The Science of Sportswear:
How does sportswear affect thermoregulation?

2026

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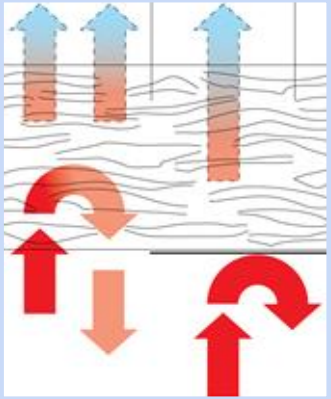
Introduction & Objectives

- Sportswear's effect on **comfort perception** is shown by studies to affect both **physical** and **psychological performance.**
- So: fabrics that cause discomfort from overheating as well as fabrics that are not insulating enough can lead to underperformance.
- Our aim: to avoid this situation by testing what fabric is the most effective at **thermoregulation** when ventilated and dampened with water or 'sweat'.
- We took into account both natural and synthetic fibres to compare their differences in **water retention, breathability** and **insulation** and how these properties better suit specific environmental conditions and sports.

The Science Behind Sportswear

- When you exercise, your body produces sweat to cool you down. This mixture of water and salt works by absorbing some of your body heat and carrying it away through evaporation.
- The effectiveness of sweat is dramatically impacted by what you wear: materials that provide less ventilation trap sweat and heat, causing overheating and discomfort.
- On the other hand, clothes can keep you warm by providing a layer of insulation - this traps air against your skin, which prevents moving air from carrying heat away from your body.
- Different fabrics vary in their properties, so it is important to choose sportswear material depending on the scenario.



Synthetic fabrics vs Natural fabrics

- Hydrophobic - water sits on the surface between fibres and is exposed to air and quicker cooling, evaporation, drying
- Designed to wick water along surface - moisture transport
- Fibres don't swell when wet; air channels remain open, gives advantage of breathability even when damp with sweat
- Thinly weaved fibres that allow heat to escape easily

- Hydrophilic - water absorbs into fibres themselves, causing them to swell and stay wet for longer
- Breathable when dry; when wet airflow decreases as air channels close
- Trap water and air - act like a wet insulating blanket
- Irregular, rough, porous - change shape when damp with sweat
- Heavy - cling to body when wet

Hypothesis

The rate of cooling of each material will differ depending on the type of fibres in the fabric e.g. synthetic or natural.

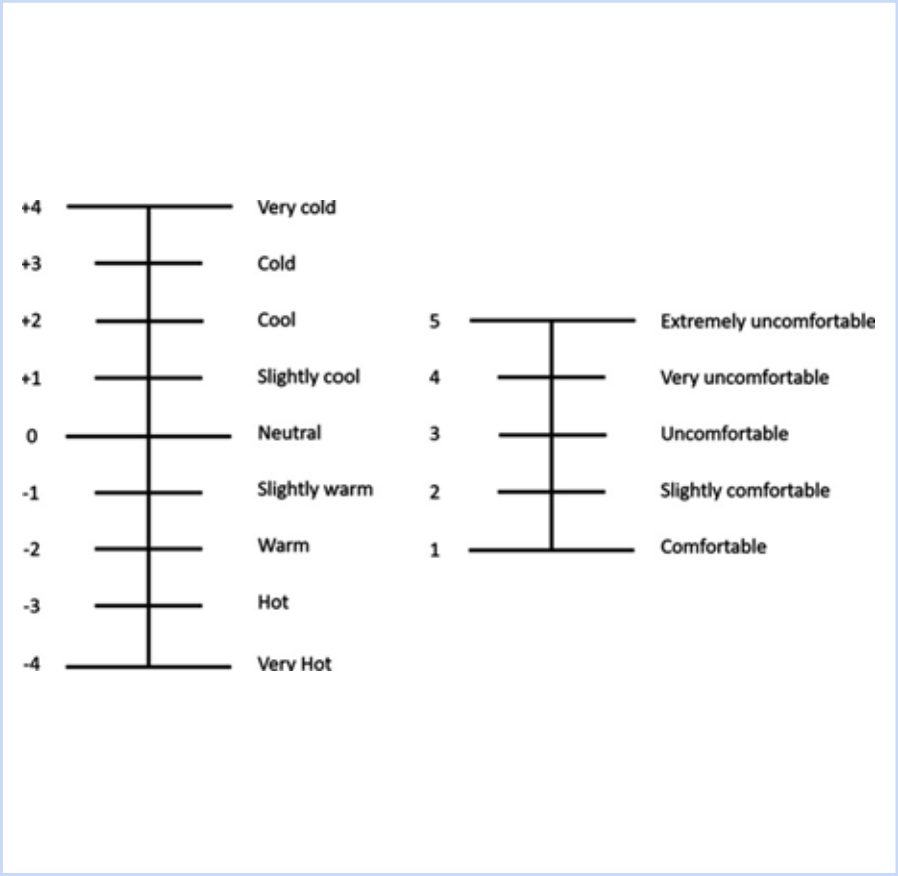
Main prediction:

