博　士　論　文　の　内　容　の　要　旨
Abstract of Doctoral Dissertation

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With the improvement in the quality of life, people pay more attention to the various properties of clothing materials when choosing clothes. For example, the elasticity, strength, breathability, softness, moisture retention, and moisture absorption of the materials for pursuing a higher quality of life. During these properties, suitable moisture absorption performance of cloth fabric can make people feel more comfortable when wearing, due to the timely adsorption of sweat from the body and regulate body temperature. In research related to moisture absorption of materials, this property is mainly expressed as the spontaneous flow of liquid in the yarn or fabric, and this surface infiltration phenomenon caused by the surface tension of the liquid is also called wicking.

However, obtaining the water absorption or function of the final material, such as fabric, generally needs to be determined after the fabric is made. Manufacturing of the fabric requires human resources and material resources, which does not meet SDGs standards. Computer technology is relatively advanced; in the future, however, it will be valuable to predict the water transport performance of the final fabric with the help of CAD instead of measurement after manufacturing. Woven fabric is a network, which is structured by warp and weft yarn. The fabric weave parameters, such as yarn parameters, weave density, weave diagram, determine the network. Water transport in fabric occurs on yarns, both interlaced and noninterlaced. For the noninterlaced, the water transport property is determined by the yarn properties. For the interlaced, the water transport is influenced by the yarn character and weave parameters. Researchers focused on the relationship between fiber and yarn or yarn and fabric in these studies.

Until now, to our best knowledge, no equipment can measure water absorption in the warp and weft way at the same time. In this research, we develop a piece of new equipment to get the wicking ability of single yarn and interlaced yarn directly. This paper introduces a new experimental setup capable of simultaneously measuring the water absorption properties of individual and intersecting yarns. For individual yarns, one end of the yarn is secured in a water tank, while the other end is connected to a pulley system and subjected to tension. A miniature water pump adds water to the tank, and the yarn's absorption process is recorded using a camera. For intersecting yarns, two columns are used to control the ends of the horizontal yarn, which is crossed at a desired angle with a vertical yarn. Water is added to the tank using a miniature water pump, and the yarn's absorption process is captured by a camera.

Woven fabric is interwoven by warp and weft yarn, it can be considered yarn's network. To clarify the wicking phenomenon of woven fabric and simulate its water transport, we

examine the wicking behaviors in the vertical direction of different kinds of silk yarn samples; after that, we clarify the moisture movement of these interlacing silk yarns; finally, we discuss the wicking relationship between the single and interlaced yarn.

In this research, we find that the void and fiber areas of the silk yarn are important factors in influencing the wicking length of single yarn. The wicking length of the silk yarn shows the same trend with the increase of void and filament areas. The cross section of the silk yarn is composed of silk fibers and the distributed irregularly void in the yarn. The void can absorb the water, as demonstrated by the capillary effect. After degumming, silk fibers are hydrophilic and can absorb water. In this study, the water absorption is conducted by the hydrophilic silk fibers and capillary phenomenon caused by the void between fibers. However, after adding the twist and tension, the void area will be changed. The area of the void is decided by the tension, twist, and fiber number of the silk yarn. Herein, with the increase of fiber area, the wicking length was found to be increased. Increasing the void area can increase the wicking length linearly. Further, the effect of the interlacing condition of the silk yarns was discussed. To the interlaced situation, the initial speed of single yarn water transport is the highest, followed by the warp direction and the weft direction. Furthermore, the wicking length of S shows a high relationship with WP and WT, which can be used to predict the wicking length of interlaced yarns based on that of the single yarn.

Besides, we also find that the twist and finesse of the silk yarn are also important factors influencing the wicking length of a single yarn. The wicking length of the silk yarn shows the same trend with the finesse of the silk yarn. Besides, the effect of the interlacing condition of the silk yarns was discussed. In the interlaced situation, the initial speed of WP is higher than WT, while the wicking length of the weft direction(10 mins) is higher than the warp direction. Furthermore, there is a strong correlation between the wicking length of S, WP and WT. This relationship can be utilized as a predictive tool to estimate the wicking length of interlaced yarns based on the wicking length of individual single yarns. The time for moisture reaching the interlaced point and moving from warp yarn to weft yarn shows a certain relationship with the interlaced point area.

To the different humidity, it was observed that in the case of silk yarn, increasing the twist reduces the impact of humidity on water absorption height for fine yarn, whereas for coarse yarn, increasing the twist intensifies the impact of humidity on water absorption height. Further in-depth research is needed, specifically by refining the parameters of the yarn, to explore these findings in more detail.

This preliminary study aims to explore the water transport mechanism in silk yarns. With the advancement of computer technology, future research can focus on predicting the final fabric by simulating the water absorption properties of the interlaced yarn network using Computer-Aided Design (CAD) tools. The significance of fundamental physics research lies in its ability to provide us with opportunities to deeply understand natural phenomena and principles. The study of water absorption, although it might seem tedious on the surface due to the extensive experiments and data analysis involved, holds profound implications for our daily lives and technological advancement. While research in water absorption demands patience and perseverance, it holds crucial importance for our everyday life, health, and environmental sustainability. With more people actively engaging in this field, driving fundamental physics research forward, it will bring forth numerous benefits for our society and technological progress.