

# Research on Universal Design of Water-based Strength Training Fitness Products

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**Abstract:** The existing strength training fitness products have the problems of single-use group and function. First of all, this paper takes the universal design as the research criterion, finds out the design pain point of the product to realize the strength training generalization, and proposes to use water as the medium to solve the problems of different groups when carrying out strength training because the products can not meet the different training intensity, universal safety, and training parts. Then, the products can be generalized to different groups and their diversified training needs. Finally, the design scheme is analyzed qualitatively and quantitatively, and compared with the best strength training universal products on the market, so as to verify that water as the medium is feasible for effectively realizing the product generalization in different groups and diversified training needs.

## 1 Introduction

Strength training is a typical anaerobic exercise, which is characterized in that the muscles undergo anaerobic metabolism with sugar under anaerobic conditions, and perform high-speed and vigorous exercise. Aerobic exercise can achieve the purpose of burning calories, but it cannot increase the metabolic rate for a long time. Although strength training cannot burn calories for a long time, it can increase the total muscle mass and increase the metabolic rate. The two are in a complementary relationship. Teenagers, young adults, and the elderly are typical representatives who can participate in sports, but most of their daily life activities are aerobic exercises, and what they lack is strength training. And reasonable strength training can effectively improve the motor system, cardiovascular system, nervous system, and respiratory system.

## 2 The technical difficulties for the product to achieve universal strength training

### 2.1. Universal design

Universal Design was proposed by Ronald L Mace in 1974<sup>[1]</sup>. Universal design can also be called design for the whole people, inclusive design, etc. <sup>[2]</sup>, which means to fully understand each user's abilities and physical function limitations to design products. This is conducive to

integrating a large number of decentralized idle resources, optimizing resource allocation, reducing repeated investment, and conforming to the concept of sustainable development.

The core of the universal design is to be inclusive to all potential users. The general design takes the product as the platform, so as to meet the diverse needs of different user groups. It involves 7-principles: fair use, flexible use, simple and intuitive use, clear information prompt, allowable error, labor-saving, appropriate scale, and space <sup>[1]</sup>. The 7 principles will be used as evaluation elements to guide and demonstrate the design practice in the early stage. The highlight of this paper is to use water as a medium to change the current strength training fitness products with poor generalization. So as to reduce the same product for different groups of access threshold.

### 2.2. Technical difficulties for product universalization

The core of realizing the universalization of strength training fitness products is that the products can meet the needs of different user groups for strength training. Taking generalization as the criterion, 7 principles as the guidance for evaluation elements, combined with the characteristics of strength training, the technical difficulties that must be solved in the product design process are analyzed: (see Figure 1)

**Crowd positioning:** Common strength training fitness products are mostly aimed at young men and women, ignoring the importance of strength training for teenagers

and the elderly. To realize the universalization of strength training products, the strength training needs of teenagers and the elderly must be included.

**Differences in training intensity of different groups:**

The product user groups can be roughly divided into teenagers, young adults, and elderly age groups according to age groups. Due to the great differences in the physical functions of different groups of users, the intensity of their strength training also varies greatly. Traditional strength training products with single functions can hardly meet the training intensity of all users.

**The safety of training in different groups:**

The existing strength training fitness products are mostly aimed at young and middle-aged people, and the safety of training for teenagers and the elderly is insufficient. The safety mentioned here is not only aimed at the safety of the body surface but also includes the safety of the muscles during training. To better realize the universalization of strength training products, it is necessary to improve the fault tolerance of the products during training for different groups of users and ensure their fitness safety.

**There are differences in training positions for different groups:**

After research and interviews, young and middle-aged men and women focus on training on the chest, abdomen, buttocks, and arms. As for teenagers, due to their living habits and methods, they face the phenomenon of operating computers, mobile phones, and other electronic devices, leading to the excessive development of small muscle groups under fine movements, while insufficient physical activity mainly caused by large muscle groups results in upper limbs, lower limbs and trunk muscles. The phenomenon of a significant decrease in power [3]. Therefore, the product must take into account the training needs of young people in upper limb muscles, core muscles, and lower limb muscles. The elderly mainly focus on extensor tension strength training to ensure flexible operation of daily life and sexual behavior and protect the spine through core muscle training. Therefore, the product needs to change the shape of the existing product to meet the needs of different body parts training in generalized use in a flexible and changeable form.

