

Effect of Elastic Properties of Protective Clothing Material on the Residual Impact Force in Impact Sports Damage

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Shanghai, 201600
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Abstract

This paper starts from the analysis of human sports damage mechanism, and then from the force in the sports impact injury and material protection mechanism analysis, concluding elastic material has a certain impact on the impact protection. with the material elasticity experiment and the impact test on a certain degree, The elastic and residual impact force is used to characterize the material's protective properties, Finally, a comparative analysis is carried out, It turns out, in a certain case, the material elasticity has a protective effect on the impact.

Keywords: sports injury, impact protection, residual impact force, protective material

1. Overview

On the process of sports injury query research, we found that the research on sports injury mainly focused on joint injury, bone injury, several muscle injury and so on, And currently, more and more people in the movement will subconsciously wear sports protective gear, so as to avoid damage to the various parts of the body. There are many domestic and outdoor sports brands products in breathable and anti friction, such as jackets, quick drying pants, while there are few anti impact performance of outdoor protective clothing or equipment in our country, in the research on these sports injury, bones injury is most likely happened in collision damage, it is very important for bone protection in the process of movement, In addition to the covering on the skeleton of the muscle to protect the bone for further protection, in the research of impact protection material, there are some foreign standards, but the domestic almost blank.

2. Collision Damage Principle

2.1 Sports Injuries

In the course of movement, the human body damage whether caused by the external force of the device or the collision between bodies, the basic principle is caused by the force caused by the interaction between the two objects [1]. Through Newton's third law, Forces between two objects exist force and reaction force, when the movement in the process of limb from different direction force from different angles, such as tensile strength, compression, torsion, shear force, if there is no wear with protective material protectors to the external force to buffer, then the force effects will through the muscles act in the human body, and sometimes the moment, sometimes is continuous, when the human body cannot burden that force, then it will cause damage to human joints and bones. Therefore, sports injuries include a lot, according to the loading time, it can be divided into: the accumulation of damage, acute injury; in accordance with the mode of force, it can be divided into: impact injury, contusion, joint strain; and we need to understand the human body structure, the body of the organization can be divided into hard tissue and soft tissue, Therefore, to protect the body, we need to protect the body's structure, specifically according to the specific parts, therefore, when in sports motion need to be equipped with the protective properties of the protective clothing and protective gear.

2.2 Impact Damage

The impact means a sudden impact, in this period strength of the muscle and bone has gone beyond the extent of damage, there are some sports, such as kickboxing, free combat, etc.

Due to the motion in the human direct impact force is larger, therefore the body structures need protective clothing of good protective performance to prevent injury of athletes. When the human body force an impact, soft tissue will be first take the force before the bones are affected, while the body is mainly composed of three parts, organs, bones, muscle. Muscle is attached to the outside of the skeleton, the human body through the external skeleton and muscle protection to increase its ability to withstand external forces to ensure that it is not easy to damage [2]. But the book points out: human bone is the last can directly accept the impact of external force, so it must be through the muscle tissue to accept the external force to slow the momentum, so as to reduce the force on the bone, which can protect human skeletal. Thus, in the process of movement, muscle is like a natural protective system of bone, which has the function of anti shock absorption, especially in the impact injury, muscle is more prominent in the buffer action of bone, while the rubber foam sponge has many similar mechanical characteristics with muscles. And these materials can be used for making protective gear to further protect the joints of the human skeleton, now many protective gear is mainly made of sponge, rubber and other materials. when achieving the requirements in moisture absorption and air permeability, the protective gear material anti-collision buffer performance is very good. Such as elbow bandage, prevent elbow due to friction and collision caused by injury or dislocation [3].

Therefore, the principles of impact damage protection is mainly in the following sides:

1. Reducing the force of external force on the human body vertical force, which is the most fundamental solution to the movement of the method, in the movement process, as far as possible to reduce the impact force, such as ball and equipment bring the injuries, etc., to achieve the effect of avoiding sports injury. Scattered through the external force to protect the bone, such as changing the collision angle, vertical force reduction, increase the friction, but in the movement process, there are many irresistible or unexpected things happen unless put an end to the sport, or sports injury occurred is inevitable.
2. by increasing the body parts to withstand the ability to achieve the effect of protection. The most common measures to prevent the occurrence of sports injuries are to enhance their ability to protect bones and joints by using the correct exercise method, and one way is to protect the human body from the protective material, which acts as the second layer.

