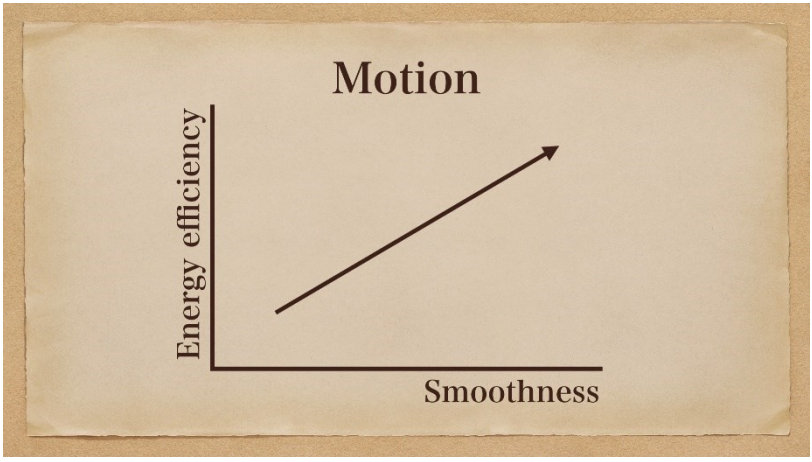
Chapter 1: Viewpoints

What is good movement? This is a theme I have been working on for many years as a physical therapist. In the process of this effort, I came to the viewpoint that it is “smoothness” and “energy efficiency”. I look at human body movements using these viewpoints. This chapter introduces these viewpoints.



1-1: Motion Smoothness

Smoothness is a word used in everyday life to describe a state of motion. What is “smooth motion”?

1-1-1: Definition

An object has the property of trying to continue its motion unless an external force acts on it. That is, an object at rest will continue to be at rest, and an object in motion will continue its motion. This property is known as the “law of inertia”. It is one of Newton’s laws of motion.

To change the motion of an object, some kind of force must act on it. Newton’s “equation of motion” states that force is the product of mass and acceleration. From this equation, we can say that force is the action that changes the velocity of an object. In other words, force is the action that changes the object’s motion.

From the law of inertia and the equation of motion, we can say the following. An object moving at a certain velocity tries to keep moving at that velocity. If the velocity at which an object moves changes, some kind of force must be acting on that object.

What about the human body? Take elbow joint flexion as an example. Normally, as the elbow joint is flexed, the forearm smoothly approaches the upper arm. Then, at the end range of motion, the forearm's velocity decreases, and finally, the forearm stops at a certain point. This is because natural resistance acts on the forearm's motion.

If excess resistance is added to the elbow movement, changes in velocity, trajectory, and range of motion that are not normal will always occur. **Smooth motion can be described as motion without excess resistance.** This definition is very practical. However, this definition is sometimes insufficient. A lack of necessary resistance within the body can cause improper changes in velocity, trajectory, and range of motion.

Thus, in this book, smooth motion is defined as motion without improper changes in velocity. Improper velocity changes will always occur if there is excess resistance or a lack of necessary resistance in a motion. To improve the smoothness of motion, it is important to remove the excess resistance generated in the body and ensure that the necessary resistance functions correctly.

1-1-2: Resistance Generated inside the Body

The human body is one system. Therefore, various resistances occur when the human body moves. The resistance inside the body is either necessary (natural) or excessive.

The resistance inside the body, whether necessary or excessive, is the action of physical forces. Therefore, forms of resistance can be classified into "push-back resistance" and "pull-back resistance".

The resistance generated inside the body is not constant. Here are some factors involved in generating excess resistance or the lack of necessary resistance.

Structural Factors

• Skeletal form

When the skeletal form is deformed at a joint, excess push-back resistance is often created at that joint during its related movement. In addition, the necessary resistance of the surrounding tissues is often lacking.

• Muscle length

When a muscle is shortened in length, excess pull-back resistance is often created in that muscle during its related movement. On the other hand, when a muscle is excessively lengthened, the necessary resistance from the muscle is often lacking.

• Tissue flexibility

When a tissue becomes less flexible, excess pull-back resistance is often created in that tissue during its related movement. On the other hand, when a tissue's flexibility is excessively increased, the necessary resistance from the tissue is often lacking.

• Tissue slide ability

When the slide ability between tissues is reduced, excess push-back or pull-back resistance is often created between those tissues during its related movement. In addition, the necessary resistance of the surrounding tissues is often lacking.

