sustainability

MDPI

Article

Dynamic Fit Optimization and Effect Evaluation of a Female Wetsuit Based on Virtual Technology

Xinzhou Wu [1,2], Zhe Cheng [1,2,*] and Victor E. Kuzmichev [1,3]

1 School of Fashion, Wuhan Textile University, Wuhan 430073, China
2 Wuhan Textile and Clothing Digital Engineering Technology Research Center, Wuhan 430073, China
3 Institute of Textile Industry and Fashion, Ivanovo State Polytechnic University, 153000 Ivanovo, Russia
* Correspondence: zcheng@wtu.edu.cn

Abstract: At present, the traditional mode of research and development for mass-produced wetsuits usually requires repeated sample making and try-on evaluation, and performance cannot be predicted, monitored and evaluated in real time; this can lead to problems including low material utilization and production efficiency. In this study, real human body static and dynamic measurements, material properties and structure data are applied through 3D software to build an accurate virtual model, and new wetsuits are designed through simulation, optimization and evaluation. The static and dynamic fitting performance above and underwater is comprehensively evaluated in virtual and real environments, and it is proved that the virtual development mode can accurately and effectively guide the development and evaluation of wetsuits, and can meet personalized comfort and functional requirements today. This simulation evaluation method avoids repeated sample preparation, some unnecessary waste of materials and environmental pollution, and improves manufacturing efficiency.

Keywords: female wetsuit virtual design; evaluation; R&D efficiency

check for updates

Citation: Wu, X.; Cheng, Z.; Kuzmichev, V.E. Dynamic Fit Optimization and Effect Evaluation of a Female Wetsuit Based on Virtual Technology. *Sustainability* **2023**, *15*, 2197. https://doi.org/10.3390/su15032197

Academic Editors: Tin-Chih Toly Chen, Chengyi Hou, Yun Su and Rui Li

Received: 16 December 2022
Revised: 17 January 2023
Accepted: 22 January 2023
Published: 24 January 2023

1. Introduction

There are many diving clubs around the world, and millions of people participate in scuba diving every year. PADI has issued more than 28 million diver certifications since 1967 [1,2]. There are more than 1300 registered diving clubs in China, and according to statistics from the China Underwater Association (CUA) in 2020, the number of people participating in diving activities in China is more than 8 million. The wetsuit is the most common type of diving activity clothing and is helpful to divers underwater for insulation, protection and dynamic fit and function. A correct shape ensures optimal thermal conditions. A wetsuit that is too loose will allow too much water to circulate over the diver's skin. A wetsuit that is too tight is very uncomfortable and can impair circulation. Therefore, the wetsuit must fit the diver's body shape adequately. Currently, more than 60% of Chinese diving enthusiasts are females under 30 years old, and 58% of purchasers of diving goods are female; female and elderly divers attach great importance to the functionality of wetsuits [3].

At present, most common wetsuit products on the market have problems such as poor fit (too loose or tight, water accumulation in the crotch), poor sports function (sports restriction), and poor thermal insulation. This is because there are few products based on scientific research, and the majority of mass-produced wetsuit products fail to meet users' requirements for good function and comfort. More than half of females with diving experience from the Chinese diving online community experience feeling uncomfortable while wearing wetsuits. They report the order of commonly misfitting areas underwater as: shoulder (25.5%), waist (15.7%), upper arm (15.4%), bust (12.6%), and crotch, legs, and others (30.8%), mainly concentrated in the maximum activity area of the upper body parts. They are willing to improve the wetsuit design or customize it for their body morphologies. The shoulder area is a more complex part of the wetsuit and needs to be more deeply studied in terms of ergonomics, design, and textile material applications. As people's fit needs become more diversified and personalized, it is essential to study the mode of design and development of functional clothing and its performance evaluation, so that people in different conditions can work and live safely, healthily and comfortably [4].

However, the traditional way of developing wetsuits is still the mainstream research method, mainly using traditional modes of 2D pattern drawing, sample making, and subjective evaluation by real people or model dummies trying them on [5,6]. It is difficult for wetsuit enterprises using these traditional development methods to predict product problems before actual manufacturing or to cope with small batch or personalized wetsuit designs. They cannot respond quickly or even receive consumer feedback to identify problems, and this often results in wetsuit products with structural and functional problems in the market.

In addition, serious problems such as low resource utilization, excessive energy consumption, and high production costs are prevalent [7]. For example, the middle layer of wetsuit material is mainly neoprene; its main component, polychloroprene, does not meet the Global Recycling Standard (GRS), its mechanical recovery is limited, and a large amount of hydrogen chloride is produced in the process of recovering chemicals through pyrolysis or energy recovery through combustion [8,9]. Therefore, using wrong samples and waste textile materials in the design process causes pollution and recycling problems. Only by solving these problems mentioned above can we achieve maximum use of our products and reduce the number of low-quality products, and this will also contribute to the good development of the human environment.

The application of virtual technology in light industry in recent years aims to solve these problems; the technology of virtual and real fusion simulation methods can be used for reference. The "fusion" data of the virtual and real world can accurately and effectively guide the virtual development and evaluation of wetsuits, reducing costs and resource waste [10]. Constructing a garment design simulation and evaluation system based on virtual and real fusion can avoid repeated prototype development, accelerate product manufacture, and enhance control and quality of research and development [11,12]. Current wetsuit construction always draws and creates lines directly on the surface of a digital model and then converts 3D surfaces into 2D cutting parts, then uses 3ds Max, Optitex, and other software to carry out virtual design and trying on of the wetsuit [13–16]. High-precision 3D body scanning technology is used to construct human body models, obtain accurate measurements and analyze key body parts [17–19]. This is crucial for creating clothing with strict fit standards. However, most existing studies have only scanned the human body in the standing position, and could not accurately reflect the dynamic wetsuit during some actions. Until now, no relevant schemes based on motion ergonomics, virtual and real design and comfort functional evaluation on the floor and underwater have been proposed.

