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A Review on Mechanical and Comfort Properties of Medical Bandages from Different Materials and Finishing Methods

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Abstract: Textile materials and items designed to satisfy unique requirements are ideal for any surgical and medical use where a variety of endurance, durability, or sometimes moisture and permeability is needed. After a few hours of wearing bandage, they can become unstable, particularly when worn too loosely. Also, removing the bandages can be impossible since it can be stuck to the wound area. The smell they leave could be interpreted as infections, and some bandages can leave a stain in the injury area. In order to know what is the best materials for producing medical bandage that complies with mechanical and comfort properties, a review of the articles available need to be conducted. This study reviewed the available literature on the mechanical properties such as tensile strength and bursting strength, and comfort properties such as air permeability and thermal resistance of medical bandage. An electronic search engine of ScienceDirect, Scopus, SpringerLink, and Google Scholar was performed. Eleven articles met the inclusion criteria. The variation in burst intensity represents the thickness of the fabric and the density of the region. Various characteristics of the fabric such as burst strength, compression extension and thickness, and weight, are essential aspects for the technology of various compression garments. The thickness, density and also porosity of the fabric. Influence the air permeability of the fabric. The use of cotton and bamboo fibers to make bandages can be extended as both fibers have good mechanical and comfort properties.
Keywords: Comfort Properties, Mechanical Properties, Medical Bandage

1. Introduction

In constructing suitable systems for the medical and healthcare sectors, textile materials play a significant and critical role. The use of medical textile production has grown dramatically, not only within the hospital, hygiene, and healthcare industries but also in hotels, homes, and other situations where hygiene is needed [1]. Textile Terms & Definitions 1995, explain medical textiles as textile

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structure that has been designed and manufactured for use in a variety of medical purposes, including implantable applications.

The medical textiles sector has expanded with new fabrics and innovative ideas. The use of textiles has recently begun to go beyond the standard treatment of injuries, incontinence pads, plasters, and others. The recent advancement, for example a broad range of woven, nonwoven, knitted textile types are progressively exploring their way into a wide range of surgical practices [2].

A bandage is a fabric that can be used to support a dressing, a splint, or other clinical devices, or may be used on its own to provide mechanical support to certain parts of the body [3]. Textile components and products built to meet specific standards are suitable for any surgical and medical use where endurance, flexibility, or perhaps moisture and permeability. The elastic properties of the bandage help to have a strong relieving power, which significantly improves venous flow and decreases venous hypertension. In addition, they are conveniently aligned around the lower limb and allow frequent changes in dressing [4]. The main point is that after a few hours of wearing, they can become unstable, particularly when worn too loosely. Also, removing the bandages can be impossible since it can be stuck to the wound area. The smell they leave could be interpreted as infections, and some bandages can leave a stain in the injury area. In order to know what is the best materials for producing medical bandage that complies with mechanical and comfort properties, a review of the articles available need to be conducted.

This research aims to review the mechanical and comfort properties of medical bandage from different material and finishing methods and also to conclude and recommend the best material and finishing methods suitable for producing medical bandage based on the study review.

2. Methodology

At the first stage of the analysis, searches were conducted to collect all the possible keywords used in the report. Four search engines; ScienceDirect, Scopus, SpringerLink, and Google Scholar were used to classify published academic journals involving similar terms. In the first stage of the analysis, the selection of the following terms and the Boolean operators had been used, such as ‘bandage AND mechanical properties’ OR ‘bandage AND comfort properties’. At this stage of the analysis, a total of 1441 publications were retrieved. Then, the results were filtered by 'article type' such as review articles and research articles. Due to this, 805 documents were removed, and only 636 articles remained. The results by years were then filtered between year 2000 to 2021, and 386 documents were discarded, leaving 250 documents to screen for the next stage. The articles were reviewed thoroughly for the title and abstract. The selected article must be focused on the chosen properties which were mechanical and comfort properties. The mechanical properties are tensile and bursting strength, and the comfort properties are air permeability and thermal resistance. The articles were read in details at the third stage of the review, leaving 11 documents for the next step.

3. Results and Discussion

Table 1 below displays 11 papers made up of research and review articles. The article was chosen based on the parameters laid down, namely the mechanical and comfort properties. The mechanical properties chosen are tensile strength and bursting strength and the comfort properties chosen are air permeability and thermal resistance.

