants, (3) the independent variable identified in the study was deep pressure, and (4) the dependent variable focused on comfort and related aspects, including sleeping disorder, attention, disruptive behavior, self-injurious behavior, or stereotypical behavior, commonly experienced by individuals with autism spectrum disorders [6], [7]. Articles written in languages other than English, articles with difficulties in accessing full texts, and product design articles without testing will be excluded from this study.

2.3. Data extraction

The selected studies underwent an evaluation process in which the DTP tools employed, the constituent materials of the DTP devices that come into contact with the user, the mechanism of touch or pressure, the specific site of the intervention on the body, and the outcomes of comfort or related aspects.

3. Results and Discussion

Scopus and PubMed databases were searched to cover all previous dates, with the last search on July 30, 2023. There were 119 articles were found, with 30 duplicates identified and removed. After screening the titles and abstracts, 41 articles were excluded as they did not meet the inclusion criteria. The exclusions encompassed one patent, two review articles, and thirty-eight articles that did not meet the eligibility criteria. A further 18 articles were excluded as they still met the exclusion criteria during the full-text examination. The authors have conducted a manual search and identified three additional papers, bringing the total number of publications to 33, which will be included in the synthesis. **Figure 2** presents a flowchart that illustrates the methodology used in searching, and Table 1 provides a summary of the collected articles.

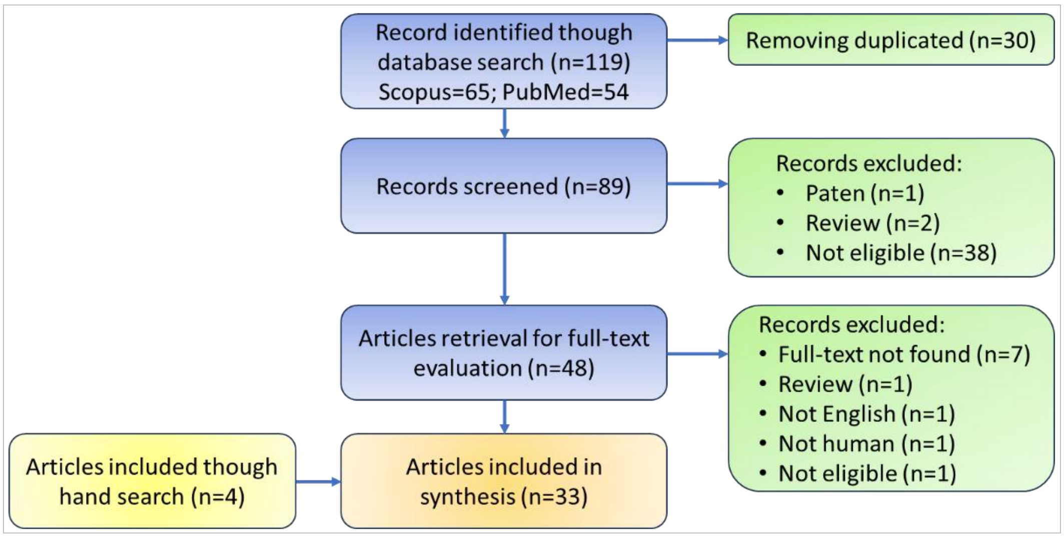

Figure 2. Search flow diagram

Table 1. Summary of detailed specifications for the use of DTP as a comfort stimulation therapy [AHMPS= Autism Hug Machine Portable Seat; WB= Weighted Blanket; WV= Weighted Vest; CV= Compression Vest]

