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For Children with Autism: Designing, Manufacturing and Testing the Universal Therapeutic Mattress

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Abstract: Every parent expects the birth of a child. The expected child of every parent is a perfect child with no flaws. Everyone does not want to be born in this world with disorder or disability. No parents are expecting the birth of a child with disability. The birth of a child with special needs does not exclude the rich, educated, poor, religious or non-religious families. Parents cannot resist the birth of a child with special needs. This research aimed to create a prototype in the form of universal therapeutic mattress for children with autism in Indonesia which aimed to provide comfort effects on the user by putting pressure on the body. There were 4 design concepts which were then designed using Fusion 360 for the selected design concepts. This therapy tool is used for children aged 8-15 years with height around 100-150 cm. The main material used was foam and cotton cloth for the convenience of the user. Then, a design concept was chosen that could reduce the stress index report by 3.8 or 1.28%.

Key words: Autism, therapy tool, Fusion 360, stress index, article history, received, accepted

INTRODUCTION

The number of children with special needs (ABK) in Indonesia continues to increase from year to year. The United Nations (UN) estimates that at least 10% of school-aged children have special needs. In Indonesia, the number of school-aged children, around 5-14 years old is 42.8 million. Following the estimation, it is estimated there are approximately 4.2 million of Indonesian children born with special needs.

In Indonesia, there is no official data released by the government. According to the latest data, it is recorded that the number of children with special needs in Indonesia is 1,544,184 children; 330,764 children (21.42%) aged around 5-18 years. From the numbers, only 85,737 children with special needs attend school. It means that there are still 245,027 children with special needs who have not attended schools, either special schools or inclusive schools. Based on the UN's (United Nations) assumption, it is estimated that at least 10% of school-age children have special needs. The number of children with special needs in 2011 was 356,192 children but only 86,645 children received the treatment and up to this year, only 105,185 children who did. In 2012, the government makes a target that at least 50% of children with special needs have been accommodated.

The centre for disease control and prevention (Anonymous, 2012) released the latest prevalence figures for ASD of 1 in 150 which is up from the 1 in 166 figure reported by the CDC in 2004. Consequently, it appears that having a brother or sister with ASD is becoming more common. For children with ASD, a primary concern is the development of social competence and thus it seems more important than ever that sibling relationships be positive given that siblings are the most frequently available play partners. As detailed earlier, positive support, effective coping strategies, open discussion, planning and sensitivity can facilitate more positive relation-ships between typically developing siblings and siblings with ASD (Beyer, 2009).

Autism is not only a little phenomenon that occurs among the Indonesian people. In addition, autism is now increasingly infecting Indonesians, especially children. This is supported by the increasing number of prevalence of people with autism in Indonesia from year to year.

Autism itself is a disorder that includes the areas of cognitive, emotional, behavioural, social as well as the inability to interact with the surrounding people. Children with autism will grow and develop in different ways than other normal children. It is caused by the gradual decline in cognitive ability. Children with autism demonstrate a variety of challenging behaviours that may impact the

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family; However, sensory-related behaviours are one area in which parents frequently report seeking treatment (Schaaf *et al*., 2011).

Autism: Autism comes from the word "autos" which means everything that leads to self. In the dictionary of psychology, autism is defined as: a way of thinking controlled by personal need or self, responding to the world based on vision, self-expectations and rejecting the reality an extreme self-enjoyment with thought and fantasy (Dominick *et al*., 2007). Autistic disorder is a disorder or developmental abnormalities in social interaction and communication and is characterized by limited activity and interest. The appearance of this disorder depends really much on the stage of development and the chronological age of the individual. Autistic disorder is considered as an early infantile autism, childhood autism or Kanner's autism (Bruinsma *et al*., 2004).