Functional Factors

• Mechanical stress

Mechanical stress is stress caused by physical forces applied to the body, such as pushing or pulling. Mechanical stress is classified as "compression stress" and "tension stress". Although there are many forms of mechanical stress, such as shear, torsion, and bending stress, all stresses are a combination of compression and tension stresses.

The physical quantity of mechanical stress is pressure, which is calculated by dividing the force by the area. Therefore, even if a certain amount of force is applied, if the area receiving the force is small, the magnitude of mechanical stress will be large.

When excessive mechanical stress occurs in a part of the body, an excessive reaction force is generated from this part, and the reaction force becomes excess resistance. For example, when flexing the lower limb, if excessive compression stress occurs on the

knee joint, excess push-back resistance is generated from the knee. When dorsiflexing the ankle joint, if excessive tension stress occurs at the Achilles tendon, excess pull-back resistance is generated from the tendon. Mechanical stress is one of the factors that causes excess resistance.

• Muscle tension

Just as there is tension in a guitar string or a tennis string, there is a certain amount of tension in muscles, referred to as “muscle tension”. Muscle tension is not always the same. There are various degrees of muscle tension when you are at rest, in motion, and under pressure. If muscle tension in a body part becomes excessive, excess resistance to pull back is generated from the body part. On the other hand, if muscle tension in a body part becomes excessively decreased, the resistance normally needed from the body part is often lacking during movement.

• Joint stability

When joint motion becomes unstable, it is difficult for joint structures to maintain proper alignment during movement. The resistance normally needed in the joint is lacking. Conversely, excess resistance is generated to the tissues surrounding the joint. Joint stability is a factor involved in the occurrence of excess resistance and the lack of necessary resistance.

I have presented some of the factors involved in the occurrence of excess resistance and the lack of necessary resistance. These factors occur in combination within the body in most cases. However, the therapist feels differently depending on which factors primarily arise. **By feeling the resistance generated from inside the body, it is possible to estimate what is going on inside the body.**

In my daily clinical practice, I make it a point to recognize the excess resistance. This is because the body part with motion limitation creates excess resistance in postures or movements. **By feeling the excess resistance generated from inside the body, it is possible to recognize the location of motion limitations in the body.**

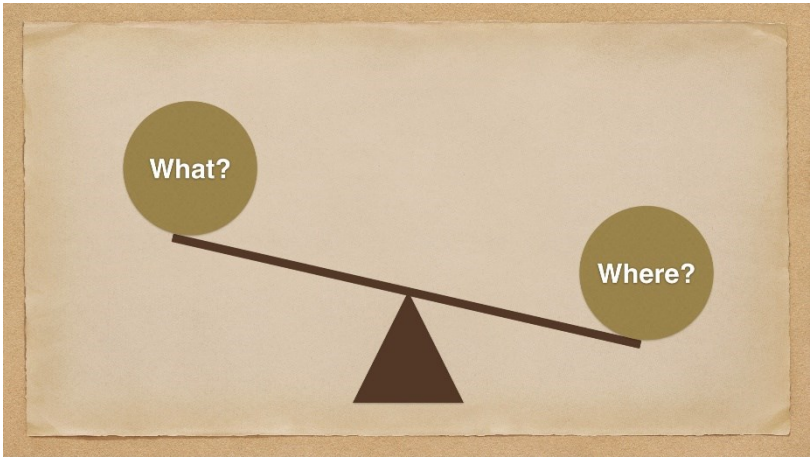
1-1-3: Motion Limitation

Motion limitation is a state in which the position of a body part cannot properly change in terms of posture or movement.

The body part that has motion limitation creates excess resistance in its related postures or movements. This effect is inevitable. Newton's "law of action-reaction" is helpful in understanding this phenomenon. For example, suppose you are driving a car and your tire comes into contact with a small stone on the road. In this case, the small stone generates a force that pushes back against the tire. This force limits the smooth motion of the car. The body part that has motion limitation creates excess resistances in its related postures or movements.

It is important to identify the part that causes motion limitation (primary limiting part) and the part where the motion limitation is caused (secondary limiting part). In the previous example, it was the small stone on the road that caused motion limitation; the car tire was the subject of motion limitation.

Motion limitation can occur in various tissues in the body. However, I do not think too much about what tissues are causing motion limitations. Rather, I focus on recognizing the location of the body part that causes motion limitation. In short, the "where" is more important than the "what". Methods for evaluating motion limitations are introduced in Chapter 3.