Refs.	Therapeutic tools	Materials	Touch or pressures mechanism	Touch or pressures load	Intervention location	Outcomes in calming effect
Afif [6]	AHMPS inflated style; and pulled style	Synthetic leather	Pressed by inflated wraps and manual straps	0.65 psi (chest) and 0.65 psi (thigh) for inflated style; 0.81 psi (chest) and 0.81 psi (thigh) for pulled style	Chest and thigh	Supports
Baumgartner [19]	WB	Cotton and/or polyester blend	Weighted with a heavy blanket	5 lbs and 15 lbs	Torso	Supports
Biswas [20]	Sleeping bag with weight and vibration	Polyamide (outer), Neoprene (insulator)	Weighted with a heavy and vibrating sleeping bag	8% of body weight	Whole body	Supports
Chen [21]	Papoose board®	Non-rigid foam pad	Wrapped like a sleeping bag	Load is unknown	Head, torso, thigh	Supports
Cox [22]	WV	Denim	Weighted	5% of body weight	Torso	Not Supports
Davis [23]	WV	fabric is unknown	Weighted	5 lbs	Torso	Not Supports
Edelson [24]	Hug machine	Foam-pad	Squeezed by V-shaped pad	According to their preferences	lateral parts of the body	Supports
Edwards [25]	Hand; and pillow	Skin; fabric is unknown	lightly palpated while head was cradled (with a pillow)	Load is unknown	sub-occipital muscles (the base of the head)	Supports
Ekholm [26]	WB	Chain blanket; fabric is unknown	Weighted with chain blanket	6 kg and 8 kg	Whole body	Supports
Foo [27]	CV	woven canvas fabric (front), foam mesh (back)	squeezed by vest's retractable shape memory alloy	Load is unknown	Torso	Supports
Gee [28]	WB	fabric is unknown	weighted with a heavy blanket	10% of the participants' body weight	Whole body	Supports
Grandin [11]	Squeeze machine	Foam-pad	Squeezed by V-shaped pad	Adult: 60 psi; Children: 30-40 psi	lateral parts of the body	Supports
Gringras [29]	WB	fabric is unknown	carries a steel-pellet blanket	2.25 kg or 4.5 kg	Whole body	Supports
Hodgetts [30]	WV	fabric is unknown	Weighted	5% of body weight	Torso	Not Supports
Kennert [31]	WB	fabric is unknown	Weighted	Load is unknown	Whole body	Supports
Lin [32]	WV	fabric is unknown	Weighted	10% of body weight	Torso	Supports
Lindstedt [33]	WB	fabric is unknown	Weighted with heavy blanket	Load is unknown	Whole body	Supports
Lo [15]	Sitting Hug Machine	Foam-pad	Squeezed by U-shaped pad	Load is unknown	lateral parts of the body (left and right sides)	Supports
Lönn [34]	WB	fabric is unknown	Weighting with fiber-WB	4-10 kg	Whole body	Supports
Losinski [5]	CV; WB	Neoprene (CV); - (WB)	Inflated vest compressing the body; WB is draped on the back while sitting	Load is unknown (CV); 6 lbs (WB)	Torso; back of the body	Supports
McGinnis [35]	Gym mat, pillows, and a blanket	fabric is unknown	touch and engage each object for 10 s	Load is unknown	Palm hand	Supports
Moore [36]	Sensory brush	Soft brush	Brushing; pushing and pulling motion	Load is unknown	Shoulders to hands, hips to feet, chest and back	Not Supports

Table 1. (cont.) Summary of detailed specifications for the use of DTP as a comfort stimulation therapy [AHMPS= Autism Hug Machine Portable Seat; WB= Weighted Blanket; WV= Weighted Vest; CV= Compression Vest]

Refs.	Therapeutic tools	Materials	Touch or pressures mechanism	Touch or pressures load	Intervention location	Outcomes in calming effect
Nakamura [37]	WB	soft-touch quilted fabric	Weighted with fiber-filled blanket	6 kg	Whole body	Supports
Nouman Aslam [38]	WB	fabric is unknown	Weighted with heavy blanket	Load is unknown	Whole body	Supports
Novak [39]	WB	fabric is unknown	Weighted with heavy blanket	Load is unknown	Whole body	Supports
Odéus [40]	WB	Ball blanket; fibre blanket; chain blanket	Weighted with 3 types of heavy blanket	The weight of the WB increased with increasing age	Whole body	Supports
Olson [41]	WV	fabric is unknown	Weighted	5% and 10% of body weight	Torso (slightly above the scapula borders)	Supports
Quigley [42]	WV	fabric is unknown	Weighted	5% and 10% of body weight	Torso	Not Supports
Reichow [43]	WV	fabric is unknown	Weighted	5% of the body weight	Torso	Not Supports
Reynolds [44]	CV	fabric is unknown	Inflated vest compressing the body	Firm hug	Chest and rib cage	Supports
Summe [45]	WB	Cotton and polyblend filled with non-molding polypellets	WB was placed over the swaddled infants in muslin or cotton wrap	1 lb (for infant)	Front body	Supports
VandenBerg [46]	WV	Denim	Weighting	5% of body weight	Torso	Supports
Watkins [47]	CV	polyester, spandex, bamboo, and cotton	Inflated vest compressing the body	Load is unknown	Torso (shoulders, back, and sides)	Not Supports