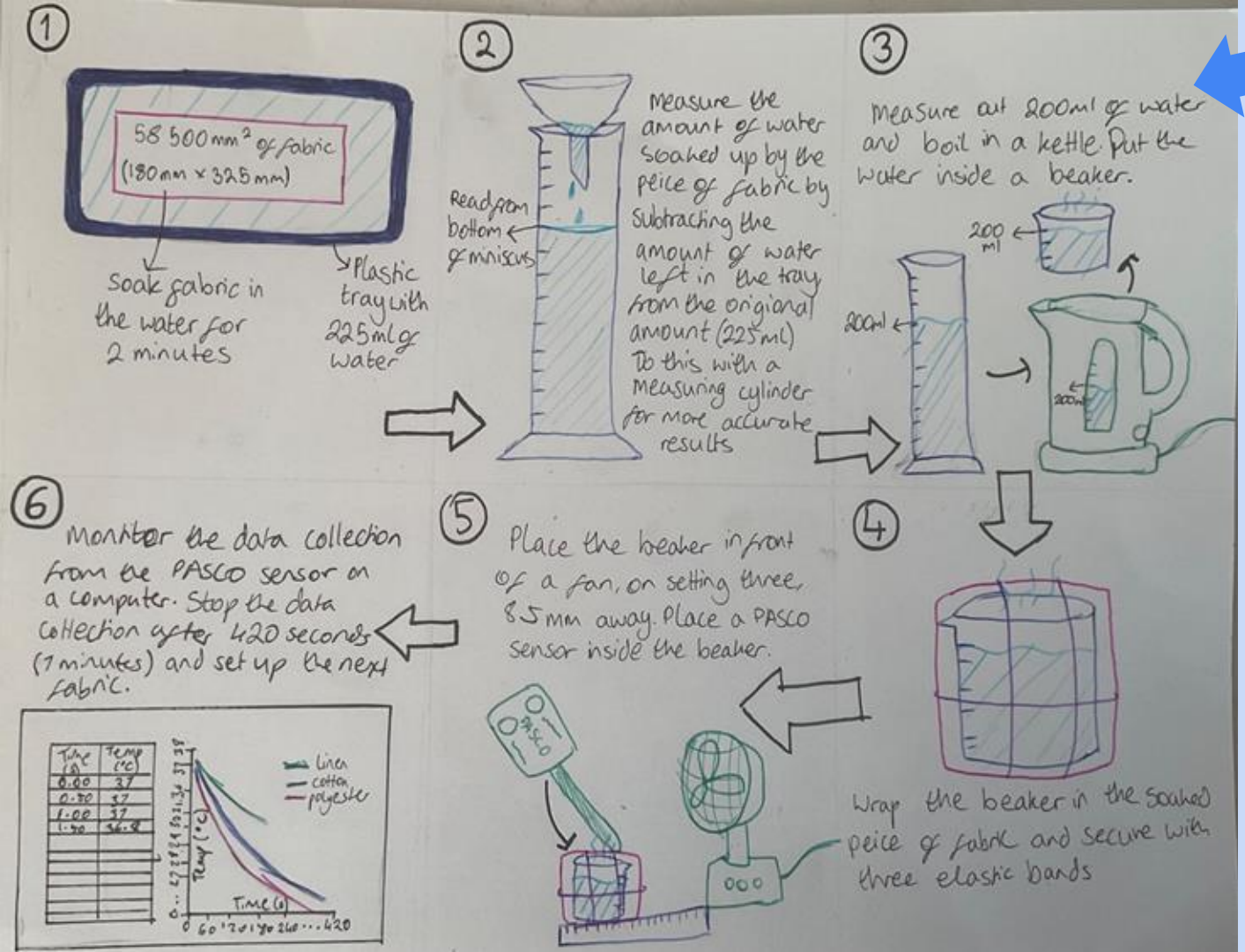
Polyester will show the greatest temperature decrease when damp and exposed to airflow

because its hydrophobic fibres are not permeable and do not absorb water so rapid evaporation can happen from the surface of the fabric.