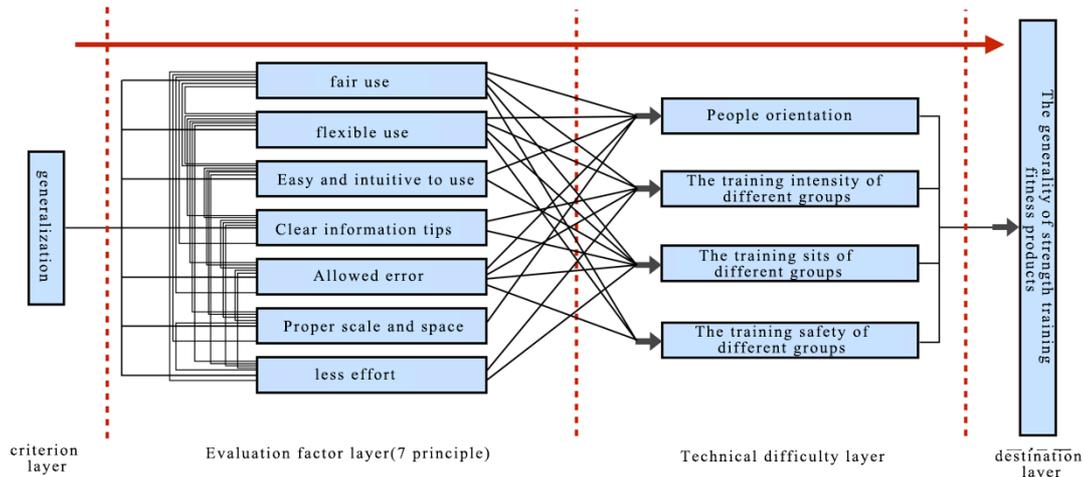


figure 1

**3 Characteristics of water medium**

**fluidity**

The molecular structure of water is round, and water molecules will rush to low places under the action of the earth's gravity, and its own cohesion makes it flow continuously, so liquid water has better fluidity. The fluidity of water can ensure that under different usage actions of water injection products of different shapes when the force conditions change, the gravity direction of the counterweight required by the user remains consistent with the gravity direction of the water.

**Cohesion**

Due to the cohesive force of water molecules, liquid water can actively adapt to and fill any product shell without considering the characteristics of the medium, making the later product design more flexible and changeable.

**Soft safety**

The flow characteristics of water determine its softness, which can better cushion the effect and ensure

that it is not harmed. The water medium used in the product can greatly improve the fault tolerance of different groups during strength training.

**Cheap and accessible**

As a necessity of life, water determines its price. Compared with many materials, water is cheap and economical. And in life, people can easily get water. This also makes the product because of the water medium can greatly reduce its cost, so as to better achieve fair use.

**4 Using water as the medium to solve the technical difficulties of generalization of strength training products**

**4.1. Use water as the medium to meet the training safety requirements of different groups Muscle safety**

Among the existing strength training fitness products, the weight medium is mostly iron and sand. Iron is a solid

weight, which is often targeted for the localized and precise strengthening of muscle stimulation. It is suitable for professional fitness people, but not completely suitable for the physical function characteristics of teenagers and elderly people. Teenagers and elderly people need more overall coordination muscles. Strength Training. The fluidity of water determines its weight as a counterweight. It is more inclined to the core coordination and balance of muscles, which is suitable for non-professional fitness groups to supplement the insufficiency of strength training in daily life. The existing sandy weights are made of materials between solid weight and fluid weight. Relatively balanced. However, the low-cost and easy-to-obtain characteristics of water quality do not have sand quality, which limits the flexibility of the product in the process of generalization. Therefore, in summary, using

water as a medium can effectively ensure the safety of muscles during training.