Not all motion limitations that occur in the body can be removed. However, motion limitations can cause various physical problems. Removing motion limitations will improve the smoothness of motion and contribute to solving various physical problems.

1-2: Motion Energy Efficiency

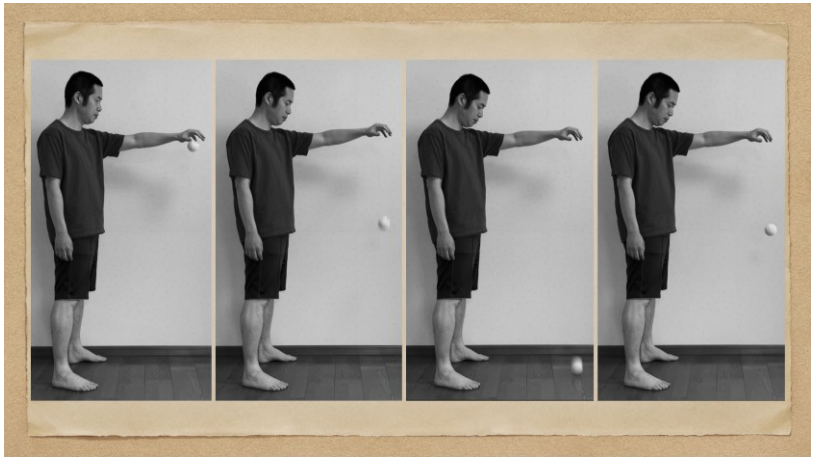
Energy is a word used in everyday life. The word “energy” means “the ability of an object to do work”. What is “energy-efficient motion”?

1-2-1: Definition

An object that is moving has kinetic energy. An object with height has potential energy. An object deformed by the action of external forces has elastic energy. There are various forms of energy, such as kinetic, potential, and elastic.

Energy does not come from nothing, nor does it disappear. This is the “law of conservation of energy”. Therefore, energy can be converted from one form to another.

For example, when a ball is lifted to eye level in the standing position, the ball has potential energy. When you release the ball from your hand, it falls toward the floor. At this time, the potential energy of the ball is converted into kinetic energy. When the falling ball contacts the floor, the shape of the ball is instantaneously deformed. At this time, the kinetic energy of the ball is converted into elastic energy. The ball bounces upward and gains potential energy again using this elastic energy.



The human body needs energy to move. It might be more appropriate to write that energy is needed to apply force. For example, to apply muscle forces, energy released via adenosine triphosphate (ATP) in the cells of the human body is needed.

What is “energy-efficient motion”? ATP in the cells of the human body is finite. In other words, the energy stored in the muscles is finite. Motions that rely excessively on muscle forces are not energy efficient. To perform energy-efficient motion, we need to make good use of some other force.

When the human body is regarded as a single system, forces acting from outside the body are referred to as “external forces,” while those generated inside the body are “internal forces”. Motions that make good use of external forces can reduce the excessive energy consumption of ATP.

Energy-efficient motion is motion that makes good use of external forces. This is the definition of “energy-efficient motion” used in this book. Muscle forces are essential for the motion of the human body. However, energy from ATP in the human body is finite. Motions that rely excessively on muscle forces are not energy efficient. To perform energy-efficient motion, it is important to make good use of external forces.

1-2-2: External and Internal Forces

In this book, the terms “external force” and “internal force” are used in reference to the human body. The sum of the external and internal forces determines the motion of the human body.

The most well-known external force is probably the Earth’s gravity. The Earth’s gravity pulls our bodies toward the ground. When our body is in contact with the ground, our body receives a force from the ground known as the “ground reaction force”. This force is a reaction force against gravity. By using these forces, we can perform various movements, such as walking and running.

