THE IMPORTANCE OF THE REPEATED WASHING PROCEDURE IN EVALUATING THE PHYSICAL DURABILITY OF TEXTILES

HAVLOVÁ, MARIE* AND HAVLOVÁ, KATEŘINA

Faculty of Textile Engineering, Technical University of Liberec, Studentska 2, Liberec, Czech Republic

ABSTRACT

In the context of upcoming EU legislation, this article assesses the physical durability of a specific textile product – a laid-in knit fabric suitable for the manufacturing of sweatshirts or sweatpants. Five key parameters – dimensional stability in the length and width directions, color fastness (both across the fabric surface and at the seams), and pilling – were monitored in relation to the number of washing cycles (1, 5, 10, 20, and 30 cycles). Our study demonstrates that when evaluating the environmental performance of textiles, assessing "initial quality" based on a new or once-washed sample may be insufficient; instead, it is essential to carefully establish a simulated deterioration procedure. Significant differences between the tested samples may only become apparent after the 20th washing cycle; furthermore, our results showed that the sample that appeared best after the first wash gradually deteriorated, ultimately yielding the poorest results after the 30th washing cycle. Our experiment and its results demonstrate, using a specific product example, that assessing the physical durability of clothing is a complex, multifaceted issue involving numerous variables, and that determining the parameters relevant to testing is merely the starting point of the entire process.

KEYWORDS

Physical durability; Color fastness; Dimensional changes; Pilling resistance; Washing cycle.

INTRODUCTION

The textile and apparel industry is one of the most polluting sectors in the world and places a huge environmental and social burden on society. It is estimated to be responsible for 8-10 % of global greenhouse gas emissions [1-3]. Global apparel production has increased dramatically over the past two decades. Consumers today buy significantly more clothing items, but they keep each item for half as long, and the number of times a single garment is worn has decreased by 30-40% [3-6]. This increase is driven by the "fast fashion" business model, which relies on the mass production of inexpensive, lower-quality clothing intended for short-term use. As a result of this overconsumption, approximately 92 million tons of textile waste are generated worldwide each year [2] [5] [7], with the majority of discarded textiles (up to 87% in Europe) ending up in unsorted municipal waste, landfills, or incinerators [1, 8-11]. Furthermore, the textile supply chain is extremely water- and energy-intensive. Washing garments made from synthetic fibers releases significant amounts of microplastics into the environment; it is estimated that up to 35% of primary microplastics in the oceans originate from this source [3, 7]. In addition, textile production and consumption are estimated to continue growing unless significant changes occur across the textile value chain [12-13].

That is why the textile industry's impact on the environment is increasingly a hotly debated topic – not only in expert discussions and articles, but also in the public sphere and the media, and it is also a subject of interest for European Union policy [14-19]. The European Union is responding to this situation with systemic changes under the European Green Deal and the New Action Plan for the Circular Economy. The central document is the EU Strategy for Sustainable and Circular Textile Products [14], whose vision is that by 2030, all textile products placed on the EU market will be durable, repairable, recyclable, made predominantly from recycled fibers, and free of hazardous substances. The fundamental legal pillar is the framework Regulation on the Ecodesign of Sustainable Products (ESPR 2024/1781), which sets binding ecodesign requirements, including physical durability, reparability, recyclability, and recycled content [18]. At the same time, the revised Waste Directive (2025/1892) requires Member States to implement

* **Corresponding author:** Havlová M., e-mail: *marie.havlova@tul.cz*

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separate collection of textile waste as of January 1, 2025, and introduces a harmonized Extended Producer Responsibility (EPR) system with eco-modulation of fees, meaning that manufacturers will pay fees based on the environmental parameters and durability of their products [19]. Measures are also being prepared under the Green Claims Directive aimed at combating greenwashing, as well as legislation supporting the right to repair. It is already clear that a product's life cycle will need to be modified or extended at various stages of its life, e.g. during design and development, during use, during repair, during return to reuse, and also by different stakeholders, e.g. designers, engineers, customers or users, textile waste collection and sorting companies, and charities [20-24].

The importance of the physical durability of textile products

Monitoring the physical (technical) parameters of textile products over time is essential for several reasons:

- Basic functional requirement. Physical durability is essential for clothing to be used over a long period without losing its primary function. Textile products are subject to aging; for example, in waterproof jackets, breathability can remain stable over time, but water repellency and resistance to water penetration gradually decrease with use and washing [25].
- Prevention of premature discard. It is technical defects caused by wear and tear – such as pilling, loss of color intensity, loss of shape or dimensional instability, and seam splitting – that are the primary technical reasons why consumers discard garments [3-4, 26-27].
- A prerequisite for circular economy models. Clothing rental services, secondhand resale platforms, and repair services can only function with garments that retain their functionality and aesthetic quality even after many cycles of wear and washing [4, 25].
- A basis for ecodesign and management. Monitoring durability provides feedback for ecodesign and prevents planned or premature obsolescence. It enables the establishment of objective aging tests (e.g., simulated washing and drying cycles under the ESPR Regulation) and provides accurate empirical data for life cycle assessment (LCA) and determining the actual environmental footprint of garments [3-4, 18, 28].

Therefore, one of the most effective solutions to reduce the environmental impact of the textile industry is the introduction of long-life textile products into mainstream use [20, 24, 29].

