

Relationship between Ease and Thermal Insulation of Men's Pyjamas Made of a Knitted Fabric with New Cotton Non-Twisted Hollow Yarn

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Abstract

We examined the relationship between ease of pyjamas and body on the thermal insulation of men's pyjamas made from a knitted fabric of a new cotton-based non-twisted hollow yarn to obtain design guidelines for higher heat retention. We made six sets of men's pyjamas that have different ease for the circumferences of chest, hip, and sleeve. We measured the heating power required for different parts of a thermal manikin to remain at a constant temperature when the manikin wore the pyjamas. We also measured the thermal insulation when the cuffs of the upper garment and the hems of the lower garment were closed with belts. To evaluate the effect of ease of wearing state on thermal insulation quantitatively, the differences of circumference and area of the cross-section between thermal manikin and a pyjama worn on the manikin were calculated from those 3D scanned data. We investigated the relationship between the heating power and the differences. As a result, the heat retention increased as the differences increased although there are variations depending on the location. There was almost no effect of convection from the cuffs and hems in the experimental environment without wind.

Keywords: Knitted Fabric; Non-twisted Hollow Yarn; Pyjamas; Thermal Properties

1 Introduction

The physical properties of fabric and the shape of clothing affect the thermal comfort of clothing. The physical properties of a fabric depend on the properties of the fibre and yarn material. The thermal properties of fabrics made from various materials have been measured to make clothing that is more comfortable [1]. In addition to material properties, the thickness of the air gap between clothing and the body strongly affects the thermal comfort of clothing. Several studies

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have investigated the relationship between the thickness of the air gap and the heat retention of clothing [2-9]. Mert et al. [2] conducted three-dimensional body scanning to investigate the distribution of the air gap thickness and the contact area for the male lower body in relation to the garment fit and style. They analysed relationships between the distribution of the air gap thickness/area of contact and the physiological response of the lower body through physiological modelling. Li et al. [3] investigated the relationship between the thermal insulation of fabric and that of clothing and the relationship between the air gap and thermal insulation. They reported that heat retention depended more on the gap between clothing and body than the insulation of the fabric. They also reported that the gap required for clothing to have high heat retention depends on the clothing type and fabric type. According to the type of fabric, the required air gap will be different even for the same ease. The effect of ease on the thermal insulation of clothing thus depends on the type of fabric. Research on the gap for various types of clothing with a specified fabric is needed.

Pyjamas are usually designed to have larger ease to allow better movement. The thermal comfort of pyjamas is also important [10], especially in winter. To guide the design of men's pyjamas with high heat retention, the present paper investigates how the ease of pyjamas affects heat retention. The designated ease on a pattern and air gap between body and clothing while wearing clothing could be different and the difference will affect the thermal insulation of clothing.

A knitted fabric made of a new non-twisted hollow cotton yarn was recently developed. Kim et al. [11] investigated the mechanical properties of this fabric and reported high thermal insulation. The knitted fabric is soft, such that the air gap in accordance with the form of clothing is different from that of other fabrics. Using the fabric, we can provide a new design of pyjamas for those who prefer pyjamas made from cotton fabrics. Manabe et al. [12] investigated the heat retention of the pyjamas made from the fabrics and reported high heat retention. However, the relationship between the ease of the pyjamas and those heat retentions is still unclear.

The present paper examines the effect of the ease between pyjamas and body on the thermal insulation of men's pyjamas made from the recently developed knitted fabric so as to provide design guidelines that achieve high heat retention. To evaluate the effect of ease of wearing state on thermal insulation quantitatively, circumference difference between thermal manikin and a pyjama worn on the manikin was calculated using the circumference obtained from those 3D scanned data. The air gap between thermal manikin and a pyjama worn on the manikin was also calculated using an area of cross-section of those 3D scanned data. Using those air gap and circumference differences, we investigated the relationship between the heating power and the air gap. We also investigated the effect of ventilation from cuffs of the upper garment and the hems of the lower garment on the insulation of the pyjamas.

2 Experimental

2.1 Thermal Insulation of Pyjamas with Different Ease

To investigate the thermal insulation of pyjamas, we measured a heating power of a thermal manikin required to maintain a surface temperature. A thermal manikin (Kyoto Denshi Kogyo Co., Ltd, Kyoto, Japan, THM-117S) operating in a constant-temperature mode was dressed in pyjamas, and the heating power required to maintain a constant temperature for each part of the