ABSTRACT

In this competitive era, many technologies have been emerging out in the designing and development of sports apparel. Comfort is an important aspect in sports apparel because it affects the performance of the wearer due to discomfort. The properties of fibres, yarns, fabrics and garments are significantly related to comfort and must be taken into account in producing suitable sports apparel items. Fabric properties depend on fibre properties, yarn structure, fabric structure, mechanical and chemical finishing treatments given to the fabric. Engineered fabrics have been developed now-a-days to improve the wearer comfort of sportswear. Thermal comfort is one of the key requirements for sportswear because when a person is engaged in sport activity the transfer of air, heat and moisture is essential to facilitate the wearer comfortable. Clothing worn by the sportsperson should not impede the air, heat and moisture transfer from the human body through the clothing.

This research work focuses on the investigation of thermal comfort characteristics of weft-knitted layered fabric for sportswear. In bi-layer knitted fabric, inner layer is made up of micro-fibre polyester or polyester or acrylic yarn and outer layer is made up of modal yarn. Inner layer is formed by dial needles and the outer layer is formed by cylinder needles and the tuck stitch is incorporated for joining inner and outer layer.

Bi-layer knitted fabric derivatives were developed with different course repeat and varying tuck stitch position. In this research work, thermal comfort characteristics such as thermal conductivity, air permeability, water vapour permeability, wicking, moisture absorbency, drying rate and moisture management properties have been analysed for bi-layer knitted derivatives. Subjective evaluation by wear trial method was conducted for shuttle

badminton players. 15 male players with same age, height and weight were selected for wear trial. Subjects rated the respective garments (T-shirt and short) in thermal environment subjective rating scale which includes thermal perception, affective assessment, thermal preference, personal acceptability and personal tolerance. The bi-layer knitted fabric with tuck stitch on 12^{th} wale and 18^{th} course showed good air, heat and moisture transfer when compared to other bi-layer knitted derivatives. The findings of objective and wear trial method indicates that among four bi-layer knitted fabric derivatives, the fabric with less tuck stitch (used for joining inner and outer layer) exhibited good thermal comfort characteristics suitable for sportswear.

The bi-layer knitted fabric with tuck on 12^{th} wale and 18^{th} course which exhibited good thermal comfort characteristics have been taken for further study. Four bi-layer knitted fabrics were developed by changing the tuck stitch placement in four different points on wale such as tuck on 4^{th}, 8^{th}, 12^{th} and 16^{th} wale with same course repeat. Bi-layer knitted fabric with tuck on 12^{th} wale exhibited better air, heat and moisture transfer compared to bi-layer knitted fabrics with tuck on 4^{th}, 8^{th}, and 16^{th} wale. The bi-layer knitted fabrics with lower thickness and lower mass per unit area exhibited better thermal conductivity, air permeability, water vapour permeability, wicking, drying rate and moisture management properties. The fabrics with less number of tuck stitch exhibited better thermal comfort characteristics both by objective and wear trial method.

Bi-layer knitted fabrics were developed by changing tuck position in course-wise manner such as 6, 10, 14 and 18 course repeat and the tuck on 12^{th} wale remains the same. Greater the distance between the successive tuck pointsbetter will be the air, heat and moisture transfer properties. Bi-layer knitted fabric with slack structure facilitates lower thickness and mass per unit area and shown better thermal comfort characteristics. By wear trial method,

bi-layer knitted fabric with tuck on 18th course and 12th wale exhibited good rating compared to other bi-layer knitted fabrics.

An investigation on influence of yarn composition on thermal comfort characteristics was carried out further. The thermal comfort characteristics of bi-layer knitted fabrics with varying yarn composition in the inner layer have been studied. Micro-fibre polyester or polyester or acrylic yarn was used as inner layer and modal yarn was used as outer layer. Based on the objective evaluation of air, heat and moisture transfer and rating by wear trial method, it is inferred that the bi-layer knitted fabric with micro-fibre polyester in the inner layer and modal in the outer layer exhibited good thermal comfort characteristics when compared to polyester or acrylic yarn in the inner layer.

Further, an investigation on influence of modification of bi-layer structure on thermal comfort characteristics of layered knitted fabrics was carried out. Three modified bi-layer knitted structures were developed in which inner layer is made up of micro-fibre polyester and outer layer is made up of modal yarn. The yarn used in the middle layer was changed as either micro-fibre polyester or polyester or acrylic yarn. The thermal comfort characteristics such as thermal conductivity, air permeability, water vapour permeability, wicking, moisture absorbency, drying rate and moisture management properties were analysed. By wear trial method, shuttle badminton players rated the modified bi-layer knitted fabric with micro-fibre polyester yarn in the middle layer was comfortable to wear. Modified bi-layer knitted structure with micro-fibre polyester yarn in the inner and middle layer and modal yarn in the outer layer exhibited better thermal comfort characteristics compared to polyester or acrylic yarn in the middle layer of modified bi-layer knitted fabrics.

The moisture management properties of bi-layer knitted fabrics such as wetting time, absorption rate, maximum wetted radius, spreading speed, cumulative one-way transport capacity and overall moisture management capacity were studied for all developed bi-layer and modified bi-layer knitted fabrics. It was observed that longer top wetting time, higher bottom absorption rate, higher bottom maximum wetted radius and higher bottom spreading speed exhibited good liquid transport properties or moisture management properties for all developed bi-layer and modified bi-layer knitted fabrics.

Correlation between various thermal comfort characteristics such as air, heat and moisture transfer and wear trial subjective judgment scales such as thermal perception, affective assessment, thermal preference, personal acceptability statement and tolerance were studied.

Based on this research work, it is concluded that air, heat and moisture transfer properties of the weft knitted layered fabric mainly depend upon yarn type, fabric structure, tuck position in wale and course and geometric properties of structure. From the objective and subjective evaluation, it is concluded that the bi-layer knitted fabric with different course repeat and tuck stitch position influences the thermal comfort characteristics of shuttle badminton sportswear. The selection of suitable course repeat, tuck stitch position on wale and yarn type are the most important criteria for fabric development and this research work will guide the knitting industry and the end users of sports to select the suitable layered weft-knitted fabrics with good thermal comfort characteristics for sportswear.