Standard EN ISO 14021 defines an extended-life product as a product designed to provide prolonged use, characterised by either improved durability or upgradability, resulting in reduced resource use or waste [30]. The durability of textiles expresses the ability of the fabric to endure and retain its essential and characteristic properties, which can be broadly divided into: physiological properties, physical properties and psychological properties [31] or only into physical and emotional properties [32]. A product can be defined as durable if it is physically and emotionally durable. The shortest of the two will determine the end of its life. Therefore, laboratory testing of textiles does not directly predict the durability of fabric or garments [31, 33]. Durability in the sense of laboratory tests of physiological and physical properties is therefore an intrinsic property of products that has the potential, but does not guarantee, to contribute to longer product life [34]. Moreover, as shown in paper [34], product lifetime extension will only have a direct effect on reducing environmental burdens if two assumptions are met: 1. Purchases are driven by replacement, and 2. Production is demand-driven.

From the point of view of laboratory testing of physical quality parameters of textile products, it is also necessary to distinguish between the initial quality of a new product (before use) and its quality during use, which changes more or less as a result of external stress [3, 32-33]. This is very important because the consumer's perceived current product quality can significantly influence their behaviour when deciding how to dispose of a textile product that they no longer use - whether to throw it away or donate or sell it for reuse [38]. In the research paper [36], the hypothesis that the product's good condition positively influences the practice of redistribution behaviours was also confirmed.

The impact of maintenance on the durability of textile products

Textile products deteriorate under real-life conditions from use, maintenance, and storage, leading to a gradual decline in their functional and aesthetic properties. The maintenance method can play a key role in the overall service life of a textile product. While gentle, balanced care combined with timely minor repairs extends the product's lifespan, improper or excessive maintenance can significantly shorten it [27] [37]. During the washing process, the textile is subjected to a combination of chemical agents, washing temperature, and mechanical stress within the washing machine drum; in the case of hydrophilic cellulose fibers, this induces swelling in water, shrinkage, and the leaching of unstable dyes [27]. Repeated cycles lead to a reduction in yarn and fiber strength, accompanied by pilling and mass loss due to fiber shedding [27, 38]. The primary risks associated with home care have been identified in the literature [27]. The gentle practices consumers employ to extend the lifespan of their garments were

also identified [27, 32, 37, 39]. These primarily include: reducing washing frequency and opting for airing instead, gentle washing at lower temperatures, shorter wash cycles, air-drying away from direct sunlight, proper storage, minor repairs, and de-pilling.

Evaluating the physical durability of textile products

Objectively assessing the quality and durability of textiles is a complex process. No single laboratory test can capture all the wear factors that occur under real-world conditions of use, and different types of clothing are subject to different wear mechanisms. The most comprehensive approach involves an evaluation that tracks the deterioration of textile products resulting from their actual use – that is, it includes both care and wear. However, such experiments are very time-consuming and can also be more difficult to interpret than standardized laboratory tests, which focus solely on the deterioration of textiles resulting from a defined care process. Laboratory testing, which follows defined maintenance procedures, can then simulate stress in a controlled environment without the distortion caused by individual user behavior [39]. Laboratory tests focus primarily on:

- Mechanical strength and structural integrity (e. g., tensile strength of fabric, seam strength, bursting strength) [3, 33, 38-41]
- Abrasion resistance and resistance to pilling [31, 33, 40-41]
- Dimensional and shape stability, including seam spirality [33, 39-41]
- Color fastness (e. g., after washing, after ironing, after chemical cleaning, to rubbing) [33, 39-41]
- Functional and comfort properties (e. g. air permeability, vapor permeability, water repellency, water resistance, thermal insulation properties) [25, 31, 42]

Subsequently, it is possible – for example, using multi-criteria analysis models – to aggregate laboratory test results into a single objective score or a comprehensive quality index, with the option to define threshold values for properties or to hierarchically rank the tests according to their importance for a given type of garment [3, 31, 33, 39-41]. In its simplest form, the results of a product quality assessment based on multiple parameters can be aggregated using a weighted arithmetic mean [43]:

$$Q = \sum_{i=1}^{n} w_i x_i \quad (1)$$

where w_i represents the weight factor associated with the i-th quality parameter, and x_i is the measured value of the i-th quality parameter.

MATERIALS AND METHODS

Materials

In our experiment, six cotton-type laid-in knit fabrics purchased from a fabric e-shop were tested using laboratory methods to determine dimensional stability, color fastness, and resistance to pilling, with the aim of identifying potential differences in the physical durability of the textile products. All of the knitted fabrics tested are suitable for producing casual or children's clothing, such as sweatshirts or sweatpants, and are therefore interchangeable in intended use. All samples were selected in a similar color – dark blue. Five samples were dyed; sample No. 3 was printed (the pattern's background was dark blue). Four samples were raised on the reverse side; two knitted fabrics were unraised. The specifications of the knitted fabrics listed on the e-shop are shown in Table 1. Photos of the face and back sides of the new samples are shown in Fig. 1. The study involved a comparative experiment to monitor the decline in selected performance properties of a specific type of textile product following repeated washing. Conversely, the study does not aim to examine the influence of material composition or the structural parameters of knitted fabrics on their performance properties. For this reason, neither the material composition nor the structural parameters of the knitted fabrics were experimentally verified, nor were the manufacturers of the knitted fabrics monitored. 0.7 m of each knitted fabric was available at full production width (145-150 cm), i.e., approximately 1 m^2.

For visual evaluation of aesthetic changes in the seam area, samples (one from each knitted fabric) were prepared with one transverse edge finished with a simple hem (20 mm wide) and the other with a sewn-on cuff (25 mm wide) – see Fig. 2(a,b). Marks

Table 1. Specifications of knit fabrics according to the e-shop.