Table 1: Outcomes for the previous studies

References	Materials	Properties	Results
Akalin et al. (2010)	Soyabean/Polyester/Elastomeric (Sample 1 and 2) Bamboo/Polypropylene/ Elastomeric (Sample 3 and 4)	Tensile strength	The first two sample, Sample 1 and 2 have greater strength and elongation than the remaining two sample, Sample 3 and 4 bandages.
Mihailovic et al. (2006)	Polyamide 6.6/Elastane (80%/20%) treated with Gentamicin Sulfate or Essential oil of Picea Abies	Tensile strength	The samples were improved in terms of tensile strength and elongation in lengthwise and widthwise after being treated with any of the antimicrobial agents.
L. Wang et al. (2011)	Nylon/Spandex (75:25) – BB Nylon/Spandex (72:28) – FT Nylon/Spandex (67:33) – PN1 Nylon/Spandex (63:73) – PN2	Bursting strength	The bursting strength is higher than 200N for all samples and the sample containing 63:37 of Nylon/Spandex (PN2) fabric is the best and the samples containing 75:25 of Nylon/Spandex (BB) is the poorest.
Janarthanan & Senthil Kumar, (2017)	Cotton treated with Sargassum Vulgare	Bursting strength	The findings indicate that a major difference ($p>0.05$) in burst intensity was identified for untreated and treated fabrics.
Ahmed et al. (2020)	Bamboo coated with Curcuma Longa / Centella Asiatica / Azadirachta Indica	Bursting strength Air permeability	The results for a bursting strength are from 5.3, 5.5, and 5.4 kg/cm^2 for bamboo fabric coated with Curcuma Longa (BFC-Cl), bamboo coated with Centella Asiatica (BFC-Ca) and bamboo fabric coated with Azadirachta Indica (BFC-Ai). Highest value of air permeability for coated are found to be bamboo fabric coated Curcuma Longa (BFC-Cl) and bamboo fabric coated Azadirachta Indica (BFC-Ai) which are 100.0.
Oğlakcioğlu et al. (2016)	Cotton, Bamboo, Tencel	Air permeability Thermal resistance	Air permeability increased in cotton, bamboo, and Tencel fabrics, respectively, and Tencel samples had the best permeability. Cotton yarn fabrics demonstrate lower resistance to heat flow due to lower thickness.

Basal & Deveci, (2016)	Polyester, Cotton, Viscose yarn,	Air permeability Thermal resistance	Samples for filament yarn (N10), regular polyester yarn (N11), and texturized polyester (NIF) had a high permeability as opposed to other samples and NIF samples has the lowest thermal resistance.
Demir & İkiz, (2017)	Polyamide 6 / Luxicool, Polyamide 6,6 / Luxicool, Polyester / Luxicool, Polyester, Polyamide 6,6	Air permeability Thermal resistance	Blended material PET/luxicool 2683 l/m^2s and the fabric formed of PA 6.6 fiber has the least air permeability values.
Majumdar et al. (2010)	100% Cotton, 100% Bamboo, 50:50 Cotton:Bamboo	Air permeability Thermal resistance	The air permeability of the fabric enhances as the ratio of bamboo fiber rises in yarn.
Kayalvizhi et al. (2017)	Bamboo/Cotton, Bamboo/Polyester, Bamboo, Cotton.	Air permeability Thermal resistance	100% of bamboo has the best air permeability and highest thermal resistance.
Maqsood et al. (2017)	Cotton	Air permeability	The air permeability of elastic knitted structures in a single location is much higher than that of the remaining knitted structures.

3.1 Tensile strength

The lengthwise tensile strength of samples treated either with Gentamicin Sulfate or essential oil of Picea Abies improved by 20 % and also increased their tensile elongation by 18 %. Changes in the width values on the tensile strength are not much different compared to longitudinal for untreated fabric, fabric treated with Gentacimin Sulfate, fabric treated with Picea Abies (Figure 1). The black bar graph represents as the untreated fabric while grey and white bar represent as fabric treated with Gentacimin Sulfate and Picea Abies respectively. The overall increase in tensile properties in the treated samples was 8 % [5]. It was also found that the elongation properties of bandages containing bamboo and polypropylene fibers are stronger than soya bean and polyester fiber fabrics [6].

