EMG of Leg Muscles in Standing Step, Walking and Running

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About the human fundamental movements such as standing step, walking and running, we examined the difference between leg muscles and the way to the level of their abilities in each. The athlete uses various muscle and muscular strength in these three movements, while the non-athlete uses a smaller amount of muscle in standing step and walking, but he uses greater amount of muscular strength in running.

The non-athlete doesn't lead to increased muscular ability just by standing step and walking, but the athlete leads to the one just by the same two movements.

1. Introducion

We human beings move after the instructions transmitted to our body from our brain, and they change into action by using part of our body. We call this action exercise. Each exercise is done by our hands, neck, legs or feet. Above all, the motions of legs are very important in point of the movement of the body. In thinking about the leg movement only, there are researchs: the reasearch in the reationship between speed and road surface slope change[1], sprint training including physical strength, sprinting ability and running action[2)3)] result of sprinting form. Fundamental stages of moving legs are divided into three areas -- standing step, walking and running. There are few examples of fundamental movements of physical exercise[4)5)].

Anyway, the exercise of moving legs shows a big individual difference of impulse and durability according to each motorial ability.

We studied the difference between leg muscles and the way to the difference of their abilities in each on standing step, walking and running. Also, we studied a way of using muscular strength in training for efficiency.

2. Experimental method and measurament system

2-1. An experimental method

Electric current for human beings is constant and it appears as electrical resistance according to moving muscle, and we can find the voltage by using both of them through

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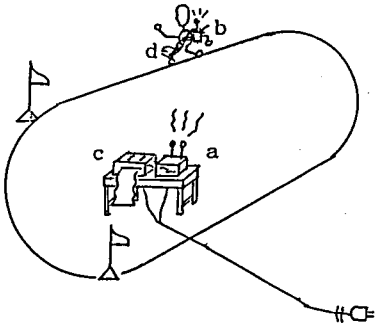
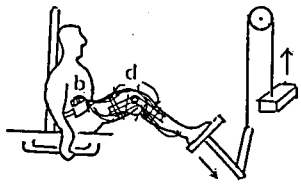


(1) Fundamental movement



(2) Leg press

a:receiver
b:transmitter
c:printer
d:small bionic electrode stuck

Fig. 1 Experimental appratus

Ohm's law. That is, we can replace the movement of muscle with voltage, and this voltage enables us to measure leg muscles on electromyogram(EMG)[6].

In measuring the electricity by the electromyogram, we used a multi-telemeter system(made in Nippon Koden Co.). This system is indicated in Figure 1. We used this system this way. We gathered the muscular voltage from small bionic electrodes stuck on the muscles and voltage is changed into a signal and the transmitter sends the information to the electromyogram. A receiver does receive it. It deals with the signals and generates ones in it according to some conditions sent by them as an electromyogram.

We elected six muscles related to a series of fundamental movements through standing step, walking and running to measure as seen in Figure 2. Our attention in this study was focused on just the right leg to measure movements of various muscles at the same time.

In the next experiment, we chose (1) an athlete active in the National Athletics (2) a non-athlete, as a subjet.

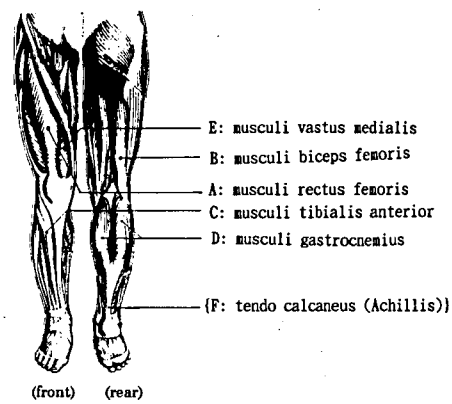


Fig. 2 Measured muscles

2-2. Method of measuring

We measured the muscular strength of six muscles(A to F) for standing step and walking in the gym as seen in Figure 2. In addition, we measured the muscular strength of four muscles(A to D) in three laps around the 300 meters track as seen in Figure 2. We took measurements five times to increase the reliability of our data. Especially, we were able to establish standard figure from those data.

2-3. Method of electromyogram's measurment using the load measuring instrument

Moving the body by using legs is transfering weight to the ground through the legs. Standing step, walking and running depend on degrees or ways and the number of times of transfering body weight. So we gram as seen in Figure 1. Then we examined the muscular strength of each muscle by using a load from 30kg to 90kg varing by 10kg.

3. Results

3-1. Case of measuring fundamental movement by electromyogram

Figure 3 compares the fundamental movements (standing step, walking and running) of the athlete and the non-athlete. It shows us the average amplitude of each movement and corresponding the value of one step.