**Body surface safety**

Among the existing strength training fitness products, iron and sand have poor soft and safe properties. In this regard, the water quality has a stronger advantage, and when it encounters resistance bodies, the water has better flow characteristics and can better Disperse and reduce the impact of force, thereby indirectly protecting the resistance body. In fitness activities, the surface of the body is the resistance surface. Using water as a medium can effectively reduce the damage to the surface of the body caused by incorrect operations during the strength training process, thereby effectively ensuring the safety of the surface of the body during training.

User groups	Security texture of material	Internal External security	
		(muscle)	(body surface)
Teenagers	Iron	Poor	Poor
Teenagers	Sandy	Moderate	Moderate
Teenagers	Water	Preferably	Preferably
Middle age	Iron	Preferably	Poor
Middle age	Sandy	Moderate	Moderate
Middle age	Water	Moderate	Preferably
Aged	Iron	Poor	Poor
Aged	Sandy	Moderate	Moderate
Aged	Water	Preferably	Preferably

figure 2

**4.2. Use water as the medium to meet the training intensity requirements of different groups**

Taking into account the differences in physical function among teenagers, young adults, and the elderly. Traditional strength training products cannot effectively solve the differences in training intensity of different groups. However, the invisible and easy-filling properties of water and the low-cost and easily available properties effectively solve this problem. The key to the second difficulty lies in a large number of audiences. The product cannot meet the weight required by everyone. The traditional way of disassembling the weight plate of dumbbells can solve the process of the product from scratch for different training intensities, but it is relatively rough. The cheap and easy-to-availability of water makes it easy for users to obtain water. Users can use their own water injection or pouring behavior without changing the product to use the fitness weight that is most suitable for their own body functions. Different groups of training intensity have different difficulties.

**4.3. Use water as the medium to meet the requirements of different groups for training different parts**

If the product wants to meet the training needs of different body parts, the requirements for the weight medium must be more flexible and changeable, and the invisible and easy filling feature of water is undoubtedly the best choice. Water provides the most foundation for the design of the later product shape. The platform and the fluidity of water provide the most comfortable gravity direction for users when training different body parts.

**5. Research on the universal design of fitness products using water as the medium**

**5.1. Product conception**

The product can be visually summarized as the strength training "warm water bag", which has changed its main purpose, material, shape, structure, and size. The warm water bag is filled with water to keep the body warm, and the product is filled with water to gain weight for strength training. First of all, the product adopts a modular structure, with three modules with different sizes and shapes, from large to small. Because each module has a water injection port structure, the water injection volume can be adjusted manually to obtain any value from 1kg-10kg. The weight provides the possibility of training

intensity required by different groups of users; secondly, the modules can be connected directly through Velcro, which provides a variety of modeling states and provides the possibility for the expansion of different training

actions. When all modules are stacked together, they can also serve as a seat for people to rest, which facilitates the transition between movement and static and saves limited space.



**figure 3**

## 5.2. Product modeling and structure design

The design of styling and structure should fully consider the differences in training positions and training intensity of different groups of users. Teenagers focus on training the trunk and core muscles, while adults focus on the abdominal muscles, leg muscles, chest muscles, back muscles, hip muscles, and shoulder muscles. The elderly focus on training extensors and muscles. Mainly core muscles.

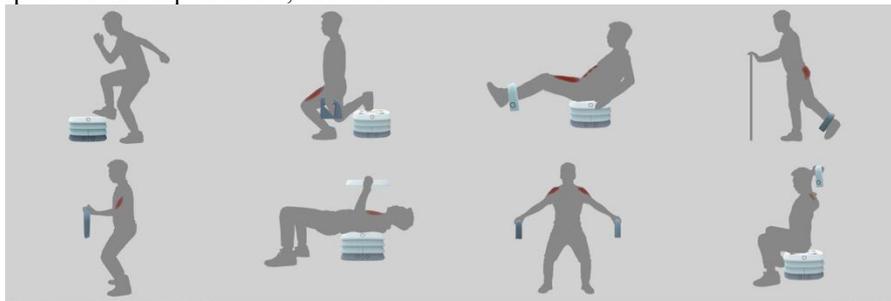
Through the combing of strength training movements, the core of different training positions can be summarized as lifting, lifting, pulling, and pushing. And the training parts can be divided into upper body torso training, core area training, and lower body torso training.