No.	Material	Mass per unit area [g/m^2]	Additional information
MP_1	62% cotton/33% polyester/5% elastane	250	Sustainable product: contains 62% recycled cotton
MP_2	70% cotton/ 30% polyester	260	Öko-Tex® Standard 100 for children up to 3 years old
MP_3	95% cotton/5% elastane	250	Öko-Tex® Standard 100 for children up to 3 years old
MP_4	95% cotton/5% elastane	245	Öko-Tex® Standard 100 for children up to 3 years old, BIO
MP_5	80% cotton/20% polyester	280	-
MP_6	95% cotton/5% elastane	210	Öko-Tex® Standard 100 for children up to 3 years old

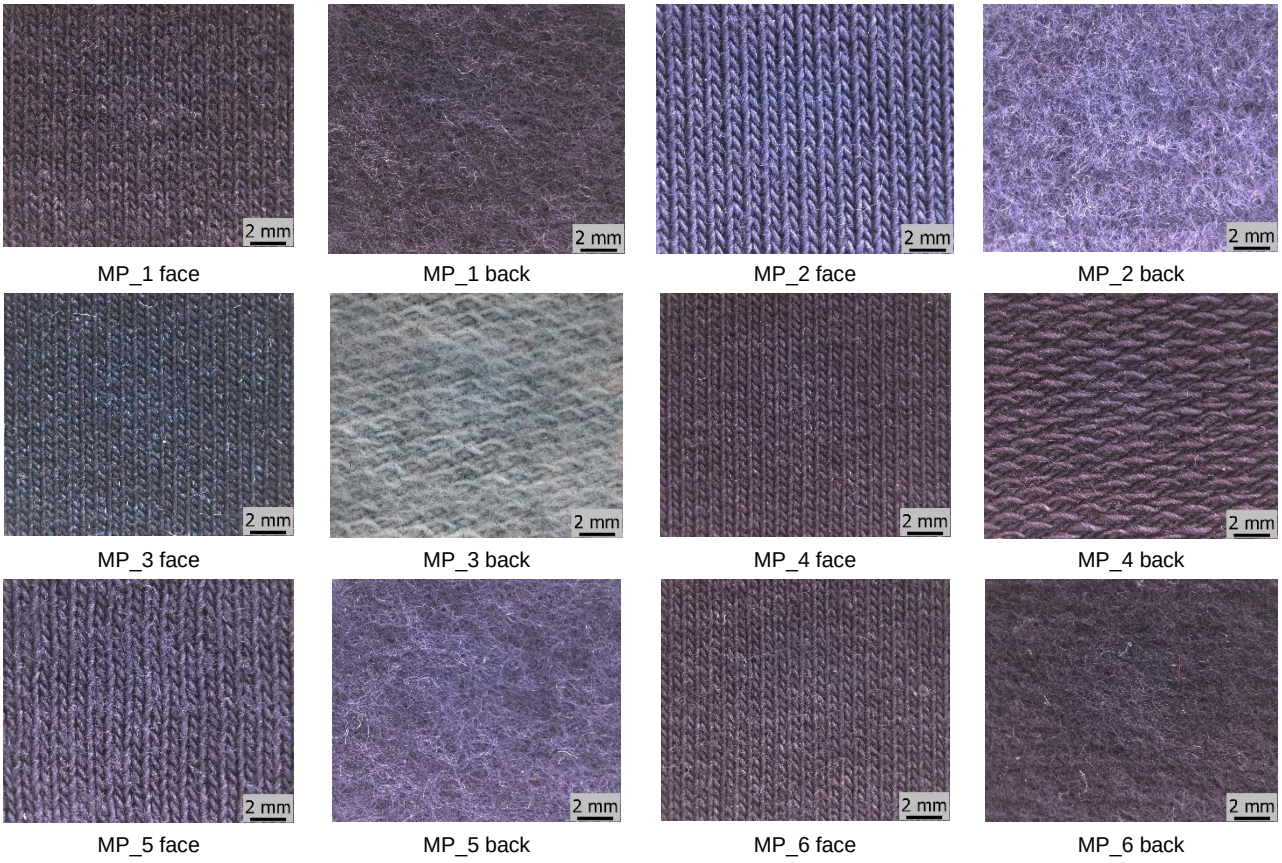


Figure 1. The face and back sides of the tested fabrics (new samples, without washing).

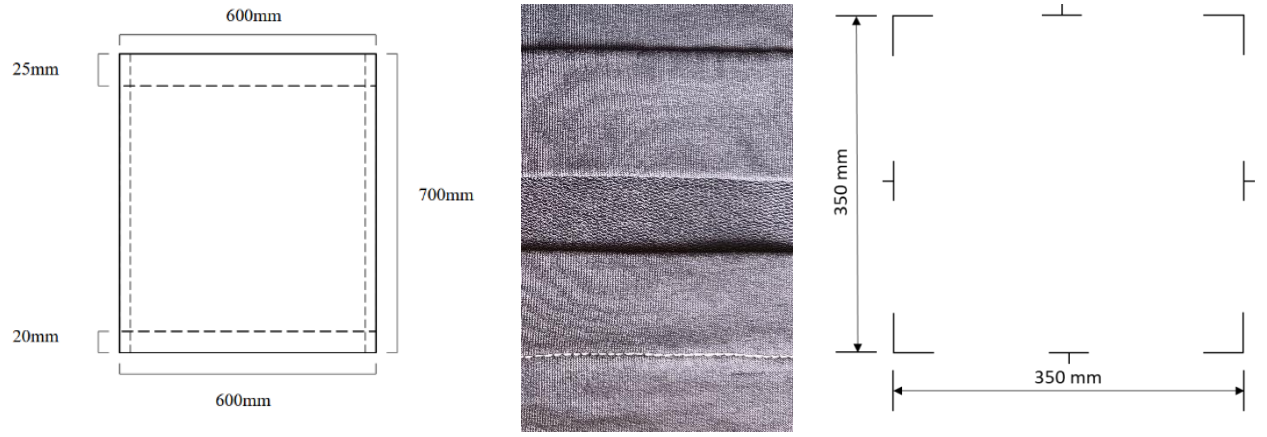


Figure 2. Sample preparation: a, b – seams along the edges, c – scheme for measuring the dimensional changes after washing.

were drawn on each sample to evaluate dimensional stability in accordance with ISO 3759 – see Fig. 2(c). The remaining knitted fabric was gradually used to prepare samples for pilling testing. After 0, 1, 5, 10, 20, and 30 washing cycles, two samples were cut: one was tested, and the other was used for rubbing against the same fabric.