The fact that every single child taking part in the experiment correctly answered the control questions allows us to conclude that they all knew (and implicitly believed) that the marble was put somewhere else after sally had left. The critical question was "Where will Sally look?" after she returns. Here a group difference appeared: Autistic children answered this question in a distinctly different way from the others. The Down's syndrome and normal preschool children answered by pointing to where the marble was put in the first place. Thus they must have appreciated that their own knowledge of where the marble actually was and the knowledge that could be attributed to the doll were different. That is, they predicted the doll's behaviour on the basis of the doll's belief. The autistic group, on the other hand, answered by pointing consistently to where the marble really was. They did not merely point to a "wrong" location but rather to the actual location of the marble (Baron-Cohen *et al*., 1985).

The causes of autism: By the increasing number of individuals with autism, more studies on the causes of autism are conducted in which it changes the initial understanding of the people. Initially heredity and biological factors are considered as the causes of autism. In addition, a cold and unresponsive mother is also considered as the causes of autism. The new theory mentions that parent with cold response and keeping the distant are natural, considering that suddenly unexpectedly, they have a confrontation with the condition of their children with autism (Tetzloff and Obiakor, 2015). Cases of autism vary from mild to profound and in the relative prominence of particular features and comorbidities. Approximately 50% of autistic children have intellectual disability, some have abnormally increased brain size, one-third have had at least 2 epileptic seizures by late adolescence and about half have severely impaired speech. Yet some children with autism, notably those with Asperger's syndrome, have highly developed intellectual skills, sometimes in specific areas such as mathematics. Because of this heterogeneity, the term "Autism Spectrum Disorder" (ASD) has come into use. ASD encompasses autistic disorder (DSM 299.00) asperger's syndrome (DSM 299.80) and pervasive developmental disorder not otherwise specified (PDD-NOS) (DSM 299.80) (Landrigan, 2010).

The negative impact of caring for a child with an Autism Spectrum Disorder (ASD) on parental well-being has been well documented. Due to the broad range of difficulties and behavioural problems that these children face, raising a child with an ASD produces chronic stress and strain on parents. A similar inconsistency in findings is evident in research examining the influence of ASD symptom severity (i.e., communication and socialization impairment, repetitive and stereotyped behaviours and interests) on general stress in parents. While the majority of studies examining career outcomes indicate a positive relationship between ASD symptoms and general stress in parents (Benson, 2006; Davis and Carter, 2008).

Some research has also indicated a lack of association between symptom severity and general stress outcomes (Hastings *et al*., 2005). These findings are surprising as greater symptom severity is likely to result in higher levels of dependency on parents increasing the strain associated with caring for a child with ASD. ASD symptom severity is strong and consistent predictor of general stress in parents, suggesting that the demands of managing a child's ASD symptoms may threaten a parent's coping resources, resulting in greater stress and concern (McStay *et al*., 2014). First, there is no doubt that current ASD prevalence estimates are significantly higher than those that had been found in previous years. However, though a portion of this documented increase may be attributed to a true increase in the prevalence rate, it is doubtful that such a significant increase actually occurred. It is not a mere coincidence that utilizing different diagnostic criteria provides researchers with varying numbers.

As was previously described, the relatively frequent change in diagnostic criteria appears to be at the core of the increasing prevalence of ASD. Such changes may have also allowed for inaccurate diagnoses to have previously occurred. Therefore, current studies are not comparable to those that had been conducted previously which had found lower rates of ASD. Without controlling

for the changes in diagnostic criteria, researchers simply cannot make such claims that increases are being observed. Furthermore, the increased awareness of ASD has drastically changed not only the assessment process but also who seeks out such assessments. The media has exploded with references to ASD assessment, treatment and awareness in general. With this boosted awareness have come greater resources for testing children with assessment now being available for children as young as 1.5 years of age. As such more and more parents are having their children assessed who may not have previously done so (Matson and Kozlowski, 2011).

Deep pressure theory: The application of Deep Touch Pressure (DTP) has been suggested to provide positive effects on anxiety modulation. However, empirical and theoretical evidence linked to the clinical effects of DTP are relatively rare. This study conducts a quantitative analysis of behavioural assessments and performs physiological measurements including those of electrodermal activity and heart rate variability, to understand the modulation of the Autonomic Nervous System (ANS) and the orchestration of sympathetic (SNS) and Parasympathetic Nervous Systems (PsNS). The results suggest that the activation of PsNS plays a critical role in ANS modulation. This study provides physiological evidence to support the positive clinical effects of DTP for reducing anxiety in dental environments (Chen *et al*., 2013).