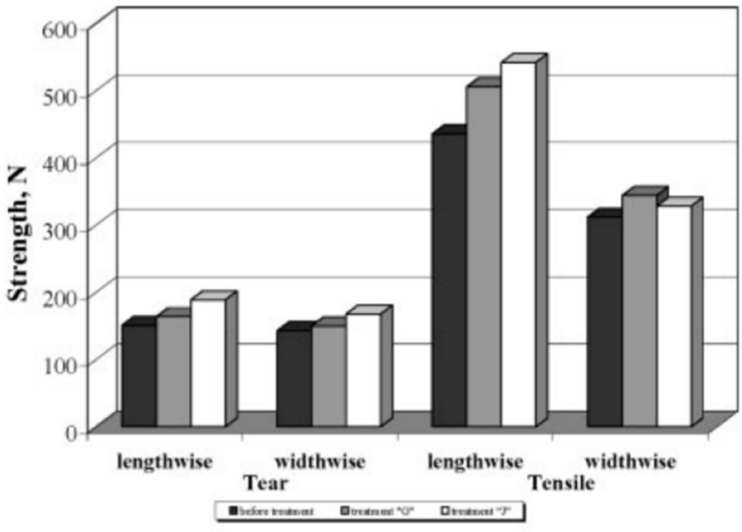

Figure 1: The effect of the antimicrobial treatment for tear and tensile strength [7]

3.2 Bursting strength

Bursting strength is a critical factor for wound dressing, where the strength of cloth is exerted under tension in both directions simultaneously. A research was conducted for Bamboo fabric coated with Curcuma longa (BFC-Cl), Bamboo fabric coated with Centella Asiatica (BFC-Ca), and Bamboo fabric coated with Azadirachta indica (BFC-Ai). Study has shown that the wound dressing component can have very high bursting strength to tolerate tension during the wound healing period, with a minimum of 5.3 to a maximum of 5.5. The finding is consistent with previous studies with a bursting strength from about 5.3, 5.5, 5.4 kg cm2 for BFC-Cl, BFC-Ca, and BFC-Ai. Therefore, the constructed material showing sufficient bursting strength can be used as the wound dressing material [7]

It has also been found that certain fabric specimens do not break even after a compressive extension of 50 mm, for example in Nylon/Spandex fabric with composition of 67/33 (PN1) and Nylon/Spandex fabric with composition of 63/37 (PN2), it has a larger percentage of Spandex yarn (Figure 2) and the amount of spandex yarn can affect the thickness of the fabric. The variation in burst intensity can affect thickness of the fabric and the density of the region. Various characteristics of the fabric such as burst strength, compression extension, thickness, and weight, are essential aspects for the technology of various compression garments [8]. The fabric treated with Sargassum Vulgare also showed to have a better bursting strength than the untreated fabric [9].

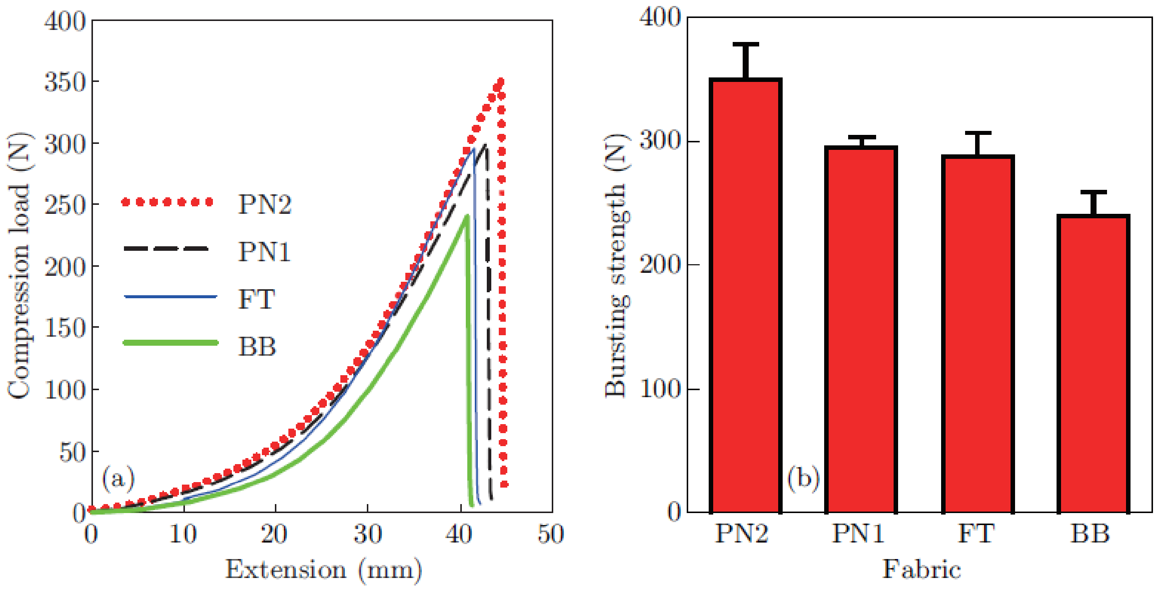

Figure 2: Bursting strength testing curves (a) and bursting strength (b) of different compression fabrics [8]