Our Experiment

- After some initial research, we decided to conduct this experiment on the basis that the more thermal comfort someone has, the better their athletic ability and endurance. For example, an athlete may prefer to feel cool when exercising in warmer conditions and vice versa.
- We investigated the effectiveness of different materials on cooling under conditions that **simulated exercise**.

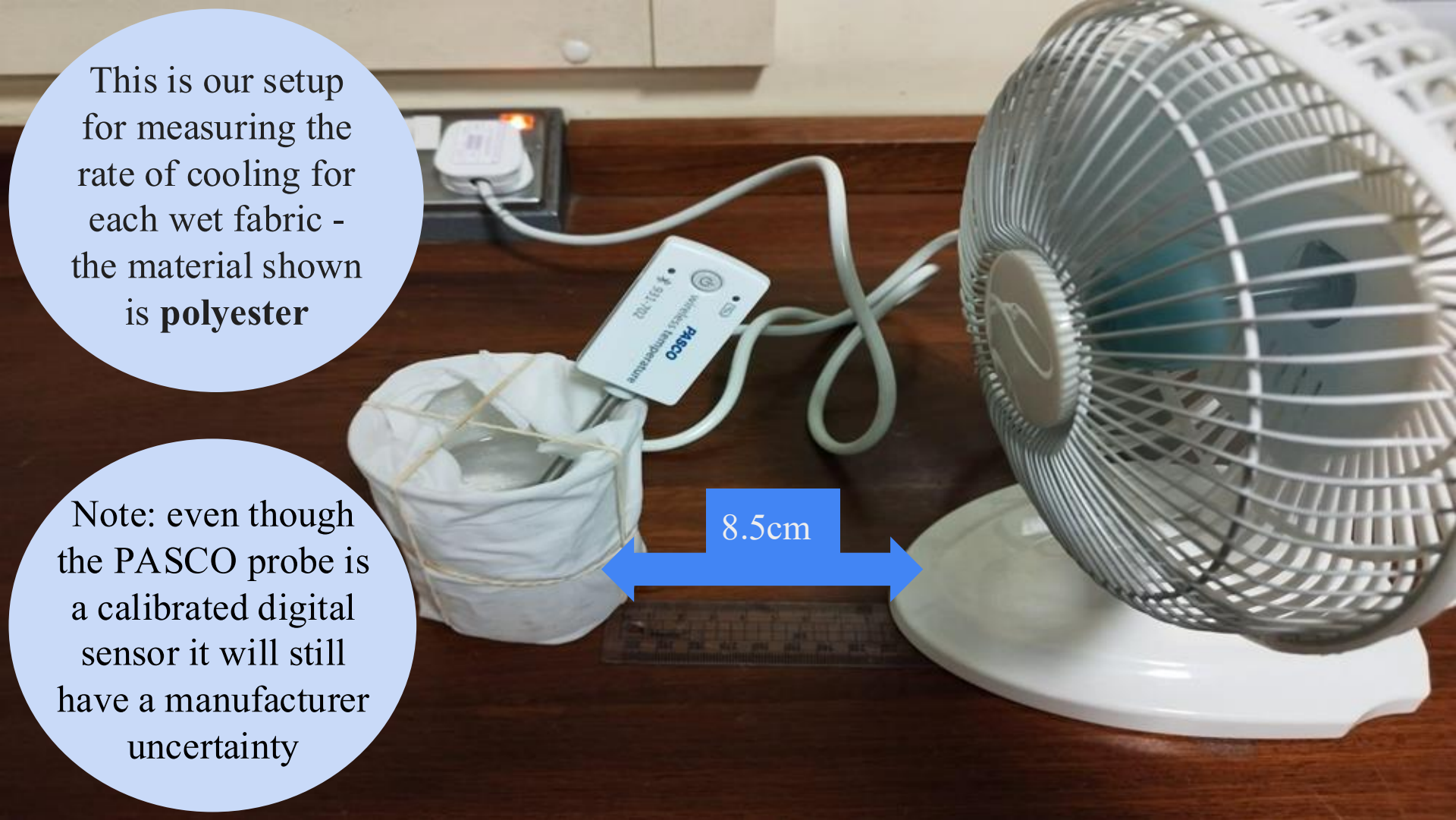




Method

Equipment:

- Tray
- Funnel
- Measuring cylinder
- Beaker
- Kettle
- Elastic band x3
- Ruler
- Electric fan
- PASCO sensor
- Computer
- Fabrics
- Water


This is our setup for measuring the rate of cooling for each wet fabric - the material shown is **polyester**
Note: even though the PASCO probe is a calibrated digital sensor it will still have a manufacturer uncertainty
8.5cm
PASCO