The definition of deep pressure is a touch given to the skin at a certain pressure in which does not hurt. Occupational therapists observe that a very light touch causes stimulation on the nervous system. In addition, the deep pressure can create a relaxed and soothing feeling because when the deep pressure is given it will produce the hormone oxytocin or so-called happy hormone (Grandin, 1992). Deep pressure is considered to have a good effect on the development of children in various clinical tests (Edelson *et al*., 1999). Based on the report, deep pressure is described to produce a calming effect to the children with psychiatric disorders. Deep-pressure simulations such as curls with the mattress, have been used to pacify children with autism and ADHD disorders (Miller *et al*., 2009). Reports that children that have problem with sleeping quality, their sleep will be better if they sleep in a sleeping bag that can adjust to their bodies. It has also been used to reduce tactile defensiveness in children who do not tolerate touch. It has also been found that the deep pressure, generated by the soft foam wrapped around the bias arm, provides self-stimulation and reduces the behaviour and unfavourable or self-defeating character to the children with autism (McClure and Holtz, 1991).

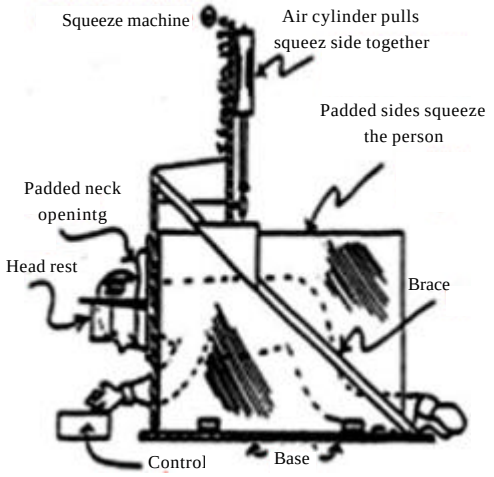

Fig. 1: Design sketch of squeeze machine (Edelson *et al*., 1999)

Have the following implications for occupational therapy practice: deep pressure input may be an appropriate therapeutic modality to use with people with difficulty with arousal regulation and sensory modulation during or in preparation for functional tasks.

Deep pressure may be useful for reducing maladaptive internalizing and externalizing behaviours increasing attention to task and reducing impulsivity, all of which would support the client's ability to successfully perform daily life activities and engage in appropriate social emotional, motor and organizational tasks (Reynolds *et al*., 2015).

Autism therapy: One method of therapy to cure or reduce the autism is using the method of deep pressure. This method is found by Temple Grandin. Based on Grandin's experience at age 3, he had symptoms of standard autism such as intolerance to be touched inability to speak and rage character. Grandin is very stiff and sensitive to touch and sound and will pull himself away when people touch him. Deep pressure helps to overcome the oversensitivity to the problem of touch and can eliminate nervousness. It is as in children with autism disorders (Grandin, 1995).

Deep pressure method is a method of therapy by way of giving a certain pressure throughout the body area, this method using the tool as the medium.

Autism therapy equipment: Based on the description above, autism therapy with deep pressure requires a tool medium for the process. Therefore, Temple Grandin creates a device that can provide a deep-pressure effect which is called the squeeze machine it is showed in Fig. 1 while Fig. 2 made by Therafin Corporation.

Fig. 2: Squeeze machine made by Therafin Corporation

The description of squeeze machine two 9×120 cm hinged board with four hinges with a soft foam base and V shape with a control box at one end and an air compressor tube, just as shown in Fig. 2. Users are between the 2 sides of the board, during the desired period using the pressure provided by the air compressor and controlled by the user, the side board provides deep-pressure stimulation evenly throughout the lateral part of the body (Grandin, 1992).