From the various DTP tools, considering the distribution of pressure applied to the body, they can be categorized into four classes: weighted blankets, which provide passive pressure sensations across almost the entire body; compression vests, offering active pressure sensations from the garment to the torso; weighted vests, providing active pressure sensations both from the garment worn (though not too tight) and the load that predominantly targets the shoulders (indicated in red); and other types such as AHMPS, offering active pressure sensations through straps on the chest and thighs, and U or V-shaped beds, providing active pressure sensations on the sides of the body. The distribution of pressure applied to the body by various DTP tools is illustrated in **Figure 3**.

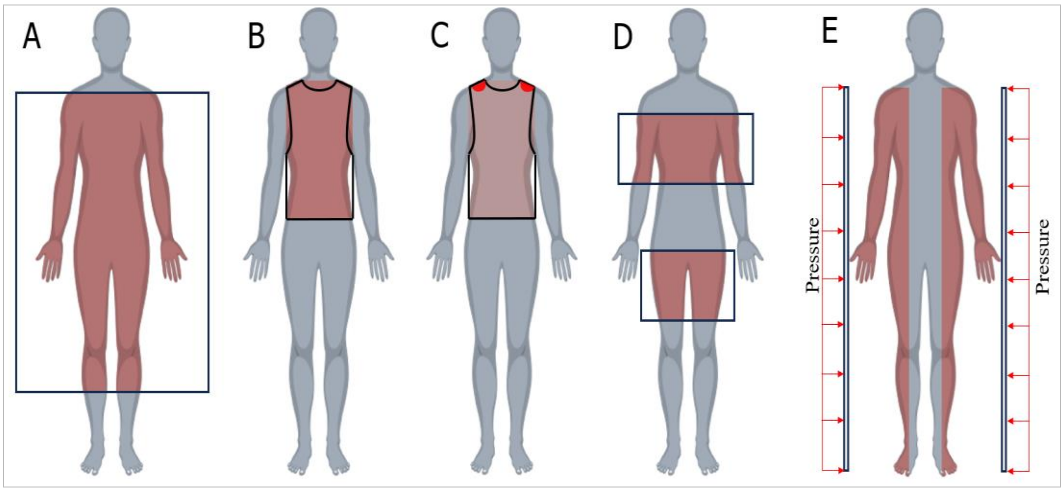

Figure 3. Distribution of contact area of weighted blanket (A), compression vest (B), weighted vest (C), Autism Hug Machine Portable Seat (D), and Squeeze machine (E)

After conducting a comprehensive review of the relevant literature, the results were categorized based on the specific DTP tool employed and its associated therapeutic effects, as depicted in **Figure 4**. Additionally, **Figure 5** illustrates the distribution of studies that consider the applied pressure and those that do not, in relation to the overall treatment outcomes.

DTP has become one of the calming stimulation therapies that apply pressure to various parts of the body to stimulate the somatosensory system. The pressure received, like the sensation of being hugged, not only has psychological relaxation effects but also provides physiological stimulation. The application of pressure involves elements from the discipline of physics, sensory therapeutic effects from the biomedical field, and the goal of providing psychological relaxation and comfort. This multidisciplinary nature of DTP therapy requires an in-depth exploration of all its aspects to enhance its benefits for humanity.