In this study, a virtual human body and wetsuit were established based on 3D body scanning technology and virtual software. The new optimized wetsuit was designed based on female characteristics, and compared with existing wetsuit products in terms of structure and function. The fit performance of the optimized wetsuit was tested and analyzed through static and dynamic simulation, and positive results were obtained. This research process can be applied to wetsuit design and evaluation. This study provides an effective and feasible new method to replace the traditional design mode of wetsuits; it also provides scientific support for wetsuit enterprises' design and production from the perspective of practical application, and improves the objectivity and accuracy of evaluation.

2. Materials and Methods

2.1. Methods and Procedures

In order to solve the structural problems of wetsuits in the market, an efficient design and development mode is proposed. On the one hand, it improves the motion function and comfort of the wetsuit, and on the other hand, it improves the traditional development model through the virtual design process. Finally, the validity of the results is verified by subjective and objective evaluation, as shown in Figure 1.

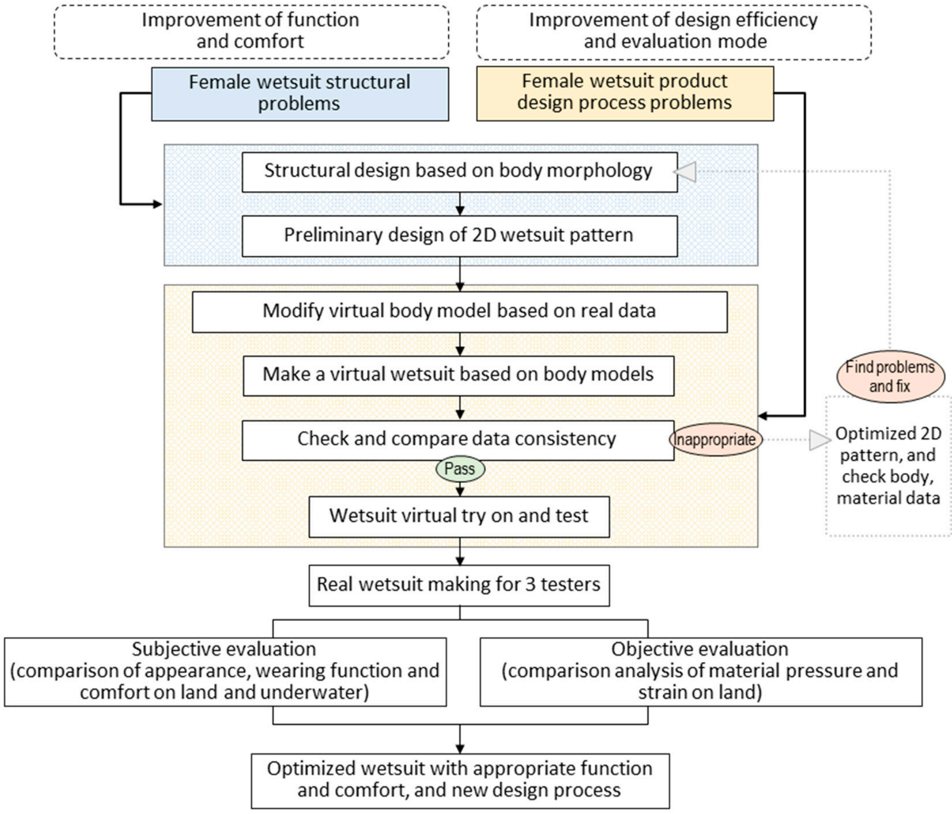
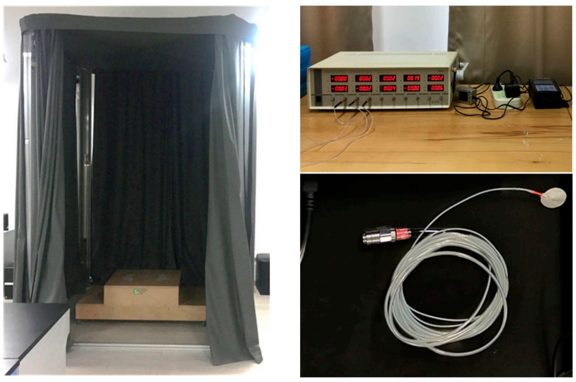


Figure 1. Experimental scheme.

The whole experiment was divided into two parts: real and virtual. The two parts respectively include research on the characteristics of the material, human body and wetsuit.

In the virtual experiment part, we built primary human body models to create a body database with the 3D scanner (Human Solutions VITUS Smart XXL, Figure 2a), and imported them into CLO and 3ds Max software to further modify the soft tissue according to its changes in dynamic positions [20]. Then we simulated material performance, conducted wetsuit modeling, and analyzed the model wetsuit's performance using 2D and 3D methods. Finally, the new wetsuit design method is obtained.



(**a**) (**b**)

Figure 2. Main experimental equipment: (**a**) VITUS smart XXL body scanner; (**b**) AMI 3037-10 air-bag sensors.

In the real experiment part, we made real wetsuit products according to the simulation results to verify their consistency. Data analysis and subjective and objective evaluations of the wetsuits' appearance under multiple postures were carried out. The objective values were measured using AMI 3037-10 air-bag sensors (Figure 2b), and a subjective evaluation of try-on feeling was carried out according to the Likert Scale, including a set number of responses for the testers to choose from (Table 1).

Table 1. Grade evaluation form.