We observed 2 clearly distinguishable types of autonomic responder in our sample. Most of the autistic children (26 out of 37) had abnormally high electrodermal activity which could be shut off by immersion of the hands in dry beans we call these children type A responders. However, there was also a second type of child, who had a very flat response with either no individual SCRs or SCRs produced only by extreme activities such as self-injurious behaviour; we call these children type B responders. Type A child's response was characterized by a widely varying electrodermal base line with large SCRs which stopped completely after immersion of the hands in dry beams. Other activities that were capable of completely shutting down the eccrine system were eating, sucking on sweets, being wrapped in heavy blanket and deep pressure massage. Attempts at interaction with other people seemed to exacerbate the hyperactivity most strongly. Interruption of their activities by other people such as turning the television set off during a favourite video, often produced extremely large responses with agitated behaviour following immediately indicating that the resistance to change one sees in autistic children may be caused or exacerbated by such burst of sympathetic activity which the child actively attempt to avoid or tries to damp down.

Autism and emotion: In light of the many social difficulties experienced by children with autism, researchers have been interested in emotional correlates of autism. For children with autism who are not high functioning, emotion-related deficits appear to be broad and pervasive involving deficits in both understanding and recognition. For individuals with HFA/AS, emotion-related deficits appear to be more specific. When prompted, HFA/AS children demonstrate relatively intact emotion concepts and recognition ability for happiness, sadness, fear and anger (Ozonoff, 1995), although, spontaneously, they may ignore the emotional properties of social stimuli, attending instead to more concrete, physical aspects. Other studies suggest that HFA children may have difficulty understanding emotions involving contradictions between expectations and knowledge states such as surprise and in relating emotional expressions to social context (Heerey *et al*., 2003).

Language acquisition in children with autism: One of the most salient examples of deviant speech in autism is echolalia, the repetition of utterance with similar intonation of words or phrases that someone else has said. Echolalia may occur immediately after or significantly later than the original production of an utterance (Noens and Berckelaer-Onnes, 2005). Immediate echolalia is produced either following immediately or within 2 turns of original production and involves exact repetition (i.e., pure echolalia) or minimal structural changes (i.e., mitigated immediate echolalia). Immediate echolalia has been considered a necessary stage of language development for verbal autistic children (Prizant and Duchan, 1981).

Delayed echolalia is repeated at a significantly later time (i.e., at least 3 turns following original utterance but more typically hours, days or even weeks later) and also involves exact repetition or minimal structural changes. The production process of delayed echolalia involves retrieval of information from some type of long-term memory while for immediate echolalia, short-term memory or working memory is most often implicated. The objective of this study is to compare the cognitive profile, the motor and language functioning and the psychosocial adaptation of children with Asperger Syndrome (AS) and with High-Functioning Autism (HFA). Subjects were recruited through the department autism and developmental disorders of the Heckscher-Klinikum. To be included in the study, the full-scale-IQ had to be at least 80. Subjects with AS had to have a normal early language development and subjects with HFA a clear delay in language development as reported by their parents. The sample consisted of 57 children with Asperger syndrome and 55 children with high-functioning autism. The mean age of the children was 10 years. All subjects were examined with a standardised test battery. Children with AS had a higher full-scale-IQ than children with HFA (Noterdaeme *et al*., 2010).

Autism tantrum: Children diagnosed with Autism Spectrum Disorder (ASD) display an array of behavioural difficulties. Two of the common maladaptive behaviours exhibited are tantrums (unrelenting vocal protestations) and meltdowns (physical displays of aggression and emotion). These behaviours create difficulties in establishing and maintain positive relationships and are the most targeted behaviours for children with ASD. Self-regulation techniques have been specifically identified as effective for reducing unwanted behaviours in students with autism, however, they are underutilized. For students with ASD or AS, tantrums (persistent verbal outbursts) and meltdowns (extreme negative emotional or physical response) are common behaviours resulting in many negative consequences such as lowered achievement levels and isolation from peers and others (Tsao, 2009).