3. Impact Protection Materials Research

3.1 Protection Principle of Clothing Material

In the last section, the main point is to explain the mechanism of its movement from the human skeleton to different components of the joints, and in the end, the human body has the first protective barrier, muscle, it protect the bones directly. To explain its protection principle, the following is a detailed analysis of the material properties of the muscle. In general exercise, the protective effect of human muscle on the skeleton is achieved by the elastic contraction of the muscles to absorb the external forces. The skeletal muscle is composed of two parts of the muscle and tendon. The muscle is composed of muscle fibers. It is the muscle contraction. The tendon is composed of parallel collagen fiber bundles, but with good elasticity, it can resist a lot of tension.

The force of impact damage is mainly instantaneous compression, so the protection of muscle is mainly reflected in the rate of deformation, which demands muscle has a high elasticity. A book mentioned that the skeletal muscle tissue is visco-elastic, and when the force is loaded on the human body, in order to restore the shape of its own, the muscle will waste some energy, so as to achieve the goal to slow down the speed and act as a cushion. This shows that the elasticity of the muscle is a crucial condition for its ability to effectively buffer the external force. For high intensity exercise injury, with external clothing materials covered the skins can protect human bodies. Such as, some sports protective gear, some mainly limiting the activities of a joint, reducing skin friction or impact energy absorption to achieve protection. While the requirements of impact protection materials are mainly elastic, higher impact resistant, of course, the weight is lighter, the overall structure, those properties can make sure it plays a good role in the protection, and reduce the impact of the movement to a minimum.

3.2 Research on Clothing Impact Protection Material

Dow Coming Active TEM Sys (Protection) is proposed in the Coming Dow company. It belongs to a special coating process of three-dimensional textile material, it can maintain soft and tough in normal circumstances, Once the impact force disappear, the impact of the loaded force will immediately return to the soft state [4-5]]. London's D30 Lab company developed a special cloth. By the impact of the rapid hardening, thereby it can reduce the impact force.

Later it will become soft, with not limiting the flexibility of wearing personnel, and the stronger the impact, the more rapid reaction [6].Nan Nan Cao, Shao Juan Chen developed a new sports protective gear, in a hot melt adhesive fiber and three-dimensional crimp hollow polyester fiber as raw material, through the hot molding. In this device, three-dimensional crimp hollow fiber is fluffy. can improve the protective performance of buffer protector. [7]Three-dimensional composite material of high strength, high stiffness, good anti impact performance, light weight, weaving is a sports protective gear necessary conditions, such as d30 material and silicon resin 3D fabric composite material, so that it can be applied in many fields of sports protective gear, accelerated the rapid development of the field of sports outdoor. [8]

4. Material Experiments

4.1 Material Preparation

Number the elastic knitted fabric from 1-10, according to the longitude and the latitude to cut into 40 cm long, 5 cm wide strips, five pieces of each kind of fabrics, under standard atmospheric pressure, hang these pieces with 5kg of gravity, keeping 10 min, left 5cm in the front and the rear. Cloth length L0=30cm, after hanging remove the clip, measuring the length after extension,L1, after 15s, measuring the rebound length, L2, load elongation = (L2-L1) /L1; fast elastic deformation rate under certain load = (L3-L1) /L1;The elastic fabric with vertical to the latitude direction cutting into 10*10cm strips in five blocks of each fibers, Under the same temperature condition, the impact force is maintained at the same height to keep the speed, and the residual impact force is measured;