Grade	Evaluation	Detailed Explanation
1	Very highly dissatisfied	Very loose, not close to the body, or other uncomfortable feelings; extremely tight feeling and movement restricted
2	Highly dissatisfied	Loose, not close to the body or other uncomfortable feelings; very tight feeling and movement restricted
3	Dissatisfied	Loose, just close to the body or other uncomfortable feeling; tight feeling and movement restricted
4	General	Close to the body, but needs tighter; can perform some movements normally in medium range
5	Satisfied	Close to the body, but needs tighter; can perform most movements normally in medium range
6	Highly satisfied	Tight, but comfortable pressure feeling; can easily perform most movements in large range
7	Very highly satisfied	Very tight feeling, but very comfortable pressure; can easily perform all kinds of movements in large range

2.2. Data Collection and Investigation

96 females (aged 18 to 27) from central China volunteered to participate in a body scanning test. All measurements were taken under the ISO 7250 standard. The total number of main measurements in static and dynamic postures, which can be used for pattern design, was 42. The participants' heights ranged from 147.3 to 173.6 cm, and the main measurements are shown in Table 2. SPSS was used to test the normality of data, proving that measurements obey the normal distribution with Cronbach's α of 0.974.

Table 2. Average of main measurements.

Measurements	Avg. S.D., cm
Bust girth (BG)	83.9 ± 4.7
Waist girth (WG)	69.5 ± 7.5
Hip girth (HG)	90.5 ± 5.3
Bust height	115.7 ± 7.8
Maximum belly circumference height	93.8 ± 5.8
Waist height	100.7 ± 6.5
Buttock height	80.5 ± 5.2
Upper arm length	30.0 ± 1.7
Shoulder length	12.5 ± 1.1
Neck front (FNP) to waist	31.1 ± 3.3
Neck back (BNP) to waist	36.1 ± 3.2
Side upper torso length	19.0 ± 2.1

2.3. Wetsuit Materials

Wetsuit material is specialized with three layers: the outside and inside layers are elastic weft knitted materials, and the middle is foam rubber (Figure 3). At present, there are various types of wetsuits made of different materials (nylon, Lycra, etc.) in the market; the most commonly used outside/inside materials are Lycra and nylon, but the price of Lycra is much higher than nylon. The names of widely used foam rubbers are abbreviated as "CR", "SCR", and "SBR" [21]. Chloroprene-rubber (CR) is a kind of synthetic rubber that is also known by the trade name Neoprene, with good performance of soft hand, thermal protection, and elasticity. This is the main material for making high-level wetsuits [22]. Styrene-butadiene rubber (SBR) is suitable for low-level wetsuits. Styrene-chloroprene rubber (SCR) is a combination of CR and SBR with good flexibility; its elasticity and comfort vary according to the proportion of CR used, and it is the most frequently used material in the market.

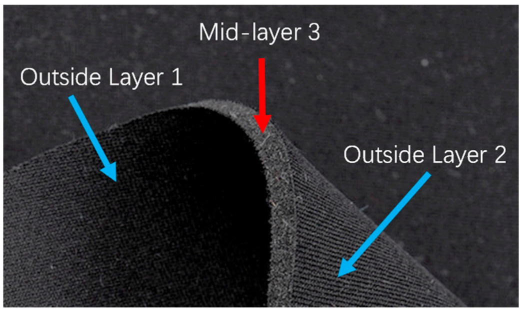


Figure 3. Experimental fabric structure of layers.

Two commonly used wetsuit materials on the market, named M1 and M2, are selected for the experiment, and the details of their composition are shown in Table 3.

Table 3. Experimental wetsuit materials.

No.	Face/Wrong Layers (Outside Layer 1, 2)	Middle Layer (3)	EMT * (%)
M1	Polyester/Polyester	100% CR	30.17
M2	Polyester/Polyester	SCR (30% CR + 70% SBR)	27.80

* EMT is an index of KES-FB1 material test equipment, the maximum elongation at 500 cN/cm load.

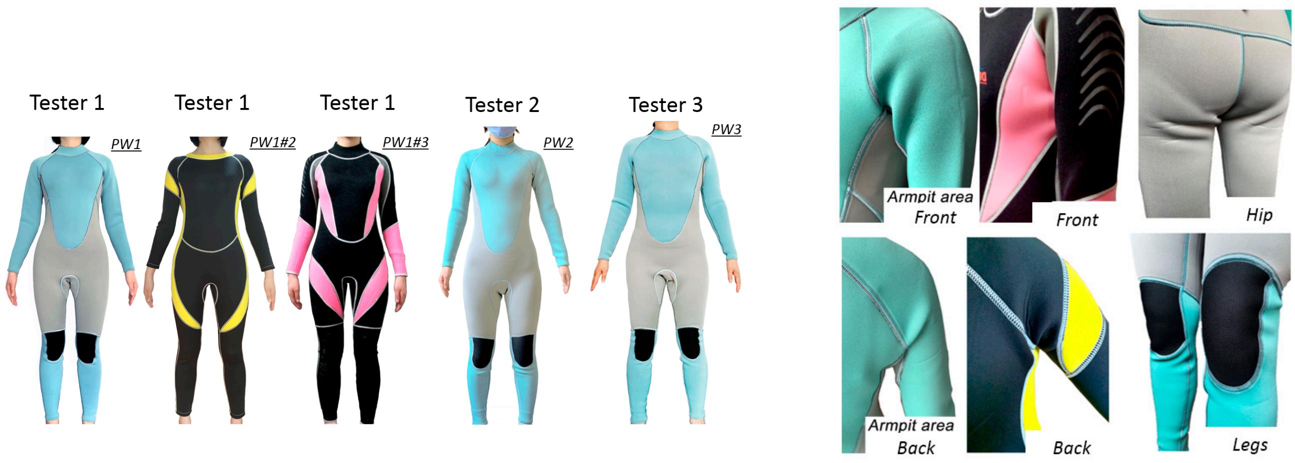
2.4. Existing Problems of Purchased Wetsuits

To find more detailed design problems, five examples of mass-produced wetsuits (PW) (conventional structures, three popular styles) sold by a wetsuit company (China) were purchased. The material has three layers, 3 mm, and the sizes are S—small, M—middle, and L—large, corresponding to the body shapes of the three testers; their body measurements are shown in Table 4. For easy description, the same style of PW was purchased for three testers and named PW1, PW2 and PW3, and the other two styles were purchased only for tester 1, named PW1#2 and PW1#3.

Table 4. Average of testers' measurements (cm).