Upper body torso training requires weight-bearing with hands, through reasonable movements to train the chest muscles, shoulder muscles, and back muscles; lower body torso training mainly involves adding weight to the feet through reasonable movements to train the leg muscles. And the purpose of the hip muscles; the core

muscles are mainly used to achieve training goals by using the hands and feet together with additional weights. The mainstream strength training products on the market often only meet the training needs of a single training site. In summary, the core of the styling and structural design is to use water as a medium to make the product use both hands and feet, and to freely switch the weight of the weight when training different body parts.

### Reasonable styling makes the product universal for training parts

The styling design of the product mainly refers to the realization of the simultaneous use of hands and feet. The existing mainstream strength training products mainly adopt the method of lifting the weight by the hand, and this method naturally limits the use of the feet, thereby limiting the product training for different body parts possibility. Through a lot of design practice, the final product adopts a hole-through shape, the hands can be used for lifting, and the feet can be used for wearing and lifting, so as to better realize the generalization of the training parts of the product.

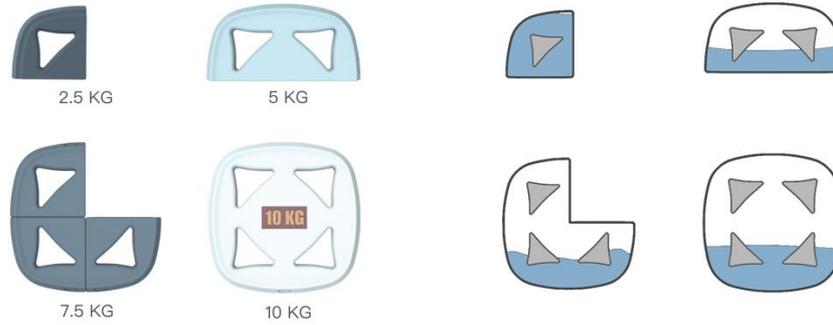


**Figure 4**

### Modular design makes the product realize the generalization of training intensity

The modular structure design allows the product to be disassembled and recombined, connected by Velcro, which can not only achieve the ideal product use state by combining the training modules according to different training positions but also can accurately adjust the water injection volume of each training module to find the training weight most suitable for your own situation so that the product can meet the needs of different groups of training intensity. The specific modular design plan is as follows: Divide according to the largest volume size (length 420mm, width 420mm, height 420mm), and

finally consists of three training modules: Module A (size length 420mm, width 420mm, height 60mm, and maximum water injection weight 10kg); B Module (size length 420mm width 210mm height 60mm, maximum water injection weight 5kg); C module (size length 210mm width 210mm high 60mm, maximum water injection weight 2.5kg). Thereby forming the possibility of training by combining multiple training modules of 1A, 1B, 1B+1C, 1C, 2C, and 3C, and the water injection volume of each module can be adjusted manually, in other words, it can achieve all weights from 1kg to 10kg, Which greatly improves the flexibility of the product for different user groups. See Figure 6 for details



**Figure 5**

lower production costs, and make products more affordable.

As shown in Figure 3, in terms of wear resistance, ease of use, water resistance, soft and hard comfort, and economy, soft PU leather, TPU thermoplastic polyurethane elastomer rubber, and silicone can all be used as a reference for selection. According to the above table, it can be found that among the above-mentioned material types, TPU polyurethane rubber is more suitable for the product shell of this product. Because of its high wear resistance, high water resistance, moderate hardness, and moderate economic cost.

### 5.3. Product shell material selection

The purpose of the product shell material selection is to maximize the characteristics of water, and the shell material is only a package and acceptance of water. That is to say, the following indicators must be met (1) The material needs to be wear-resistant and easy to use, so as to avoid wear and damage during use; (2) Waterproof performance is good to prevent water leakage; (3) The material is moderately soft and hard to maximize Use the characteristics of water to better realize the above-mentioned technical difficulties; (4) Higher economy,

Name	Wear resistance and ease of use	Water resistance	Soft and hard moderate	Economy
Soft PU leather	Moderate	Weak	Soft	Higher
TPU polyurethane rubber	Higher	Higher	Moderate	Moderate
Silica gel	Moderate	Weak	Relatively soft	Moderate