Variables

Dependant Variable - Rate of cooling

Independent Variable - Fabric material

Linen - natural fibre

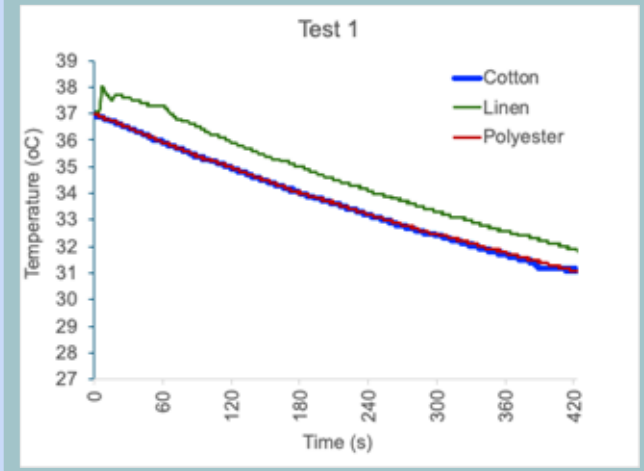
Cotton - natural fibre

Polyester - synthetic fibre

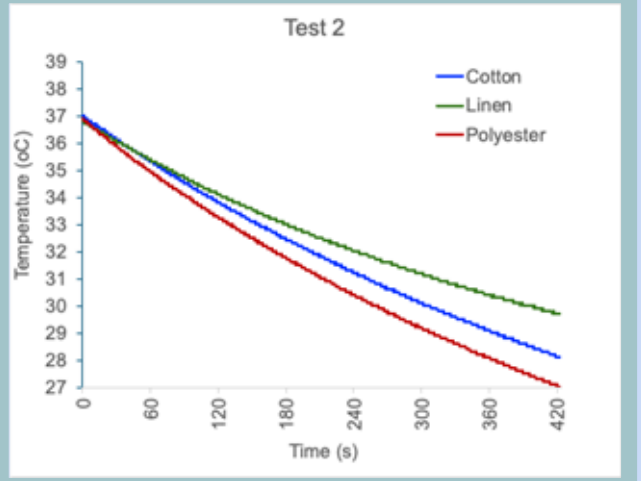
Control Variables

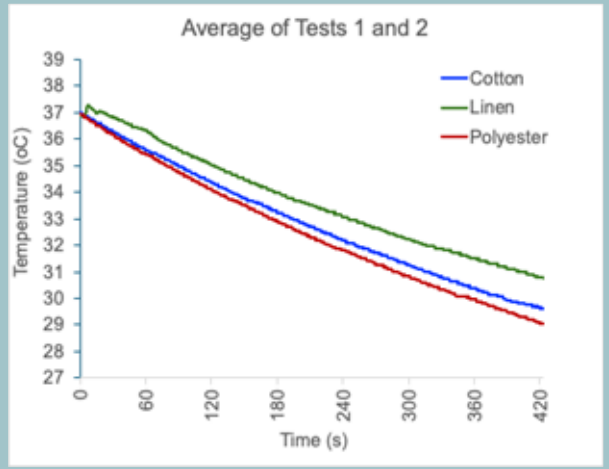
- Type of beaker
- Volume of water in container: 200 ml ± 0.5 ml
- Starting temperature of water: 37°C ± 0.5 degrees
- Volume of 'sweat' or water used to dampen fabric: 225 ml ± 0.5 ml
- Area of fabric: 585 cm
- Air flow - distance from fan: 8.5 cm, fan setting: 3/3
- Temperature/humidity of room - we tested the fabrics on the same day to ensure the conditions were as similar as possible to eliminate random error

Result Graphs



We collected our data using the PASCO Sparkvue software and converted the data into graphs on Excel as they are easier to read and understand.





Evaluation of Data

The graphs all had a similar trend:

- **The beaker wrapped in linen cooled the slowest** - this is because it is made from natural fibres (flax plants). It is very absorbent and has air gaps that make it insulating, so the water in the beaker stayed warmer for longer.
- **The beaker wrapped in cotton cooled at a similar rate to polyester and faster than linen** - although cotton is a natural fibre, it is very tightly woven so it has less air gaps between the fibres and is less insulating. However, cotton is thought of as being less absorbent than linen as the fibres are not hollow, which makes these results interesting because theoretically linen should be more efficient at absorbing and wicking away sweat to allow cooling.
- **The beaker wrapped in polyester cooled fastest on average** - because polyester is synthetic and thus is the most effective at moisture wicking. This means that it is the most efficient for cooling by sweat. This won't always be the case as some makes and blends of polyester can be very tightly woven, causing it to trap heat and become more insulating.