Methods

Some earlier studies [26-27, 33, 44-46] have identified the main reasons why consumers stop wearing their clothes. When it comes to physical durability, the following issues consistently rank among the top causes: loss of shape/changes in size (shrinking or expanding), loss of color, holes, and pilling. These key properties were therefore monitored in our experiment on fabrics exposed to 1, 5, 10, 20, and 30 washing cycles. The washing conditions were selected to simulate a standard domestic wash. All tested samples were washed together. For washing, a Miele Professional W 6071 washing machine was used with settings for gentle washing at 40 °C, 3 rinses, and 1,000 rpm, for a total time of 50 min. Regular Ariel Color liquid detergent

was used – 30 ml for approximately 2 kg of laundry (the tested samples were supplemented with two dark cotton T-shirts). Air-drying was conducted under laboratory conditions; the samples were hung as in a home setting.

Dimensional change after washing was determined using the diagram corresponding to ISO 3759 (see Fig. 2 c) and in accordance with ISO 5077, except for the drying position – hanging rather than lying flat. One sample with a schematic drawing was available for each knitted fabric.

Color change after washing was carried out in accordance with ISO 105-A05 using a Konica Minolta CM spectrophotometer. The obtained color difference values dE^*_{ab} (D65) were converted to grey scale degrees using a conversion table provided in ISO 105-A05. Measurements were performed three times at different locations on the washed knitted fabric. Changes in color at the seams were evaluated visually using a grayscale – the resulting values were determined based on the consensus of three evaluators.

The samples were visually inspected on an ongoing basis for holes in the knitted fabric or in the seam.

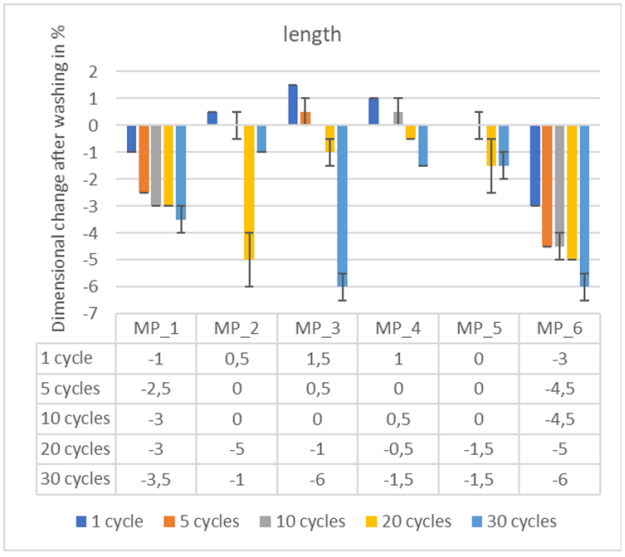
Pilling resistance was evaluated in accordance with ISO 12945-2 using a Martindale M235 tester. The degree of pilling was assessed by visual comparison with reference standards according to the classification scale specified in ISO 12945-2. The surface of the knitted fabrics was evaluated after each pilling phase – up to a total of 7,000 revolutions – by a single evaluator using a uniform procedure for all tested samples. The average value of the values obtained during the individual pilling phases was used as the material characteristic. This procedure was chosen with the aim of obtaining a single characteristic value for each knitted fabric, while also taking into account their scores from the individual testing phases.

RESULTS AND DISCUSSION

Dimensional changes after washing

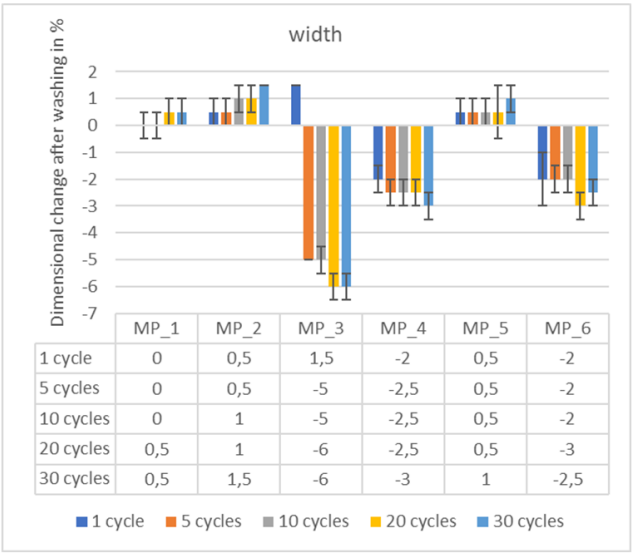
A fabric is a structurally complex material composed of fibers and air pores. As a result of external factors, such as mechanical stress or exposure to heat and moisture, changes may occur within the textile that cause the garment to change in size or shape over time. Shrinkage within a range of +/- 5% is generally tolerated. What does this mean in practice? For example, if a men's sweatshirt is 60 cm wide under the armholes and the fabric shrinks 5% in width, the width of the sweatshirt will decrease by 3 cm, which is more than one ready-to-wear size (assuming the sizes are graded in 4-cm increments around the circumference). This can be a problem for consumers and a reason to discard the garment. The results of the evaluation of dimensional changes after washing of our tested samples are presented in Fig. 3.