The nature of tantrums and meltdowns can also lead to severely negatively affecting the family as a whole resulting in poor sibling and parental relationships (Beyer, 2009). In the school setting, teachers are trained to address behavioural issues, however, parents are rarely involved in formal training or education to improve their child's maladaptive behaviours. Research has found that involving parents in the intervention process is a crucial part of an intervention's overall success. Since, this component is often disregarded, this study implemented a self-management intervention to empower the child with ASD to control overstimulation and avoid tantrums and meltdowns (Bennett, 2014).

MATERIALS AND METHODS

The research consists of systematic steps that simplify the process of work and thinking. In a research, it requires a method to minimize errors in decision making. The method used is the method of morphology in which the decision-making is assessed based on the comparison aspects to obtain the best result.

Data collection method: The data collection methods used in this research are:

Literature review: To learn the theories that deal with the replication of the knee bottom foot to run through the literature, lecture materials and print and electronic media.

Observation and interview: To conduct direct observation in the field by conducting interviews with the care-taker of children with special needs and directly with children with special needs.

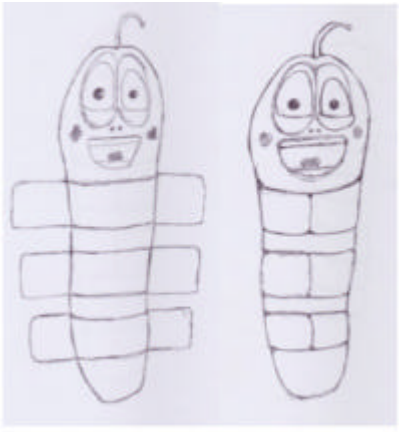

Fig. 3: Concept design 1

Testing and analysis: To test the tool that has been created, so that, the researchers can conclude the data obtained from the test results using stress analyzer "uBioClip v70" which can measure the stress index.

The 2 aspects of the product are the physical form of product and product function. Physical form of the product can be broken down into several components and the components can be broken down again into several sub-components or elements and so on.

The product concept is the physical form of the product; even it is still in the form of sketches or schematic drawings. The concept of the product can be expressed by a sketch or can also be expressed with a description which is an abstraction of the product to be designed. The following are the design of some product concepts in determining the draft concept using the drawing sketch.

Concept design 1: In the first concept design Fig. 3, it is a form of animated television movie in the form of Larva cartoons. It has the shape resembling a caterpillar animation, so that, the binding wings are made, so that, it can put pressure on the user; the binding wing is placed on the body of the Larva that has the shape of the lines, so that, when it is used, the form becomes the animated cartoon of larva. It aimed to make the user interested with this tool.

Draft design 2: In the second concept design (Fig. 4) the user is in a sleeping position, the mattress has 2 large binding wings which can bind the body of the material from this mattress to the base of the wood that is used for weight to keep the mattress in a fixed state at the time of the measurement.

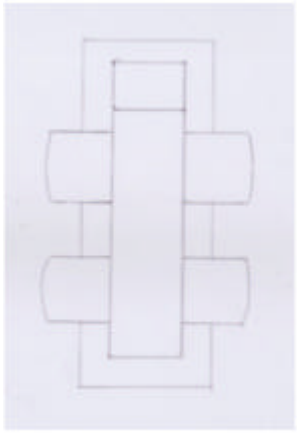

Fig. 4: Concept design 2

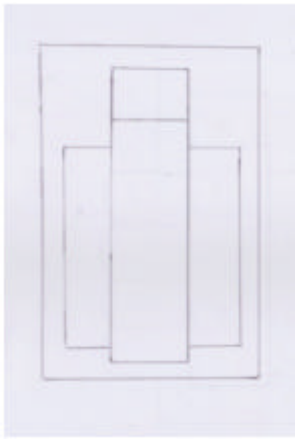

Fig. 5: Concept design 3

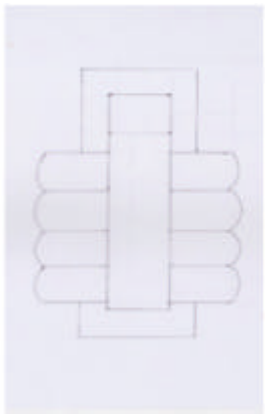

Fig. 6: Concept design 4

Concept design 3: In the third concept design (Fig. 5), the concept uses the whole material of the foam; The base used in this tool covers the entire main mattress to keep the user comfortable. It has single wing binder that is large enough to give the effect of body's embrace and pressure.