3.3 Air permeability

Air permeability is an essential component in the comfort of the fabric, as it takes part in the transfer of moisture vapor from the skin to the environment. The theory is that the vapors travel through fabrics spaces by air diffusion from one side of the material to another [10]. Experimental data found that air permeability improved in cotton, bamboo, and Tencel materials, respectively, and that Tencel samples had the greatest permeability in all samples due to lower hairiness and a more compact design in the Tencel yarn [11]. The air permeability of the fabric relies on the thickness, density, also porosity of the fabric. Air permeability decreases at higher thickness and density and lower porosity. The thicker yarns used for these samples resulted in low air permeability. This observation is supported by comparing the number of filaments that these yarns produce. Finer fibers result in higher surface area and lower air permeability [12].

Polyester/luxicool mix fabric has the greatest air permeability. The porous nature of the fabric often plays a very important role in the permeability of the air. The fabric made of Polyamide 6.6 fiber have the least permeability values [13]. As the ratio of bamboo fiber increases in yarn, the air permeability of knitted fabric improves. The rise in air permeability is noticeable by an increase in the number of bamboos fiber from 50 % to 100 %. Air permeability improves for fine yarn fabrics [14].

In bamboo/polyester blended knitted cotton, the amount of bamboo improves air permeability but will decrease if the content of polyester increases. It can be seen from the Figure 3 below that 100 % bamboo has the highest air permeability level. The air permeability of the blended fabric continues to decline as the fabric thickens. Bamboo delivers the best air permeability to the fabric due to the tiny spaces in the construction of the fabric and lower hairiness than cotton fiber (Figure 4) [15]. The air permeability of uncoated and bamboo fabric coated Curcuma Longa (BFC-Cl), bamboo fabric coated Centella Asiatica (BFC-Ca), bamboo fabric coated Azadirachta Indica (BFC-Ai) coated fabrics measured to be 100.0, 99.9, 99.8, and 100.0 $cm^3/cm^2/s$ each. The permeable surface of the wound dressing has the capability of absorbing a high degree of the exudation, and studies say that the air permeability of the uncoated and coated fabric displayed between 72.83 and 56.6 $cm^3/cm^2/s$ on the herbal fabric [7].

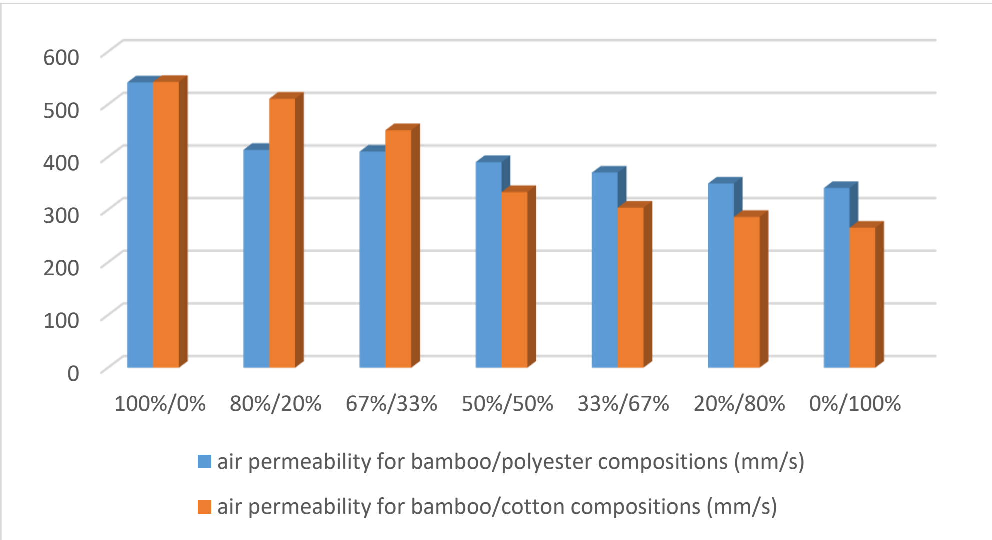

Figure 3: Air permeability results [15]