Measurements	Tester 1	Tester 2	Tester 3
Height	158	157	160
Bust girth (BG)	81	82	86
Waist girth (WG)	62	67	74
Hip girth (HG)	87	91	86.5
Thigh girth	46	52	49
BG front part measuring length	44.9	44	46.4
WG front part measuring length	33.8	35.6	38.3
HG back part measuring length	43.8	48.3	50.4

Figure 4a shows the try-on performance of tester 1 with the three wetsuit styles PW1, PW1#2, PW1#3, and testers 2 and 3 with wetsuits PW2 and PW3. Figure 4b shows the try-on details including some obvious wrinkles.



(**a**) (**b**)

Figure 4. Purchased wetsuit try-on: (**a**) front view; (**b**) details view.

In visual appearance, generally the PW has structural deficiencies and a feeling of low wearing satisfaction while standing. Similar design defects exist in the same places when the three testers try on different wetsuits: extra ease exists on the shoulder, armpit, and so on. Additionally, because of female characteristics, the front upper bust part needs to be tightly compressed by wetsuits to reduce water accumulation. These problems will be optimized and evaluated in the following steps.

3. Results

3.1. Designed Wetsuit Virtual Construction

In order to solve the previously described problems, an optimized wetsuit design approach based on the relationship between dynamic posture change underwater, material properties and pressure sensitivity was proposed in our earlier work [22]. Based on the previous results, in this study, the division lines of the armpit, upper arm and side of the wetsuit are reasonably designed to increase the fit degree of the upper limb movement while satisfying comfort according to the anatomical features and measurements of the human body. The design details are illustrated below.

As shown in Figure 5a, to the wetsuit structure (black line) a value of −16.6% is added on the girths; this is the maximum acceptable comfortable stretch (the max. negative ease) of the wetsuit material on the human body. The wetsuit structure (gray line) has a value from −8 to 0% (the min. negative ease) added on the girths; the minimal negative value is just to make the wetsuit fit, but the maximum negative value is to make the wetsuit as tight as possible within the acceptable comfort range.

The designed wetsuit (DW) pattern was imported into CLO software to construct a virtual wetsuit. The commonly used materials, M1 and M2, were selected to make the DW in this study. The maximum elongation of the materials under 500 cN/cm is 30.2% and 27.8%, and the shrinkage is about 2% and 3%. Due to the particularity of wetsuit material, the default value of elastic knitted material is selected to conduct a simulation in CLO. The thickness (main value) is set to 3 mm, with the following property indicators: “Physical Property”—“Preset” is Knit_Jersey, “Density” is 400 g/m^2 and 460 g/m^2, “Simulation Properties”—“Shrinkage warp” is 100%, “Surface”—“Skin offset” is 0.1 mm. Two tools—“tack” to fix a wetsuit and “sewing” to sew wetsuit pieces—were applied to conduct try-on.