Duvall stated in his hypothesis that pressure distribution could be a crucial aspect in determining the success of DTP therapy [48]. However, no studies have yet examined this relationship. The studies compiled in this review were then divided based on the therapy's outcomes, as displayed in **Figure 4**, which shows that the therapy with the most support for calming stimulation is provided by weighted blankets [5], [19], [38]–[40], [45], [20], [26], [28], [29], [31], [33], [34], [37] followed by AHMPS [6], Squeeze machine [11], [24], compression vests [5], [15], [21], [27], [44], and then weighted vests [32], [41], [46]. These results show that DTP, with a larger contact area, has been proven to provide a better calming effect. Maula et al. [8] also reported that the broader contact area provided by inflatable AHMPS gives a more calming effect compared to the manual pull AHMPS. This finding supports Duvall's hypothesis and provides insight into the relationship that a larger contact area for DTP application may increase the likelihood of successful calming stimulation.

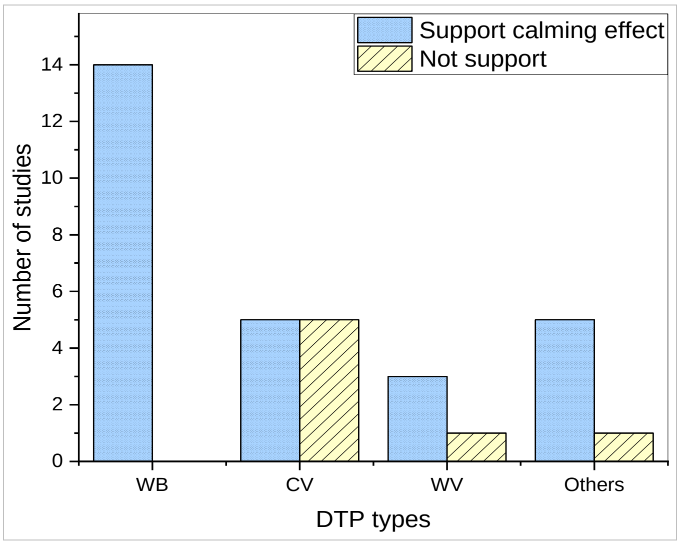

Figure 4. Distribution of studies based on the deep touch pressure types and the effect of calming

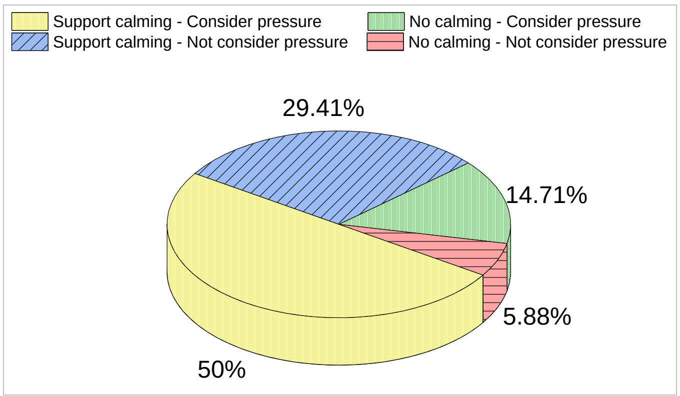

Figure 5. Distribution of studies based on pressure load and the effect of calming

Each type of DTP tool has its pressure mechanism, and the pressure load provided also varies. Some determine the pressure load based on occupational therapist recommendations or the user's age, while others do not specify the pressure load in their studies. According to the findings presented in **Figure 5**, the distribution shows that studies yielding positive effects are mostly those that consider the pressure load used, whether based on comparative studies, occupational therapist recommendations, or user age. This observation is consistent with Duvall's hypothesis, stating that pressure distribution plays a significant role that should be considered.

4. Conclusion

This review study indicates that wider contact areas of DTP tools across the body influence the efficacy of DTP therapy by providing a better calming effect. This observation implies the importance of using appropriate DTP tools and techniques to ensure that the therapy is effective. Future research could explore the optimal contact area of DTP tools and the most effective techniques for administering DTP therapy.

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Authors' Declaration

Authors' contributions and responsibilities - The authors made substantial contributions to the conception and design of the study.

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Availability of data and materials - All data are available from the authors.

Competing interests - The authors declare no competing interest.

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