Conclusion

- The results of our experiment showed that the material of a fabric **does affect thermoregulation**.

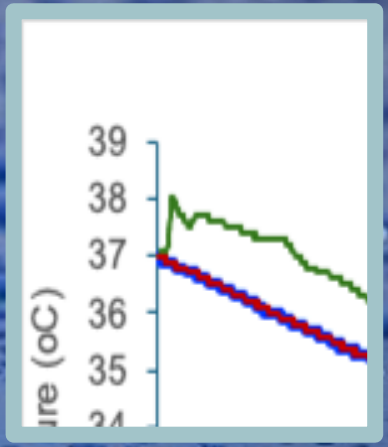
- Overall, fabrics that absorb more water and have larger air gaps (such as natural fibres) are more insulating than the thin, moisture-wicking fibres usually found in synthetic materials - **demonstrated by polyester** which had the fastest cooling rate.

- For low intensity exercise or in cold climates, natural and insulating materials would be appropriate as they would help keep you warm in the given conditions.

- For high intensity exercise or in hot climates where you would be sweating much more, wearing lighter and synthetic fabrics would allow your sweat to evaporate faster and keep you cool.

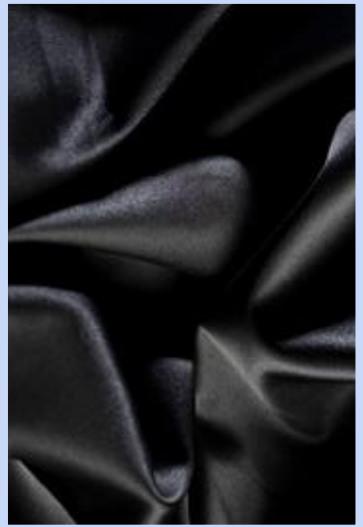
Improvements to our Experiment

- To ensure that most of the heat loss was through convection from the water inside the beaker to the material, we could have put a lid on the opening at the top or covered it in fabric. This would have reduced heat loss to the surroundings by convection and steam.
- Our results would be more accurate if we had data for three or more tests, but due to a software error we were unable to save this data.
- There is also an anomaly in our data: at the start of test one, the temperature of the water in the beaker wrapped with linen fluctuated. We have concluded that this was caused by factors beyond our control that affected the results: **the probe moving closer to the center of the beaker, probe response time, linen shifting as it became damper and heavier or movement of people / fan affecting air currents.**



Elite Sports - The Olympics

- In professional sport (eg. the olympics) athletes are competing at the limits of human ability, so even minor enhancements in thermoregulation can improve their reaction time, comfort and stamina.
- Most commonly used in competition wear are synthetic fabrics like polyester, elastane and nylon which are engineered to be more aerodynamic, lightweight and less insulative when wet, allowing faster evaporation during high intensity activity.
- When performance maximisation is not important, cotton blends are used: in training, recovery and skill-based sports that prioritise breathability, flexibility and tactile factors more than rapid cooling.



Cost Effectiveness of Common Sports Fabrics

Material	Synthetic?	Accessibility to public	Approximate cost per m2	Common sports use
Linen	Non-synthetic	Moderate	High (£15-£25)	Summer training wear, casual sport - low intensity
Cotton	Non-synthetic	Very high	Low-medium (£5-£12)	Training wear, cricket, golf - skill-based sports
Polyester ★	Synthetic	Very high	Low (£4-£10)	Running, football, athletics - high intensity
Cotton blends	Mixed	Very high	Medium (£8-£15)	Training, warm ups
Merino wool	Non-synthetic	Moderate	High (£20-£40)	Mountain hiking, skiing, cycling, winter base layers
Elastane (spandex or lycra)	Synthetic	High	Medium (£10-£18)	Compression wear, swimming, cycling
Nylon	Synthetic	High	Medium (£9-£16)	Outdoor sports

Real World Applications

- In colder climates or conditions, athletes do not want maximum cooling - cotton blends and wool are used as base layers in winter where fully synthetic fabrics could feel cold and clammy after prolonged use.
- Merino wool is naturally antibacterial, comfortable across a range of temperatures and odour resistant, making it especially suitable for everyday clothing, travel and outdoor activities.
- ★ However, as shown in the table, polyester is cheap to mass produce and is therefore accessible to the general public.
- Polyester sportswear dries faster and is longer lasting; it will use less washing and drying energy and won't need to be replaced as often, reducing long term energy consumption and cost.

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