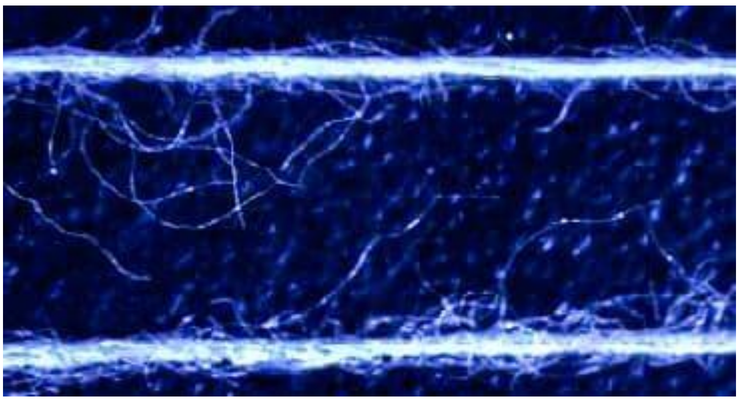

Figure 4: Microscopic of cotton and bamboo yarn images [11]

3.4 Thermal resistance

Clothing comfort is an essential component in the point where the persons select their outfits. The thermal resistance of the fabrics is the biggest factor of body heat loss in cold areas [16]. Cotton, bamboo, and Tencel are all cellulose fibers, so they are supposed to have identical thermal conductivity properties. However, the air contained inside the surface of the fabric has a direct effect on thermal characteristics. Cotton yarn fabrics showed low heat resistance due to lower thickness and good thermal conductivity [11].

A sample consisting of Polyester/Luxicool mixture has the greatest thermal resistance compared to samples consisting of Polyamide6/Luxicool, Polyamide66/Luxicool, Polyester, and Polyamide66 [13]. Basal & Deveci, 2016 said that thermal resistance would be a significant factor that controls the fabric's insulation properties. The influence of the type of fiber was more obvious with bandage samples made of plied yarns and filament yarns. Polyester spun yarn and filament yarn generated better thermal resistance compared to cotton and normal polyester yarn [12].

As the ratio of bamboo fiber in the yarn increases, the thermal resistance of the plain knitted fabric decreases. The higher proportion of bamboo fiber decreases the thickness and thermal conductivity of the plain knitted fabric [14]. For bamboo/polyester blended fabric, because of the content of bamboo, it improves the thermal resistance and as the content of polyester increases the thermal conductivity drops. When the thickness of the cloth increases, the thermal resistance tends to increase [15]

4. Conclusion

In conclusion, there are many types of material used in the market nowadays in manufacturing bandages that can comply with its properties, such as comfort and mechanical properties. These properties are undoubtedly essential to assure comfort and scale down the pain so that the wearer recovers quickly. Tensile strength has shown that bandages containing bamboo blended with polypropylene are much stronger than soyabean blended with polyester. Other than that, the sample treated with antimicrobial agent essential oil of Picea Abies improved in terms of tensile strength compare to untreated and sample treated with Gentamicin Sulfate.

On the other hand, for bursting strength properties, Nylon/Spandex fabric with composition of 63/37 (PN2) is the best, and the Nylon/Spandex fabric with composition of 75/25 (BB) has the poorest bursting strength. This is because the thickness and density of the PN2 fabric are higher than other fabric due to the higher value of spandex containing in the fabric. Cotton fabric treated with Sargassum Vulgare shows higher bursting strength compared to untreated fabric. Bamboo coated either with Curcuma longa or Centella Asiatica or Azadirachta indica have lower bursting strength than uncoated fabric.

For air permeability, the fabric containing Tencel fiber is better than bamboo and cotton due to lower hairiness and more compact design compared to bamboo and cotton but, fabric containing bamboo has the highest thermal resistance compared to cotton and Tencel. For PET/luxicool blended fabric, it has the highest value in air permeability and thermal resistance. Air permeability is better for fabric containing a higher ratio of bamboo, and also in thermal resistance. Also, bamboo fabric coated with Curcuma Longa and Azadirachta Indica has highest air permeability.

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