Concept design 4: The fourth draft design (Fig. 6) is a composite form between concepts 2 and 3 the base used is made of foam and it has 4 binding wings, so that, the pressure applied to the body can be adjusted for each binder based on the convenience of the users.

RESULTS AND DISCUSSION

From several alternative concepts that have been made, to determine the best concept, it can be performed based on the decision-making matrix. The concept with the highest score is the selected concept. The decision making matrix can be seen in Table 1. The concept of this therapy tool of mattress is a hug tool that can wrap the body of the user from shoulder to foot. This tool has 4 wings that function as a hug wing whose pressure level can be set based on user convenience. This tool uses a cotton cloth as a coating to be gently in the contact with the skin of the user. Designing a product requires many alternatives in the assessment of the best concept to be further developed and produced and to choose one of the best product design concepts.

Data collection method: After the assessment of each product concept is made, then the highest assessment is in the concept of number 4 with a value of 44. So, in the next stage, the design process number 4 will be used as a selected concept that will be produced and developed based on its usefulness and criteria that have been set before. Product design is a process of improvement and further development of the concept of product design that has been defined before by the concept design 4. The design of the product concept is in the form of sketch. This stage will show 3D shape by using Fusion 360 Software.

In the process of giving form to the elements of the product, must also estimate the existing products and provide some development that will be carried out on the product in accordance with predetermined criteria to make it easier in the layout of the elements to be used. As shown in Fig. 7 (layout) and Fig. 8-10 (assembly).

Testing of universal therapeutic mattress: This test is perform to ensure that the tool can be used and can bind the whole body, so that, the effect of pressure on the body can reduce body stress on the body. The tool to be