**Figure 6**

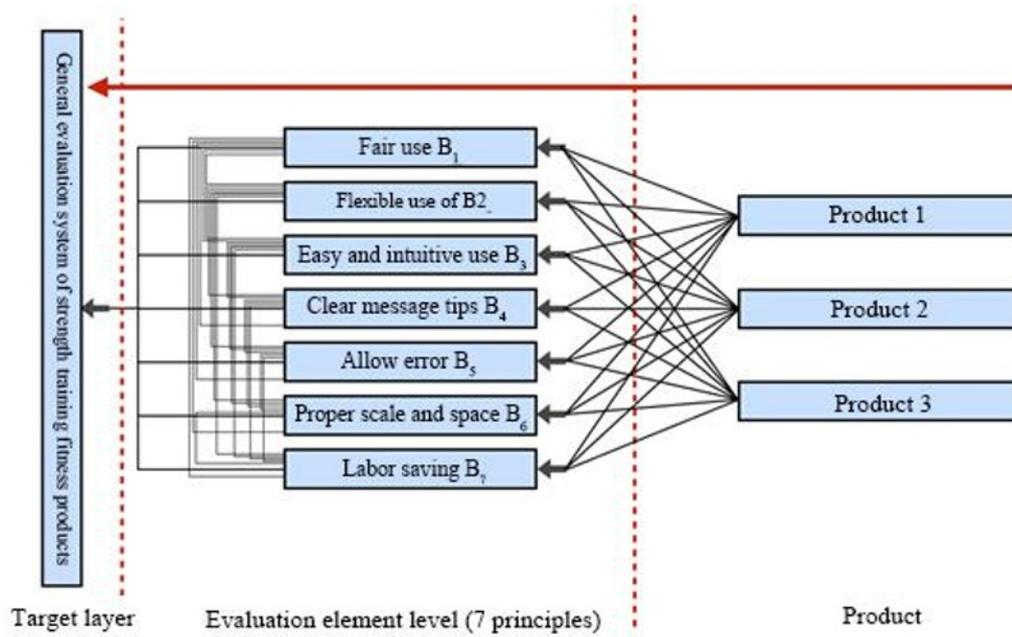
### The water injection port design makes the product realize the universalization of behavior habits

The design of the water injection port should conform to the characteristics of simple and intuitive use in the universal design principle, that is, the water injection operation should conform to the cognitive habits and physical behavior operation capabilities of teenagers, children and the elderly so that the water injection behavior is simple and easy to operate. This product adopts the design of the "bottle cap" type water injection port, which is intended to meet the special needs of teenagers, children, and the elderly in terms of consciousness and behavior to the greatest extent.

Product design evaluation needs both qualitative analysis and quantitative reference. In qualitative evaluation, a general evaluation system of strength training fitness products is established by using hierarchical analysis method, as shown in Figure 7. Then, the design research results and two representative products on the market are evaluated according to the system. In quantitative evaluation, the scale method and judgment matrix are used to calculate the weight ratio of 10 evaluation elements and each product to each evaluation factor, and finally the comprehensive evaluation results of products are obtained. The author will select the market mainstream strength training general product 1 (see Figure 8) and the latest concise integrated strength training fitness product 2 (see Figure 9) and the research product 3 (see Figure 10) for comprehensive comparison and evaluation.

## 6 Design argumentation and summary

### 6.1. Evaluation method



**Figure 7**



**Figure 8**



**Figure 9**



**Figure 10**

**6.2. Scale determination and construction of judgment matrix**

This paper adopts the 1-9 scale method with a high degree of discrimination, memorability, and high perceptibility, as shown in Figure 11.

