

# Effect of Washing and Drying Conditions on Dimensional Change in Various Articles of Knitted Clothing<sup>★</sup>

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## Abstract

We investigated the effect of washing and drying conditions on dimensional change in various articles of knitted clothing, taking into account drying temperature, temperature change during drying, external force at dehydration, external force during drying, and humidity during drying. We immersed samples in water at  $25 \pm 2$  °C for 30 min, then dried them in a chamber at 40, 60, and 80 °C, and at 5% relative humidity (RH). We also investigated the effects of increasing the temperature from 40 to 60 °C and decreasing it from 60 to 40 °C. After dehydration, we dried the samples using a roller and a front-loader washing and drying machine at various humidity levels. We measured dimensional changes in the samples before and after drying. We investigated five samples of knitted clothing: men's socks, women's socks, men's underwear, women's underwear, and women's t-shirts. We detected no difference in the dimensional change ratio in the cotton or polyurethane underwear and t-shirts when the drying temperature was varied. However, the dimensional change ratio of acrylic-containing men's socks varied depending on the drying temperature. When drying acrylic-containing men's socks from 40 to 60 °C, the dimensional change ratio was larger than under other drying conditions. A lower temperature in the final drying stage could effectively reduce the shrinkage of socks made from acrylic, polyester, and polyurethane. The deformation due to external force during dehydration affected dimensional change. The external force during drying also greatly affected dimensional change in the knitted clothing. The humidity and drying time did not affect dimensional change in the knitted cotton clothing.

*Keywords:* Shrinkage; Knitted clothing; Drying temperature; Knitted fabric

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## 1 Introduction

Knitted fabric has been widely used for various types of clothing such as t-shirts, trousers, skirts, and socks. Knitwear is comfortable owing to its high extensibility. However, there are unsatisfactory aspects to knitwear such as dimensional changes, pilling, and changes to the “hand” of the fabric. Among these disadvantages, the shrinkage of the knitted fabric after washing and drying is one of the major causes of consumer dissatisfaction. Therefore, it is necessary to investigate the reason for shrinkage.

Many researchers have investigated the factors that affect the shrinkage of different types of knitted fabrics, and have considered the material, structure, finish, laundering conditions, etc. Fletcher et al. [1] investigated dimensional changes in knitwear made from various materials during laundering by measuring the spacings of the wale and course, and reported rearrangement of the fabric structure. Abbott et al. [2] investigated the mechanism of fabric shrinkage, taking into account the role of fiber swelling. Suh [3] also investigated the shrinkage of cotton jersey fabric by conducting a geometrical analysis of loop reorientation resulting from yarn swelling. He determined that the length shrinkage of a plain knitted cotton fabric depends mainly on two phenomena: loop migration and the change in course curvature. Other parameters in addition to fiber swelling have been investigated by many researchers. Onal and Candan [4] also investigated fabric shrinkage statistically and experimentally, taking into account knit characteristics and wet treatments. They found that fabric shrinkage is strongly affected by the type of yarn and the blend of the fiber. Quaynor et al. [5] investigated dimensional changes in knitted silk and cotton fabrics during laundering. They demonstrated that cotton shrinks more than silk. McKinney and Broome [6] investigated the dimensional differences between knitted jersey fabrics made with open-end and ring-spun yarns; the fabric made from open-end yarns had relatively good dimensional stability.

Laundering conditions also affect the shrinkage of knitted fabric. Van Amber et al. [7] investigated the effects of laundering and water temperature on the properties of silk and silk-blend knitted fabrics. Anand et al. [8] investigated the effects of washing and drying conditions on the dimensional stability and distortion of knitted fabrics during laundering with a detergent. Quaynor et al. [9] investigated the effects of laundering and laundering temperatures on the surface properties and dimensional stability of plain flat knit silk, cotton, and polyester fabrics with varying cover factors. However, they did not specifically investigate the effect of drying temperature on dimensional stability.

Drying machines are now used in the home, and drying as well as washing conditions affect dimensional stability. Therefore, it is also necessary to investigate the effect of drying conditions on dimensional changes. Higgins et al. [10] investigated the effects of various home laundering practices on the dimensional stability, wrinkling, and other properties of cotton plain woven fabrics. They also investigated the effect of the rinse cycle softener and drying method, and the effects of tumble sheet softener and tumble drying time [11]. Mikučionienė and Laureckienė [12] investigated the behavior of knitted fabric during drying under various conditions, and the influence of these conditions on the dimensional stability of finished knitwear. However, the effect of drying temperature on the dimensional changes in various knitted clothing—excluding other factors such as gravity and wind—remains unclear. Hashimoto et al. [13] investigated the influence of drying temperature on the shrinkage of various knitted clothes. However, temperature changes during drying could affect the dimensional changes in knitted fabrics. Therefore, in the present study, we investigated the effect of washing and drying conditions on the shrinkage of