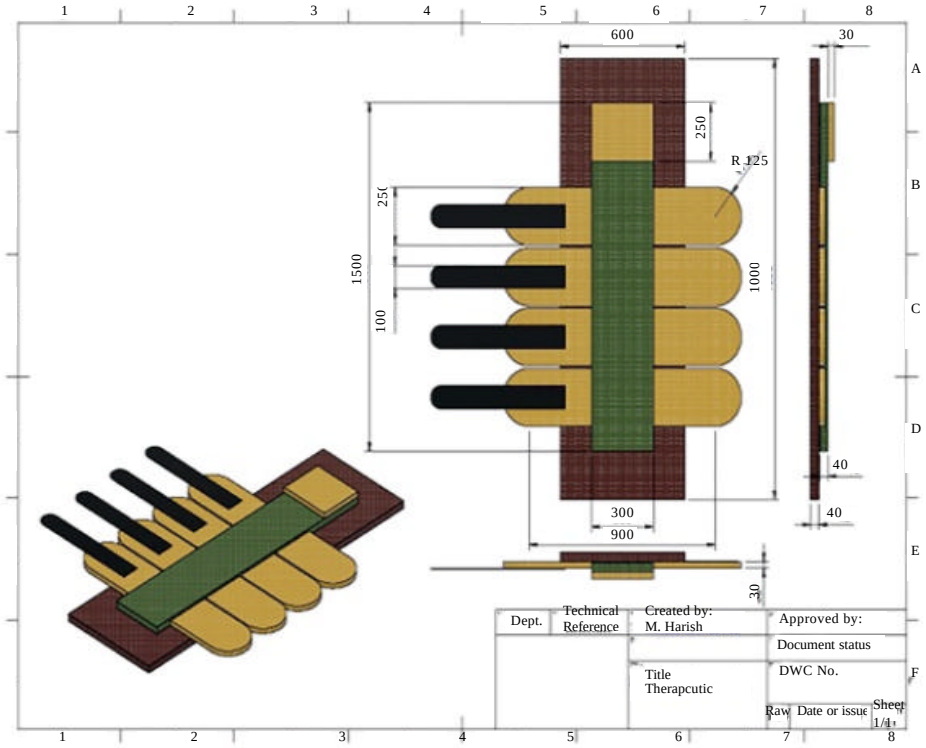

Fig. 7: The layout figure of universal therapeutic mattress

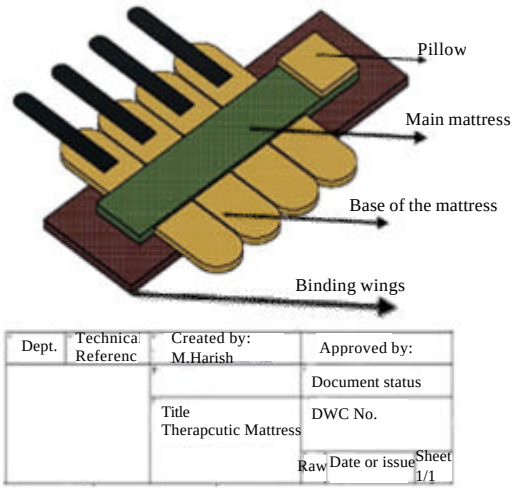

Fig. 8: Image of universal therapeutic mattress assembly

Table 1: Decision-making matrix

	Concept				
Criteria	Weight	1	2	3	4
Covering the whole body	10	9	9	10	9
Interesting shape	10	10	9	9	9
Ease of manufacture	10	6	7	7	8
The use material	10	5	7	8	9
Ergonomic	10	7	8	8	9
Total		37	40	42	44

Wt = Weight of maximum value

Fig. 9: Wings position before use

Fig. 10: Wings position on use

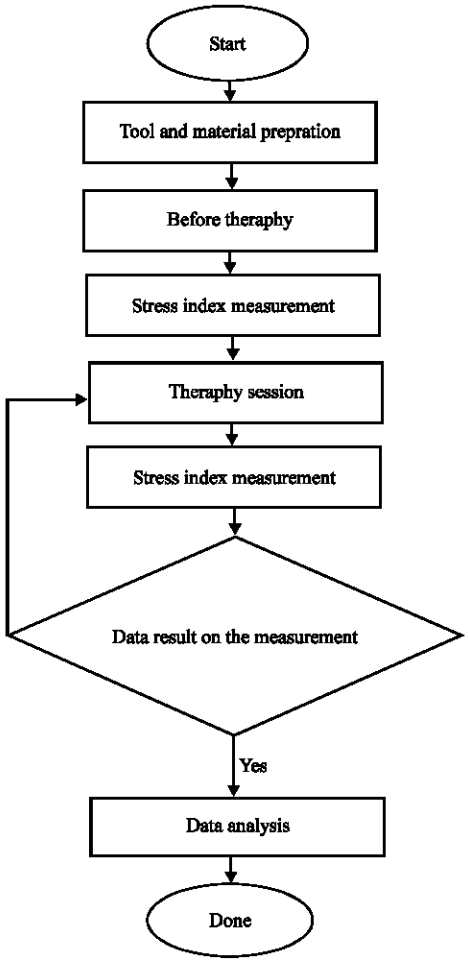

Fig. 11: Test flow

used in index stress measurement is a stress analyzer "uBioClip v70". The test flow can be seen as shown in following Fig. 11.

The testing tool to be used is a universal therapy mattress for children with autism, whose measurements use a stress analyzer uBioClip v70 where it can detect a stress index in a person with a measurement time of 2.5 min. Measurement of the stress index of this tool is performed on the finger as much as twice measurement, namely before and after therapy. This measurement toll requires connectivity on the computer to read the results. This test is performed for children aged about 6-15 years with a maximum height that can be measured of 150 cm. The test conducted on 30 children in which each child is performed twice assessment before and after therapy. In the data collection, it was given an interval of 3 min and sometimes for therapy for 5 min.