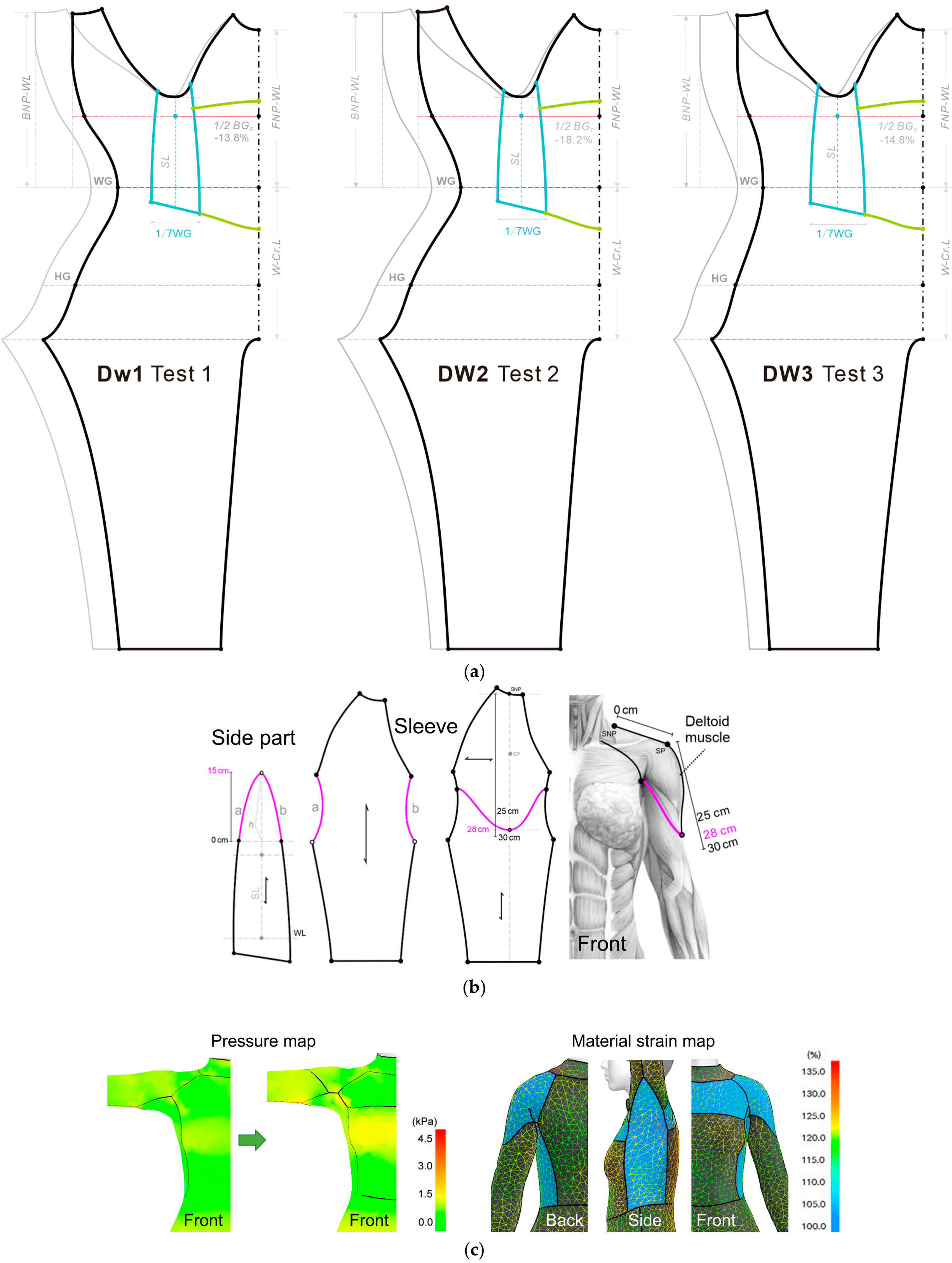


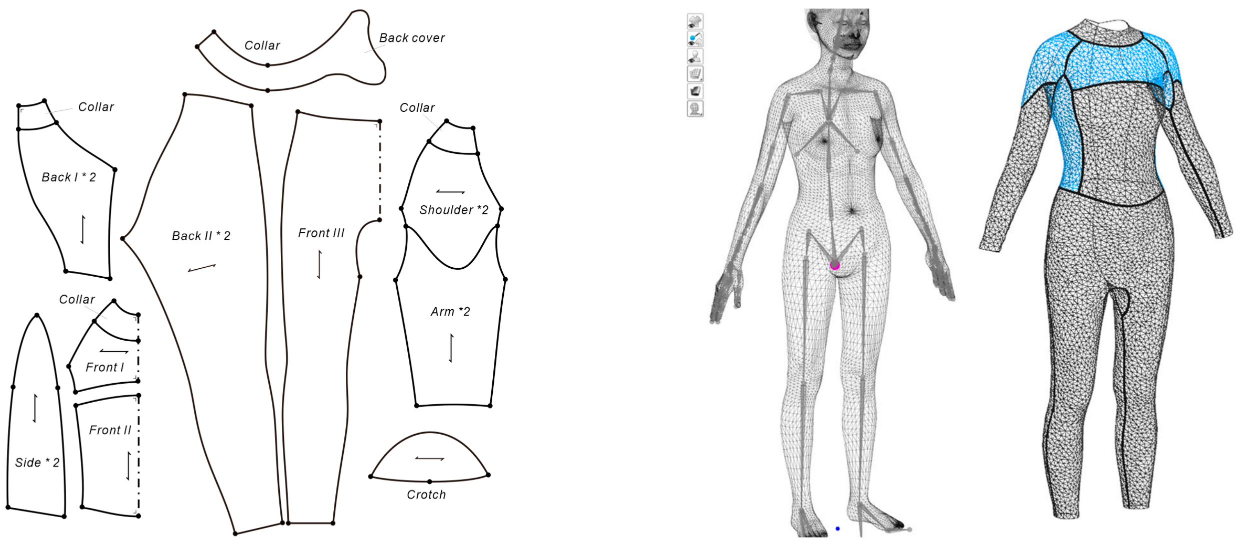
Figure 5. Wetsuit optimization: (**a**) the wetsuit pattern blocks for 3 testers; (**b**) the front yoke and the central part design; (**c**) virtual wetsuit model details in pressure and strain grid.

The torso side (Figure 5a, blue line) is individually divided to provide high fit under the armpit, and to improve the excessive material stretch caused by upper arm movements. The width of the bottom of the side part is designed to be 8–12 cm, approximately oneseventh of the waist girth. The side part to sleeve connection uses a design of bullet type (Figure 5b), increasing armpit flexibility as well as significantly reducing excess ease under the armpit. The raglan sleeve is designed to enhance the fit degree of the shoulder, and the division curve is within the average length 30 cm (the position of the lower deltoid) of the upper arm, which increases the flexibility of the shoulder.

The design has a horizontal division at the bust (Figure 5a, green line), which provides good compression and control of the female bust area. It increases the dynamic tightness of the shoulder and neck parts. According to the average bust height, the additional bust seam is above the BL (bust line), and can be raised along the front center line 0–5 cm. The additional seam curve on the abdomen is below the WL (waist line), and declines 0–8 cm along the front center line.

It can be seen from Figure 5c that the fit degree of the upper bust, arm and abdomen parts are obviously improved in the raised and natural positions based on the above designs. The measured virtual pressure on the bust (when the curve position is 0–5 cm) is from 1.98–1.77 kPa, and on the abdomen it can reach a maximum of 0.67 kPa at 8 cm. The experimental pressure results show that the best design, from the perspective of appearance and objective measurement, includes the curves 3 cm above BL and 8 cm below WL.

After several optimization steps, the DW pattern block is shown in Figure 6a, and a perspective view of the 3D model and wetsuit is shown in Figure 6b.



(**a**) (**b**)

Figure 6. DW: (**a**) pattern blocks; (**b**) 3D wetsuit with human body model.

3.2. Wetsuit Subjective Evaluation

Real DW products in three sizes were also made for the same three testers. They are named DW1, DW2, and DW3. In order to further verify the consistency of the real and virtual wetsuits, the appearance, pressure and strain data were compared.

Figure 7 shows the wetsuit try-on simulation with two materials for three testers.

Figure 7a,c show that the visual appearance was evaluated by testers (tightness, appearance). It can be seen from the appearance that the virtual wetsuits are the same as the real ones; the virtual wetsuit, in standing position, has an appearance of fit and high consistency with the real ones. Figure 7b,d show that the DW is almost without folds, and the design of the shoulder parts is more fitted than those of the previous PW after optimization.

Figure 7. Wetsuit DW: (**a**) virtual DW try-on; (**b**) virtual DW details; (**c**) real DW try-on; (**d**) real DW details.

The virtual and real wetsuits were further compared to check the accuracy and reliability of the virtual design. In a subjective test, the perceptual evaluation of each body part for real PW1, 2 and 3 and DW1(M1), 2 and 3 was rated using the Likert 7-level scale, as shown in Figure 8.