**1-9 Scaling method**

Scale	Definition and description
1	The two attributes are equally important to each attribute
3	Compared with two elements, one element is slightly more important than the other
5	Compared with the two elements, one element is more important than the other
7	Compared with two elements, one element is obviously more important than the other
9	Comparing two elements, one element is much more important than the other
2, 4, 6, 8	A scale that represents a compromise between two adjacent judgments

**Figure 11**

Find 30 interviewees engaged in strength training (8 teenagers, 7 young people, 7 middle-aged people, 8 seniors) to compare the 10 principles of the evaluation element layer in pairs and use the 1-9 notation method to mark them. The final comprehensive construction matrix is shown in Figure 12. Finally, the weight value of each evaluation element is obtained, and the largest feature root

is calculated through the cloud computing system to obtain the consistency index CI, the random consistency index RI, the consistency ratio CR, and the final CR=0.0370<0.1, the proof matrix And the rationality of the index weight. And the evaluation indicators are sorted from large to bottom according to the weight value, as shown in Figure 13.

Judgment matrix of factor weight in A-B layer evaluation

A	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	B <sub>6</sub>	B <sub>7</sub>	Road haul	extraction of a root	Weight(W <sub>i</sub> )
B <sub>1</sub>	1	4	6	7	2	3	8	8064.0000	2.1161	0.2637
B <sub>2</sub>	1/4	1	3	4	1/3	1/2	5	2.5000	1.0793	0.1345
B <sub>3</sub>	1/6	1/3	1	2	1/5	1/4	3	0.0167	0.7109	0.0886
B <sub>4</sub>	1/7	1/4	1/2	1	1/6	1/5	2	0	0.5706	0.0711
B <sub>5</sub>	1/2	3	5	6	1	3	7	945	1.7699	0.2205
B <sub>6</sub>	1/3	2	4	5	1/3	1	6	27	1.3147	0.1638
B <sub>7</sub>	1/8	1/5	1/3	1/2	1/7	1/6	1	0	0.4639	0.0578
summation									8.025466	1

Annotation:  $\lambda_{max} = 7.3025$  ;  $CI = 0.0504$  ;  $RI = 1.36$  ;  $CR = 0.0370 < 0.1$

Figure 12

Ranking of weight values of each evaluation index

evaluating indicator	assessment element	Weight value
Fair use	B <sub>1</sub>	0.2637
Allow errors	B <sub>5</sub>	0.1345
Appropriate scale and space	B <sub>6</sub>	0.0886
Flexible use	B <sub>2</sub>	0.0711
Simple and intuitive use	B <sub>3</sub>	0.2205
Clear message tips	B <sub>4</sub>	0.1638
Labor saving	B <sub>7</sub>	0.0578

Figure 13

When calculating the weight of each evaluation element for the three products, due to a large amount of data and the same reasoning, the calculation process will

not be shown, and the weight value of each evaluation element of the three products will be directly displayed, as shown in Figure 14.

The weight score of each evaluation factor of the three products

	B <sub>1</sub>	B <sub>5</sub>	B <sub>6</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>7</sub>
Product 1	0.2384	0.2368	0.2142	0.2429	0.4101	0.4101	0.3333
Product 2	0.3233	0.3051	0.3611	0.3242	0.2950	0.2950	0.3333
Product 3	0.4383	0.4581	0.4227	0.4329	0.2950	0.2950	0.3333

Figure 14

Finally, the weight value of each product in each evaluation element and the weight value of each evaluation element in 10 evaluation elements are

multiplied and added to calculate the final score of each product. The final score result is shown in Figure 15.

Final combined score for all three products

Product plan	Final score
Product 1	0.2676
Product 2	0.3217
Product 3	0.4104

Figure 15

The comparison between Figure 14 and Figure 15 shows that the final result of this research, product 3, can

obtain higher scores than product 1 and product 2, which can be attributed to factors such as fair use, allowable

errors, appropriate scale, and space, and flexible use. prominent. The prominence of these elements is precise because the design practice of this research is based on the characteristics of water and the characteristics of combined water. In summary, using water as the medium to realize the universalization of strength training fitness products is an extremely effective measure.

### **6.3. Summary**

The essence of generalization is that the product can satisfy the strength training and fitness needs of different user groups at the same time. The research of this paper is to give full play to the value of water, let the water everywhere in life serve as the medium, and through reasonable product design, let teenagers, young adults, and old people all can use it together. The general use of strength training fitness products will greatly avoid the waste of resources, so as to realize the sustainable development of life and fitness.

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