In Fig. 3, the averages from three measurements of three characteristic dimensions, in accordance with the diagram in Fig. 2(c) (right side, vertical middle, left side; top side, horizontal middle, bottom side), along with their corresponding standard deviations, are shown. The results indicate that dimensional changes after washing may be problematic for consumers in some samples (MP_2, MP_3, MP_6), and that these changes do not occur only after the first or fifth wash cycle but may also occur after a longer period of use. Therefore, it is not sufficient to evaluate only the fabric's initial quality. From a durability perspective, it is necessary to monitor changes in its performance characteristics over time/over the number of washing cycles.



	MP_1	MP_2	MP_3	MP_4	MP_5	MP_6
1 cycle	-1	0,5	1,5	1	0	-3
5 cycles	-2,5	0	0,5	0	0	-4,5
10 cycles	-3	0	0	0,5	0	-4,5
20 cycles	-3	-5	-1	-0,5	-1,5	-5
30 cycles	-3,5	-1	-6	-1,5	-1,5	-6

(a)



	MP_1	MP_2	MP_3	MP_4	MP_5	MP_6
1 cycle	0	0,5	1,5	-2	0,5	-2
5 cycles	0	0,5	-5	-2,5	0,5	-2
10 cycles	0	1	-5	-2,5	0,5	-2
20 cycles	0,5	1	-6	-2,5	0,5	-3
30 cycles	0,5	1,5	-6	-3	1	-2,5

(b)

Figure 3. Dimensional changes after washing in %: (a) length (wale direction), (b) width (course direction).

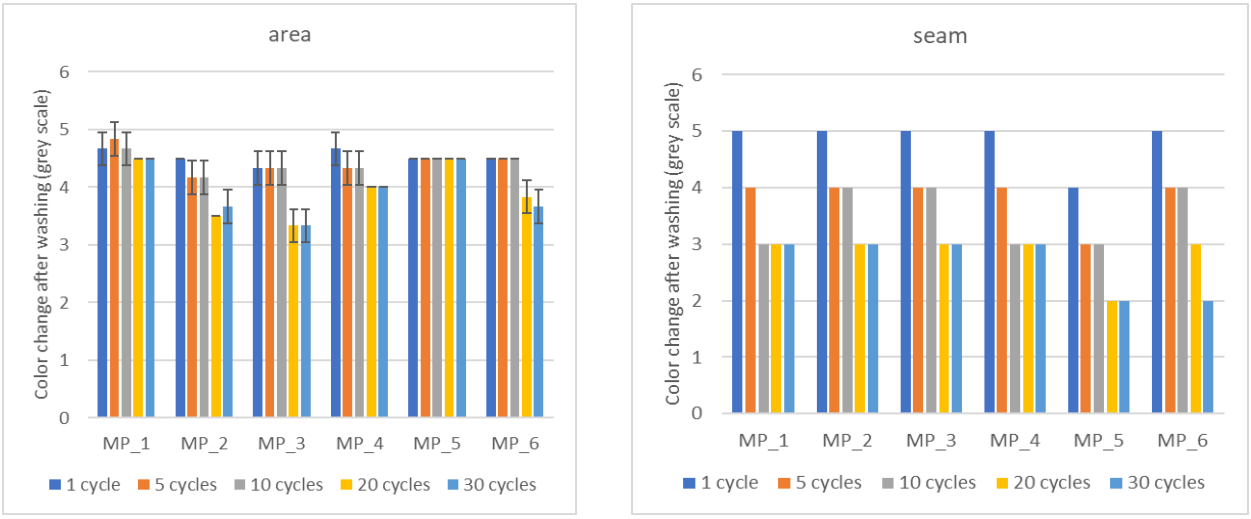
Color fastness after washing

Color fastness refers to the ability of a textile fabric to retain its original color intensity for as long as possible. Changes in color intensity occur not only as a result of washing but also due to other factors, such as perspiration, sunlight, or ironing. Moreover, these changes may not be uniform across the entire product. This unevenness is often the reason a garment is discarded, with problem areas typically including the seams, which are subjected to greater mechanical stress during washing. A change in color intensity across the entire product may not be perceived by the consumer as an aesthetic defect for an extended period, given the lack of a reference sample showing the original color. However, if a more pronounced loss of color intensity occurs in certain parts of the product compared to others, this aesthetic defect becomes obvious. For this reason, the color fastness of our samples was evaluated both across the general surface and at the seams. The results of both tests are presented in Fig. 4 (expressed in degrees of the grey scale). Fig. 4(a) shows the average values from three measurements and the corresponding standard deviations; Fig. 4(b) shows the values obtained based on the consensus of three evaluators.

The results in Fig. 4 show that, particularly in the seam area, significant aesthetic changes occur after just 10 wash cycles. Regarding aesthetic changes in the seam areas, relatively significant changes occur in the tested samples MP_1, MP_4, and MP_5 as early as the tenth wash cycle – the rating corresponds to grade 3 on the grey scale. Sample MP_5 appears to perform the worst in this respect, even though it achieved the best results for color fastness across the knitted fabric surface – see Fig. 4(a). Sample MP_6 retains its original color relatively well up to the tenth wash cycle; however, after the twentieth cycle, it deteriorates significantly in this regard – both across the surface and at the seams. Sample MP_3 shows a similar pattern.