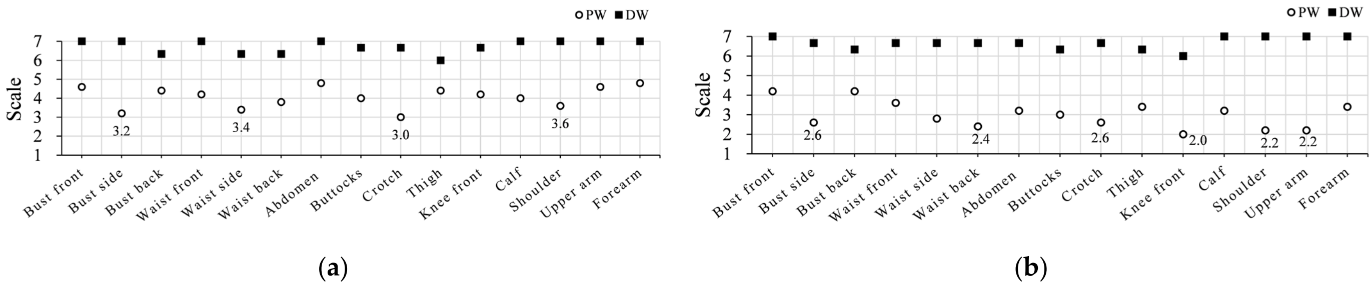


Figure 8. The subjective evaluation results: (**a**) static results; (**b**) dynamic results.

It can be seen from Figure 8 that DW has a high degree of satisfaction, and the wearing comfort has been significantly improved. The results of the static and dynamic (hands up) subjective evaluations indicate that the lower satisfaction ranking points (average is 4.07 ± 0.57 in static and 3.0 ± 0.69 in dynamic) of the PW are mainly found at the front knee (squatting), bust side, waist side, back, shoulder, and upper arm. The average results for the DW are the same, 6.73 ± 0.34 in static and 6.67 ± 0.31 in dynamic positions; the positive evaluation means that the rankings for our wetsuit design are higher than "6—highly satisfied" and significantly higher than the rankings of PW.

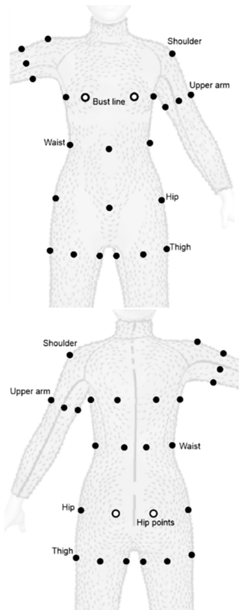
3.3. Wetsuit Objective Evaluation

The wetsuit objective evaluation includes two comparison experiments: the comparison of real and virtual products, and the comparison of real PW and DW samples.

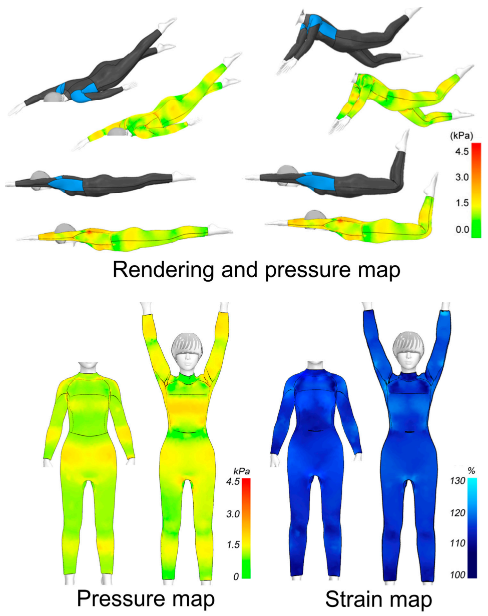
In the comparison of real and virtual products, the real and virtual parameter values are tested and compared using AMI sensors and CLO respectively; Figure 9 shows the test points and comparison maps between pressure and material strain in the virtual product; Figure 9a shows 34 test points in six main parts; Figure 9b shows the material pressure and strain of the wetsuit in virtual try-on. The dynamic changes of body parts after the arms are raised cause great material deformation, which leads to a relative pressure value change ΔP (equation 1). This is an important evaluation factor; the smaller the ΔP, the better the quality of the wetsuit.

$$\Delta P = 100\ (P_d - P_s)/P_s, \tag{1}$$

wherein ΔP is a relative difference between the pressure measured in static and dynamic postures, %; P_d is the pressure when arms are raised, kPa; P_s is the pressure value when arms are down, kPa.



(**a**)



(**b**)

Figure 9. Wetsuit virtual try-on performance: (**a**) test points; (**b**) material pressure and strain of wetsuit during virtual try-on.

As shown in Figure 9b, the green color means weaker pressure contact values generated by CLO, while a yellow or orange color means that the pressure values are stronger than green. The pressure distribution of the wetsuit in the static standing and dynamic positions is reasonable and balanced, without unusual conditions (very high or very low pressure values). When the arms are down, the average virtual and real P_s are 1.89 kPa and 1.65 kPa; when the arms are raised, the average virtual and real P_d are 1.75 kPa and 1.60 kPa. The deviation between real and virtual is less than 0.24 kPa, meaning that there is little difference between the virtual and real compression. It can be concluded that the objective compression experience can be used to predict real pressure performance.

As for virtual material strain (original value is 100%), when the arms are down, the average value in six positions is 13.1%; when the arms are raised, the average value is 16.2%. The wetsuit material strain is within the range of the real EMT measurements of the material, which is also close to the average value of the real design's structural ease (−16.6%). The percentage difference between the values when the arms are up and down is less than 2.8 ± 4.1%.

For the comparison of real PW and DW samples, the objective pressure evaluation results are shown in Table 5.

Table 5. The pressure difference between real PW and DW when arms are up and down.