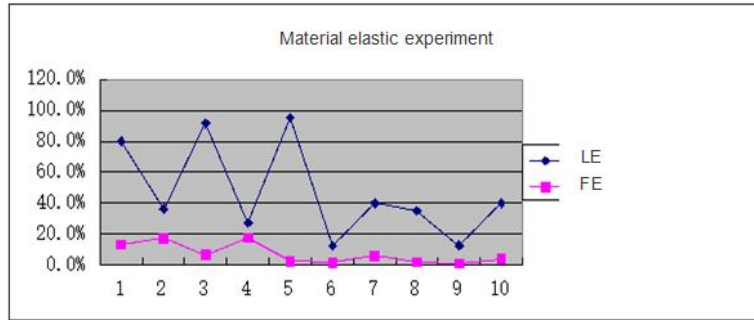
4.2 Data Analysis

Chart 1: Material Elastic Experiment

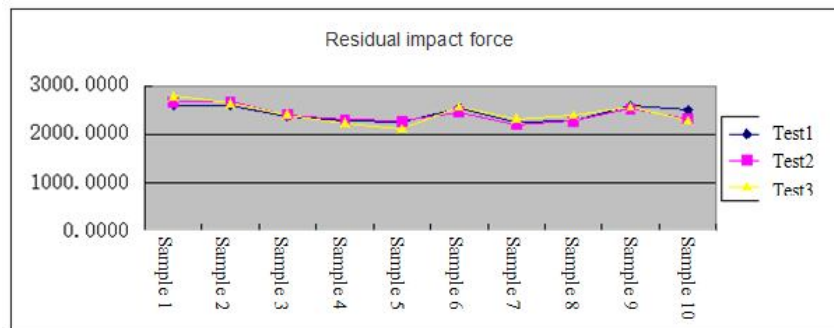
	L1 (cm)	L2 (cm)	L3 (cm)	LE	FE
sample1	30.0	54.0	34.0	80.0%	0.1333
sample2	30.0	40.9	35.2	36.3%	0.1733
sample3	30.0	57.5	32.0	91.7%	0.0667
sample4	30.0	38.2	35.3	27.3%	0.1767
sample5	30.0	58.6	30.7	95.3%	0.0233
sample6	30.0	33.7	30.5	12.3%	0.0167
sample7	30.0	42.0	31.8	40.0%	0.0600
sample8	30.0	40.5	30.6	35.0%	0.0200
sample9	30.0	33.8	30.3	12.7%	0.0100
sample10	30.0	42.0	31.2	40.0%	0.0400

Chart 2: Residual Impact Force Test

Residual impact force(N)				
	Test1	Test2	Test3	average
sample1	2596.9100	2669.5500	2787.6000	2684.6867
sample2	2593.8900	2681.6600	2645.3700	2640.3067
sample3	2363.8600	2403.2000	2400.1800	2389.0800
sample4	2291.2200	2309.3800	2230.6800	2277.0933
sample5	2257.9200	2273.0600	2109.6100	2213.5300
sample6	2545.4600	2460.7100	2562.2700	2522.8133
sample7	2242.7900	2191.3300	2318.4600	2250.8600
sample8	2273.0600	2276.0800	2391.1000	2313.4133
sample9	2585.6600	2530.3300	2563.6200	2559.8700
sample10	2497.0300	2318.4600	2279.1100	2364.8667

Picture 1: Material Elastic Line Chart

* LE:load elongation = $(L2-L1) / L1$; FE:fast elastic deformation rate under certain load = $(L3-L1) / L1$;

**Picture 2: Residual Impact Force Line Chart**

From the two charts and two pictures, here is the conclusions:

- 1) In range of the elastic, the higher the percentage elongation, the better elasticity, the smaller the elastic deformation rate, the better elasticity;
- 2) By comparing Picture 1 and 2, it can be concluded that, in a certain situation, when the elasticity is greater, the smaller the residual impact force, the better the protection performance. From the table 1, the load elongation rate of sample 5 is 95.3%, and the rate of rapid elastic deformation is 0.0233%, Table 2 shows that the average value of the residual impact force is the lowest,
- 3) In these two graphs, some samples are not completely follow this rule, which is due to the existence of errors in the experiment and other properties of the material are different, and the elastic factor is a more important factor to influence the protective force.
- 4) The most fundamental reason for the anti impact performance of elastic material is that it can improve the security of the application of the time, while the elastic material can be extended by the elastic energy. There are still a lot of knowledge in the research of impact protection materials, which need to combine other concerning objects, such as the bio-mechanics, the mechanics and the dynamics, etc.

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