The deterioration of the tested samples in the hem area after 30 wash cycles is shown in Fig. 5.

No holes were found in any of the tested samples, even after 30 wash cycles.



(a) (b)

Figure 4. Color changes after washing: (a) in the general surface, (b) area surrounding the seams.



Figure 5. Tested samples after 30 washing cycles (from left MP_1, MP_2, …, MP_6).

Pilling resistance after washing

Pilling is an undesirable but natural property of textiles that manifests as tiny spherical structures (pills) forming on the surface of the material due to mechanical stress from contact with other surfaces. From the consumer's perspective, pilling is an aesthetic defect. However, the decline in aesthetic qualities occurs even before a pill is fully formed. Even the initial stages of pill formation – in the form of loose fibers on the fabric's surface and their gradual clumping – disrupt the "flawlessness" of the fabric's smooth surface and may be perceived by consumers as a reduction in the product's aesthetic value. The decision about when to stop wearing a particular item of clothing is a very personal matter for each consumer. The results of the pilling resistance test are shown in Fig. 6. For each knitted fabric, only one test sample was available after each washing stage. In addition to the washed samples, this test was also performed on new samples. Fig. 7 shows photographs of changes in the surfaces of the knitted fabrics resulting from 20 wash cycles alone (without pilling on the Martindale machine).

Based on the results shown in Fig. 6, sample MP_1 appears to be the most problematic in terms of pilling; at the same time, it is evident that its significantly poorer results compared to the other samples only become apparent after it has undergone one or more maintenance processes. This is very important from the perspective of comparative testing and once again highlights the need to evaluate physical durability over time and after maintenance, rather than merely as the "initial quality" of a new fabric. The photographs shown in Fig. 7 clearly reveal relatively significant changes (wear) caused by washing on the surface of the knit fabric on the right side of samples MP_1, MP_3, and MP_6, and on the back side of the brushed samples MP_2 and MP_5. Changes to the back side are not primarily an aesthetic flaw in the garment, but they can alter its sensory and thermal insulation properties.

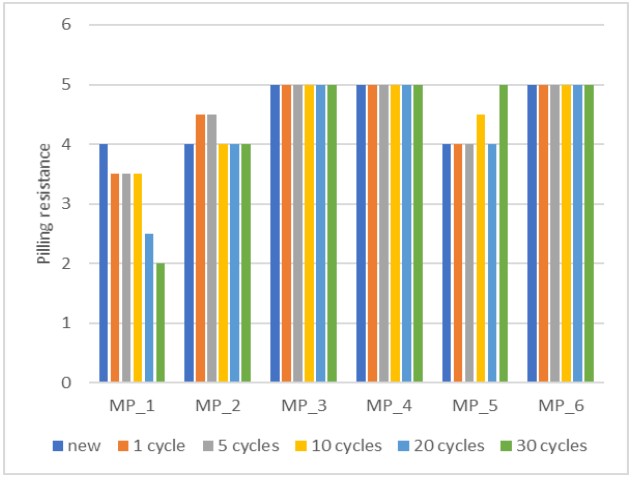


Figure 6. Pilling resistance after washing.