	DW			PW		
Measuring Parts	**P_s, kPa**	**P_d, kPa**	**ΔP, %**	**P_s, kPa**	**P_d, kPa**	**ΔP, %**
Bust	1.87	2.03	8.9	1.98	1.99	0.7
Waist	1.11	1.04	23.4	0.47	0.77	63.1
Buttocks	1.12	1.20	7.1	0.89	1.05	18.0
Thigh	1.34	1.46	8.4	0.45	0.48	7.5
Shoulder	1.98	1.71	−4.9	2.07	1.05	−49.4
Upper arm	1.11	1.48	33.6	0.27	1.16	324.4
Avg.	1.42 ± 0.40	1.49 ± 0.36	12.8	1.02 ± 0.80	1.08 ± 0.51	60.7

The results indicate that the maximum pressure ΔP_{PW} measured on the upper arm was 324.4%, and the maximum pressure difference was −1.02 kPa. The maximum ΔP_{DW} was 33.6%, and the maximum pressure difference was 0.37 kPa. We reduced the maximum pressure difference on the upper arm by 89.6% and the difference on the shoulder by 90.1% in the newly designed diving suit. In addition, the pressure balance in the waist and chest was appropriately enhanced, resulting in an average pressure greater than PW (0.4 kPa) and a better fit. At the same time, the standard deviation of the pressure in the six parts was kept at a smaller value.

The results show that the differences between the suit when the arms are down and up, in critical parts, are small, and that the wetsuit can adapt well to the deformation state in static and dynamic extreme conditions and provide stable pressure.

3.4. Evaluations Underwater

To further test the performance of DW in all aspects, an underwater experiment was carried out. The testers were equipped with SCUBAPRO professional equipment. Testers 1 and 2 conducted the test. The test project was conducted in a professional diving training center (Wuhan, China), and the water temperature was about 25 °C. Under the guidance of experienced instructors, the testers mainly dived underwater within 6 meters. The underwater dynamic motion includes replications of the postures shown in Figure 9b, and more free swimming and diving.

It can be seen from the underwater professional camera results that in the diving postures, the shoulder, armpit, leg and other parts have no excessive loose volume (wrinkles), and the DW closely fits the human body (Figure 10). After performing free swimming, diving and squatting, the subjective evaluation rating is nearly 6.90 ± 0.21 (Figure 11). The shoulders and the knees can move well without any obvious restriction, and there is no local or overall water accumulation phenomenon. Therefore, the volunteers gave high ratings for the fit of the wetsuit.

Figure 10. Diving test.

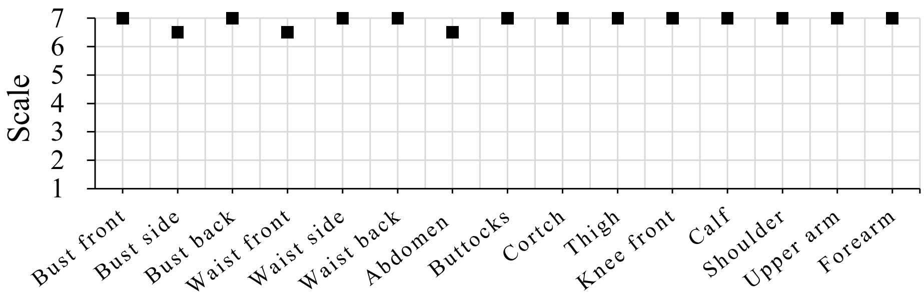


Figure 11. The underwater dynamic subjective evaluation results.

4. Discussion

In this study, the research is divided into four stages: in the first stage, a 2D wetsuit pattern based on anthropometric measurements was designed to solve dynamic misfit problems in the shoulder, armpit, bust and other major parts, and the details were designed and optimized for real-time simulation and evaluation using a 3D system. The try-on effect and material strain were taken into account, as well as the simulation of some postures underwater. In the second stage, a virtual body model was generated based on measurement features of real human dynamic postures underwater, including deforming the human body and material using 3D software. The simulation was completed with the design of the minimum virtual ΔP and tensile strain values selected through pressure and strain analysis, and the ergonomic-based dynamic optimization in the upper limb and torso areas was completed.

In the third stage, the finished DW product was completed based on the simulation results for three testers. After a real try-on experiment, the performance results were highly consistent with the virtual results, the material pressure error was small (<0.24 kPa), and the virtual material strain value was also in line with the real design's value. Finally, real underwater experiments were carried out, and the testers gave positive evaluations of the DW's good dynamic performance at upper limbs, bust areas, etc. The results show that the wetsuit designed using the virtual system has a reasonable pressure range and good fit performance; the wetsuit can adapt well to static and dynamic wearing fitness and extreme deformation, and provide stable pressure. After an overall and detailed comparison, as well as subjective and objective analysis, the DW's results were comprehensively better than those of the PW products in the market.

5. Conclusions

The whole research process shows that theoretical knowledge of virtual design and optimization can solve the practical problems of wetsuit development, and that the performance results of virtual and real experiments are consistent. The DW has a good static appearance on land, and meets the requirements of dynamic wearing comfort and sports function underwater well.

The technical results of this study provide an efficient and flexible way to develop and test enterprise products by effectively controlling labor and material costs and reducing sample production. The results will also help wetsuit designers to cope with rapid modification and evaluation, and improve customers' wearing experience. It is possible to design a suitable wetsuit based on the tester's size with high satisfaction. At the same time, the new wetsuit evaluation mode can avoid making a lot of samples for testers to try on, and it can also omit actual repetitive manufacturing work to increase productivity, significantly lower production costs, and reduce resource consumption. This also helps to improve the enterprise's current state of scientific research and practical production.

This method will further promote the development of information technology in the field of industrial manufacturing and will explore the basic theoretical problems of virtual technology in the field of elastic materials and functional garments. It can help to solve bottleneck problems in simulation, evaluation and other key technologies in the current virtual systems used by the related manufacturing industry, and provide some references for virtual simulation and evaluation research, which has important economic value and scientific significance.