The stages of the measurement and the use of the tool are performed with the following ways: arrange the universal mattress and adjust the binding wings in

Fig. 12: Universal therapeutic mattress

Fig. 13: Measurement of stress index

Fig. 14: Application connected to uBioClip v70

accordance with the figure of assembly (Fig. 12). Get the uBioClip v70 that is connected to the computer on the right index finger of the child; attach the tool to the base of the finger, so that, it is easier to read the signal and the measurement is accurate. At the time of measuring the stress index, the user is not allowed to use hand accessories such as bracelets, hand-wrists and rings. The installation of uBioClip tool is shown in Fig. 13.

Then open the uBioClip v70 app on your computer and make sure the indicator shows that the app has been connected to uBioClip v70 just like in in Fig.14. Then

Fig. 15: Child data

Fig. 16: Stress index column

Fig. 17: A child is lying down on the bed

Fig. 18: Therapy session

Table 2: The results of stress index testing

	Stress index report	
Names	Before therapy	After therapy
Adetya	37	35
Agung Permana	35	33
Andi Darmawan	39	26
Andik hermawan	32	31
Desi Dwiyani	38	34
Dian Friska	22	15
Diana	34	31
Diki Agung	27	25
Dimas Wahyu	21	26
Dwi Ratna	24	25
Eka Kurnia Ulfa	28	26
Farah Nadya	30	23
Fitryana	39	36
Helmi Zaenal Fikri	33	28
Ikhsan	36	23
Katarina	38	27
Khoirun Arbaadin	38	41
Luthfi	38	24
M Satria Imadudin	54	38
Maya Dewinta	29	28
Muhammad Nur Badarudin	29	18
Neny Utami	34	22
Novie Adyana	29	18
Sausan	35	26
Susanti	39	36
Teguh handoyo	29	25
Tia apriviani	33	30
Vicky septian	26	25
Yudha pratama	36	34
Zulfa M	50	37
The average of stress index report	33.7	29.9

input child data in the form of full name and place and date of birth and sex; for new users before the measurement (Fig. 15).

After the data is complete, the next step is to select the stress index test column and start running the test index measurement, wait for 2.5 min of measurement before the therapy will be obtained (Fig. 16). The child will lie down on the mattress as shown in Fig. 17.

After that, the attachment is mounted and the pressure to be applied to the child is based on their convenience, tighten the velcro fabric, so that, the binding wings can bind perfectly (Fig. 18). The tool testing was performed for 5 min. After 5 min, do the measurement again using uBioClip v70 with the measurement procedure starting from number 4.

Test results: The results have been obtained by testing 30 children with special needs with age about 8-15 years with height around 100-150 cm. Test results can be seen in Table 2.

This therapy tool of universal therapeutic mattress uses foam as its main component because the foam is very soft to press the body which is added with the layer of cotton cloth, so that, when a friction occurs to the skin

surface, it feels comfortable and smooth to be used. This therapy tool also serves as a great giver of pressure against its user. Pressure can be adjusted using adjustable Velcro fabric pressure level which will be given to the user in accordance with their convenience. This tool is designed based on the concept that has been selected and able to bind the whole body so it can provide a comfortable hug effect on the user.

In the test results that have been conducted before, there is the number of decreases in the stress index report that is equal to 3.8 or by 1.28%. Based on the data obtained, this universal therapeutic mattress can provide a sense of comfort to the users. The effect of this therapy mattress on each child is the same: giving the effect of pressure and giving stimulation of the hug, thus giving a sense of comfort.

CONCLUSION

The conclusion of the research that has been conducted on the universal therapeutic mattress for children with autism in Indonesia is as follows: the researcher successfully creates a prototype based on the concept design that has been selected which is able to put pressure on the user's body, so that, users feel comfortable when having the therapy. This mattress is designed for children aged about 8-15 years with height around 100-150 cm.

From some design alternatives that have been designed, the chosen design proved that it is capable of embracing and giving effect to the pressure on the user's body. Concept design 4 is the best design that can reduce the number of stress report index of 3.8 or 1.28% to the users.

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