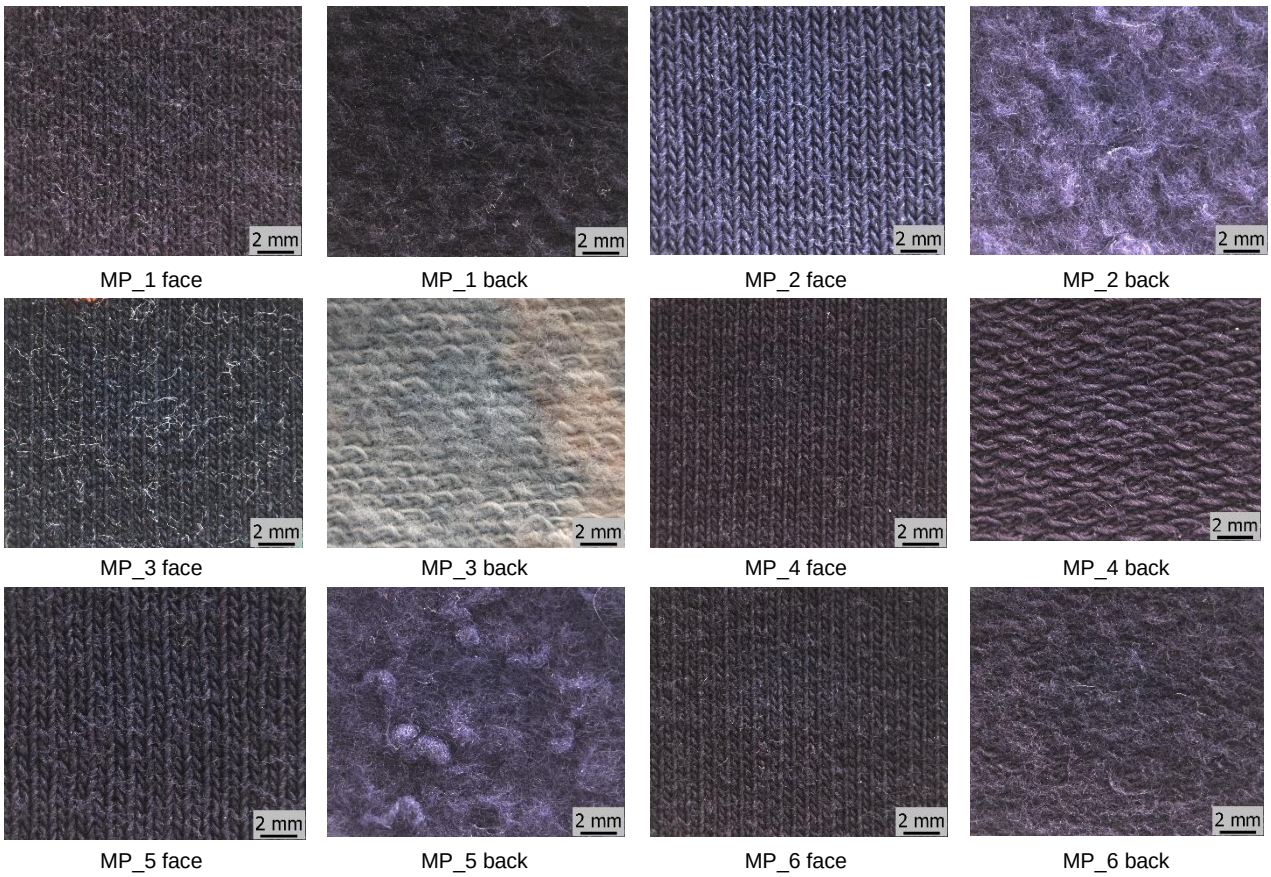


Figure 7. The face and back sides of the tested fabrics (after 20 washing cycles).

Assessment of the durability of the tested samples

The results presented above indicate that the tested knit fabric samples exhibit variable performance across the evaluated parameters. None of them is unequivocally the best when all monitored properties are taken into account.

The color fastness after washing and drying, and the resistance to pilling are benefit functions (more is better), while the dimensional changes after washing and drying are cost functions (less is better). Therefore, the dimensional stability results were redesigned to adopt a "more the better" approach, as introduced in Table 2.

Now, it is evident that sample performance varies with the number of wash cycles. A comparison of the results shown in Fig. 8 reveals that, while differences in the performance of the tested samples are relatively minor after one wash cycle, significant variations in quality become apparent after twenty or thirty cycles.

Assessing the durability or quality of clothing using a single summary parameter is the subject of both earlier studies and upcoming EU legislation, and the methodologies involved vary in complexity [3-4, 31, 33, 39-41]. Based on equation (1), the durability DUR_m [-] of the evaluated knitted fabric samples after the *m*-th washing can be assessed, in its simplest form, using a basic quality index expressed as the weighted arithmetic mean of the performance across all monitored parameters:

$$DUR_m = w_{DL}x_{DLm} + w_{DW}x_{DWm} + w_{CA}x_{CAm} + w_{CS}x_{CSm} + w_{RP}x_{RPm} \quad (2)$$

where x_{im} is the score for the *i*-th quality parameter after the *m*-th wash cycle; that is, x_{DLm}, x_{DWm}, x_{CAm}, x_{CSm}, and x_{RPm} are the values for dimensional stability in the width direction, dimensional stability in the length direction, color fastness in the area of fabric, color fastness in the seam area, and resistance to pilling after *m*-th washing, respectively, and w_{DL}, w_{DW}, w_{CA}, w_{CS}, w_{RP} are the corresponding weights expressing the importance of the individual quality parameters of a given product to consumers. The sum of all weights equals 1. In the context of the suitability for use of our evaluated samples – for sweatshirts and sweatpants – and the discussions mentioned above, the weights were set as shown in Table 3. The weights were determined based on the assumption that the parameters of dimensional stability, color fastness, and pilling resistance are equally important for a sweatshirt-type product – i.e., a weight of 0.33. For the dimensional stability and color fastness parameters, this value was subsequently subdivided into length/width and surface/seam components; specifically, a dimensional change in the width direction was assigned a slightly higher weight than one in the length direction, and color changes at the seams were assigned a slightly higher weight than those on the surface. The weights established in this manner should be viewed as an expert estimate specific to the product type in question, based on the discussions presented above, and cannot be generalized without further studies. At the same time, it should be emphasised that the weight coefficients significantly affect the final scores for the durability of the compared knitted fabrics, as calculated according to equation (2).

The results shown in Fig. 9 and in Table 4 indicate that sample MP_3 has the best overall rating after the first washing but rapidly loses performance relative to the other samples during subsequent washing cycles. After 30 washing cycles, it is already the lowest-rated product, along with sample MP_1. Sample MP_1 still shows results comparable to the other samples after 5 wash cycles, but begins to lag behind starting with the tenth wash cycle. Samples MP_4 and MP_5 exhibit the best and most stable quality, although sample MP_5 had the lowest rating after the first wash.

These results show that, in addition to defining key parameters of the physical durability of textile products, it is essential to pay close attention to the design of their simulated aging protocols, as deterioration dynamics can vary significantly both across the physical durability parameters under study and across the tested textile samples. The true durability of the product – which is very important for assessing its environmental impacts – may not become apparent until after 20 or 30 wash cycles. In any case, it is insufficient to evaluate only the "initial quality" of a new or once-washed textile. In our experiment, the sample MP_1, sold as a "sustainable product" due to its recycled cotton fiber content, showed one of the worst results in the physical durability tests performed.

Table 2. Scale for evaluating the degree of dimensional stability.

Score	1	2	3	4	5
Dimensional change x [%]	8 ≤ |x|	6 ≤ |x| < 8	4 ≤ |x| < 6	2 ≤ |x| < 4	0 ≤ |x| < 2

Table 3. The weights of tested parameters.

Parameter	Dimensional stability (length)	Dimensional stability (width)	Color fastness (area)	Color fastness (seam)	Pilling
Weight	0.13	0.2	0.13	0.21	0.33



Figure 8. Test results after 1, 10, 20, and 30 washing cycles, dimensional stability expressed using the scale from Table 2.