Author Contributions: Conceptualization, X.W. and V.E.K.; methodology, X.W. and V.E.K.; software, X.W. and Z.C.; validation, Z.C. and X.W.; investigation, X.W. and Z.C.; data curation, X.W. and Z.C.; writing—original draft preparation, X.W.; writing—review and editing, X.W. and Z.C.; project administration, Z.C and X.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Hubei Provincial Department of Education—Philosophy and Social Sciences Research Project (21Q104), Nurture Project of WTU (20220609), Teaching and Research Project of WTU (20220100108, 2021JY105), and Innovation and entrepreneurship training program for college students of WTU (202210495020, S202210495053X).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: Thanks for the support of Wuhan Clothing Digital Engineering Technology Research Center. Thanks to the participants who participated in the survey. Thanks to anonymous reviewers for their valuable comments.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Cerrano, C.; Milanese, M.; Ponti, M. Diving for science-science for diving: Volunteer scuba divers support science and conservation in the Mediterranean Sea. *Aquat. Conserv. Mar. Freshw. Ecosyst.* **2017**, *27*, 303–323. [CrossRef]
2. PADI. 2021 Worldwide Corporate Statistics. 2021. Available online: https://www.padi.com/sites/default/files/documents/2021-02/2021%20PADI%20Worldwide%20Statistics.pdf (accessed on 19 August 2022).
3. Michaelson, D.; Kim, D.E.; Ha, Y. Scuba Diver's Use of Selection Criteria for Assessing Wetsuit Using FEA Model. *Int. J. Costume Fash.* **2018**, *18*, 45–64. [CrossRef]
4. Kuzmichev, V.E.; Zhe, C. Sizing and fit for pressure garments. In *Anthropometry, Apparel Sizing and Design*; Woodhead Publishing: London, UK, 2020; pp. 331–370.
5. Dan, L. Research on the Basic Type Structure of Women's Wet Diving Tops. Master's Thesis, Donghua University, Shanghai, China, 2015.
6. Yunxiang, L. Research on the Design Method of Wet Diving Pants Structure. Master's Thesis, Donghua University, Shanghai, China, 2014.
7. Roy Choudhury, A.K. Environmental impacts of the textile industry and its assessment through life cycle assessment. In *Roadmap to Sustainable Textiles and Clothing*; Muthu, S.S.K., Ed.; Springer: Singapore, 2014; pp. 1–39.
8. Kaminsky, W.; Mennerich, C.; Andersson, J.T.; Götting, S. Pyrolysis of polychloroprene rubber in a fluidised-bed reactor—Product composition with focus on chlorinated aromatic compounds. *Polym. Degrad. Stab.* **2000**, *71*, 39–51. [CrossRef]
9. Aracil, I.; Font, R.; Conesa, J.A. Chlorinated and nonchlorinated compounds from the pyrolysis and combustion of polychloroprene. *Env. Sci. Tec.* **2010**, *44*, 4169–4175. [CrossRef] [PubMed]
10. Serkan, B.O.Z.; Necef, Ö.K.; Kiliç, A.Ş.E.N.; Öndoğan, Z. The usage of 3D technologies in assessment of body fitting of clothing. *Turk. J. Fash. Des. Manag.* **2019**, *1*, 27–34.
11. Zhe, C.; Kuzmichev, V.E.; Adolphe, D. A digital replica of male compression underwear. *Text. Res. J.* **2020**, *90*, 877–895.
12. Tao, F.; Qi, Q. Make more digital twins. *Nature* **2019**, *573*, 490–492. [CrossRef] [PubMed]
13. Matsuda, A.; Tanaka, H.; Aoki, H.; Shimana, T. 3-Dimensional joint torque calculation of compression sportswear using 3D-CG human model. *Procedia Eng.* **2015**, *112*, 40–45. [CrossRef]
14. Naglic, M.M.; Petrak, S.; Gersak, J.; Rolich, T. Analysis of dynamics and fit of diving suits. *IOP Conf. Ser. Mater. Sci. Eng.* **2017**, *254*, 152007. [CrossRef]
15. Petrak, S.; Naglić, M.M.; Geršak, J. Sizing and fit for swimsuits and diving suit. In *Anthropometry, Apparel Sizing and Design*; Woodhead Publishing: London, UK, 2020; Volume 2020, pp. 255–287.
16. Naglic, M.M.; Petrak, S.; Stjepanovič, Z. Analysis of 3D construction of tight fit clothing based on parametric and scanned body models. In Proceedings of the 7th International Conference on 3D Body Scanning Technologies, Lugano, Switzerland, 30 November–1 December 2016.

17. Staal, T.; Huysmans, T.; Molenbroek, J. A 3D anthropometric approach for designing a sizing system for tight fitting garments. In Proceedings of the 2nd International Comfort Congress, Delft, The Netherlands, 29–30 August 2019.
18. Hu, P.; Kaashki, N.N.; Dadarlat, V.; Munteanu, A. Learning to estimate the body shape under clothing from a single 3-d scan. *IEEE Trans. Ind. Inform.* **2020**, *17*, 3793–3802. [CrossRef]
19. Brubacher, K.; Tyler, D.; Apeagyei, P.; Venkatraman, P.; Brownridge, A.M. Evaluation of the accuracy and practicability of predicting compression garment pressure using virtual fit technology. *Cloth. Text. Res. J.* **2021**, *5*, 1–18. [CrossRef]
20. Xinzhou, W.; Kuzmichev, V.E. Study on the body girth dynamic size for wetsuit ease design. *Proc. IOP Conf. Ser. Mater. Sci. Eng.* **2018**, *459*, 012085.
21. What is Neoprene and Information. Available online: https://www.neopren.com.de/What-is-neoprene (accessed on 19 August 2022).
22. Xinzhou, W.; Kuzmichev, V.E. A design of wetsuit based on 3D body scanning and virtual technologies. *Int. J. Cloth. Sci. Technol.* **2020**, *33*, 477–494.