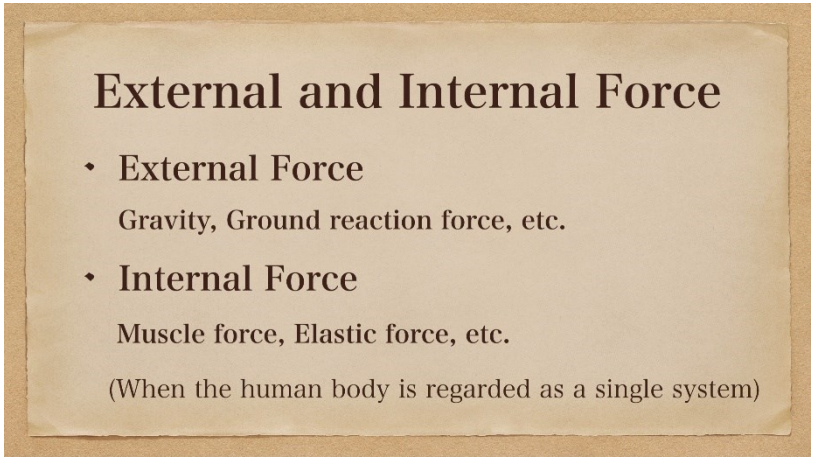
Imagine you are in space. Walking around freely in a weightless space is impossible because no external force is available. External force is necessary for various movements.

The most well-known internal force is probably muscle force. While muscle cannot

stretch by itself, it can contract. Therefore, for the muscles to exert force properly, they must be properly stretched during movement.

There are other internal forces. When an external force is applied to a body part, the shape of the body part changes. At this time, the force that tries to return the body part to its original shape is generated, known as the “elastic force”.

Elastic force occurs in various tissues. For example, when a muscle is passively stretched, it exerts tension at that moment. This is a type of elastic force. When a bone is compressed, it tries to push back. This is also a type of elastic force, although it is stiff. Various tissues, such as bones, muscles, skin, and membranes, are also involved in the exertion of elastic force.



Energy-efficient motion is motion that makes good use of external forces. This is my basic idea. However, much of the mechanical energy derived from external forces is converted to elastic energy in the body. Using elastic energy, the body exerts elastic force. **Thus, energy-efficient motion also makes good use of the body’s elasticity.**

1-2-3: Advantages of Using External Forces Well

By making good use of external forces, it is possible to make the body’s elasticity work properly in postures and movements. This prevents excessive energy consumption in the muscles and allows for energy efficient postures and movements. Using external forces well is energy efficient, which is an advantage.

There are other advantages. What I am about to describe is my subjective opinion based on my clinical experience. There are no quantified data of any kind. In my daily clinical practice, I feel that postures and movements that make good use of external forces are associated with less improper mechanical stress in the body than postures and movements that rely too much on muscle forces. **The risk of physical injury is small.** This is one of the advantages of using external force well.

Why do postures and movements that rely too much on muscle forces cause improper mechanical stresses? I would like to share my thoughts. When we perform some posture or movement by relying too much on muscle forces, an excess force that is not directly related to the posture or movement is inevitably generated. As a result, a discrepancy occurs between the action of external and internal forces. It can be written that the direction of the force action is not aligned. I think that the discrepancy between the action of external forces and the action of internal forces causes improper mechanical stress.

Excessive reliance on muscle forces results in high levels of improper mechanical stress. This tendency is more pronounced in people with low water content inside the body. Fluid can absorb shock. As the body's internal water content decreases, converting kinetic energy from excessive muscle activity into thermal energy becomes more difficult. As a result, excessive kinetic energy has undesirable effects.

To avoid misunderstanding, I do not deny the worth of muscle forces. Muscle forces are essential for the motion of the human body. I mean that motion that uses external forces well is energy efficient and is associated with a lower risk of physical injury. In addition, such motion leads to well-balanced muscle activity. Therefore, it is also possible to move powerfully with this approach.

Using external forces well has the following advantages:

- **Energy efficient**
- **Small risk of physical injury**
- **Sufficient power**

Summary of this chapter

This chapter introduced the viewpoints of “motion smoothness” and “motion energy efficiency”. I look at human body movements from these viewpoints.

The viewpoint of motion smoothness looks at the relationship between motion and force. Underlying this viewpoint is Newton’s laws of motion. Smooth motion is motion without improper changes in velocity. This is my basic idea. To improve the smoothness of motion, it is important to remove the excess resistance generated inside the body and ensure that the necessary resistance works properly. Removing motion limitations will improve the smoothness of motion and contribute to solving various physical problems.

The viewpoint of motion energy efficiency looks at the relationship between motion and energy. Underlying this viewpoint is the law of conservation of energy. Energy-efficient motion is motion that makes good use of external forces. This is my basic idea. External forces are forces acting from outside the body, such as the earth’s gravity and ground reaction forces. By making good use of external forces, it is possible to improve the energy efficiency of motion. This approach will contribute to reducing the risk of physical injury.