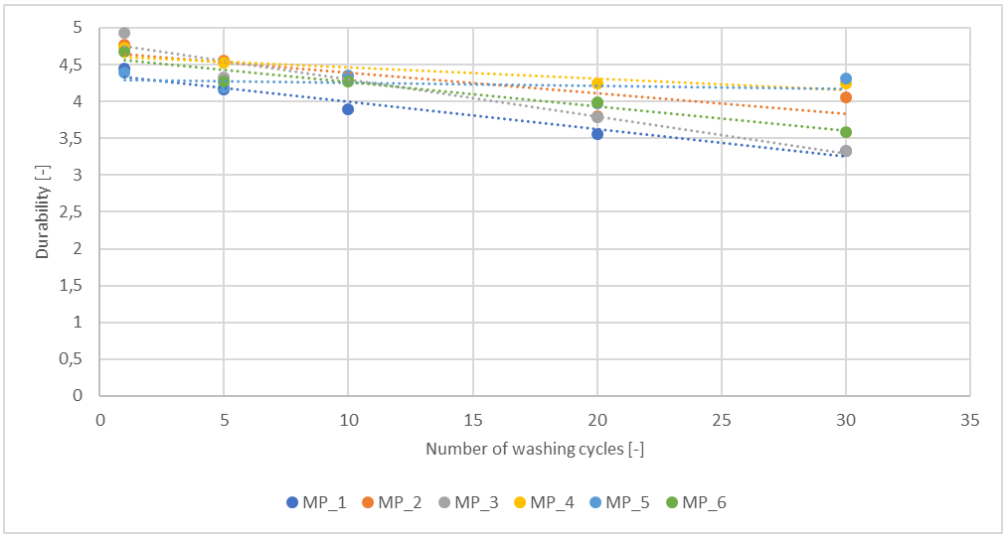


Figure 9. The durability of the tested samples.

Table 4. Evaluation of the obtained data by linear regression; R^2 is the coefficient of determination; $m \leq 30$.

No.	Equation	R^2	No.	Equation	R^2
MP_1	DUR = -0.037*m + 4.368	0.96	MP_4	DUR = -0.015*m + 4.614	0.71
MP_2	DUR = -0.028*m + 4.671	0.72	MP_5	DUR = -0.004*m + 4.302	0.10
MP_3	DUR = -0.050*m + 4.802	0.94	MP_6	DUR = -0.033*m + 4.589	0.93

CONCLUSIONS

The assessment and regulation of the physical durability of clothing are undergoing a fundamental legislative transformation in the European Union. Durability is evolving from what were originally voluntary or passive minimum standards into a mandatory, measurable, and regulatory-enforced parameter. The ESPR Regulation [18] establishes a comprehensive legal framework for setting mandatory ecodesign requirements. Within this framework, durability is considered a key performance attribute. The ESPR Regulation integrates durability into both mandatory design requirements and provisions regarding consumer information. It provides an explicit definition of durability as a product's ability to maintain its function and performance over time under specified conditions of use, maintenance, and repair. This definition is intended to serve as the basis for subsequent regulatory mechanisms designed to operationalize durability across product groups. The specification of requirements for individual product categories is proceeding gradually, with the clothing and footwear category ranked as a high priority for action. A structured approach is envisaged, based on standardized tests and simulations of the aging process, which serve to quantify the loss of performance characteristics for key parameters such as dimensional changes, pilling, colorfastness, and others.

At the same time, it is necessary to find a simple way to communicate that consumers can easily understand. Using parameters that consumers themselves perceive as important for the physical durability of clothing is a very effective approach. However, while defining the parameters of a garment's physical durability is relatively straightforward, determining their importance is a highly individual matter for each consumer. Furthermore, it can be assumed that the importance of individual performance parameters of a textile product will vary not only with each consumer's personal preferences but also with the type of product in question. While dimensional changes are a more common problem with knitted products, such as T-shirts, pajamas, or socks, pilling is a typical problem with hoodies or sweaters, and color changes along seams are particularly noticeable in shirts or polo shirts. Further research must therefore also focus on understanding consumer preferences across different product types.

It will therefore be essential for the procedures for assessing the physical durability of textile products to include all three integral components:

- Determination of key physical durability parameters for the product in question
- Determination of the significance of each of these parameters, taking into account both prevailing consumer preferences and the type of product being assessed
- Determination of a simulated deterioration protocol that accounts for both key parameters and product type, and consumer preferences

And, of course, the cost of testing, which ultimately impacts the product price, must also be taken into account. More testing means higher costs.

Our study is limited in scope and therefore does not aim to generalize the findings. These limitations include, above all, the limited number of only 6 knitted fabrics compared, the number of samples tested (only 1-3 samples per test), the number of tested parameters (e.g., abrasion resistance is not included in the evaluation), the simplified determination of the weights of the tested parameters based solely on expert estimation, the simplicity of the calculation of the summary parameter DUR_m, the range of monitored wash cycles up to 30, and the fact that the simulated deterioration of the samples is limited solely to the washing process. However, our results, based on a specific product example, show that assessing the physical durability of textile products is a complex, multifaceted issue involving multiple variables. All of these variables should be given due consideration before the reporting of textile product durability becomes a mandatory legislative requirement.

The task now facing the professional community is to gain a proper understanding of consumer behavior patterns and the products themselves, ensuring that requirements for testing and verifying textile durability are as effective as possible – meaning they reflect real environmental efficiency, are understandable to consumers, and entail reasonable costs.

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