By the way, the size of amplitude on the electromyogramed is proportional type degree of muscular strength. The unit is expressed by 10mm/1mV. Comparing the electromyogram between the two persons in walking, the size of amplitude is different, but their timing is about the same. On the other hand, the size of amplitude and timing in standing step and running show more than 3 variations between them. That is to say, their way of using, is almost the same, but the muscular strength is different. As for ways of using their muscular strength instanding step and running, both are different.

The non-athlete uses a smaller amount of muscle in standing step and walking, but

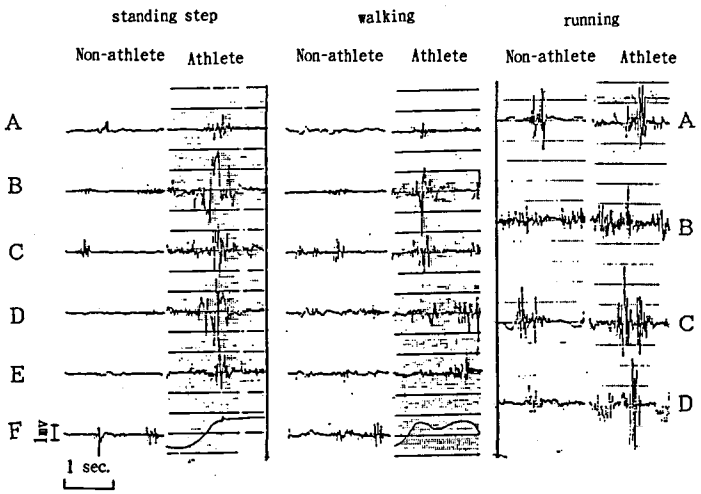


Fig. 3 EMGs of each muscle during 2 second

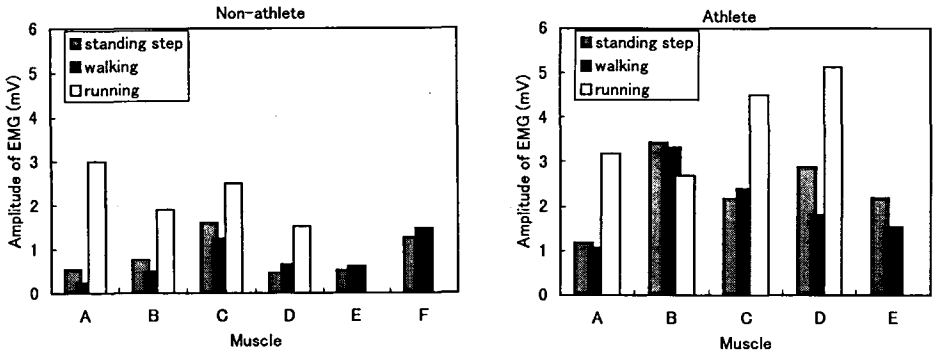


Fig. 4 Relationship between amplitude of EMG and measured muscles in fundametal movements

he uses greater amount of muscular strength in running, while the athlete uses various muscle and muscular strength in these three movements. As a result, the non-athlete doesn't lead to increased muscular ability just by standing step and walking, but the athlete leads to the one just by the same two movements as the two examples above.

Next, figure 4 shows the relation between amplitude of electromyogram and each measured muscle in the fundamental movements. The amplitude is average of fifteen steps. We can realize that each muscle has about two or three times the size in the difference of amplitude relatively. Also, ways of using each muscle are different, that is, the athlete uses musculi biceps femoris(B), in standing step and walking, while the non-athlete uses muscli tibialis anterior in three kinds of movements. Especially, comparing muscli biceps femoris(B) in point of three movements, the athlete uses it seven times in walking, four point five times in standing step, twice in running more than the non-athlete. In running the athlete uses musculi tibialis anterior(C) and musculi gastrocnemius(D) sufficiently, while the non-athlete uses musculi tibialius anterior(C) more than the other musculi and doesn't use musculi gastocnemius. Speaking of musculi tibialis a bit more, it is used often and a lot in skiing and various turning in sports activities. This fact has been clearly proved by Kitamura's study[7].

So we can conclude that in running the athlete has strengthened the musculi gastronemius(D) more.

3-2. Examples of Electromyogram Measurement by Load Measuring Instrument

Figure 5 shows the relation between amplitude of the electromyogram and load weight in training. We added a staged load weight to musculi rectus femoris(A), musculi biceps femoris(B), musculi tibialis anterior(C), musculi gastrocnemius(D), musculi vastus medialis(E) and tendo calcaneus(Achillis)(F) by using the load measuring instrument and examined gradual muscular strength of each muscle. As a result, the athlete uses the

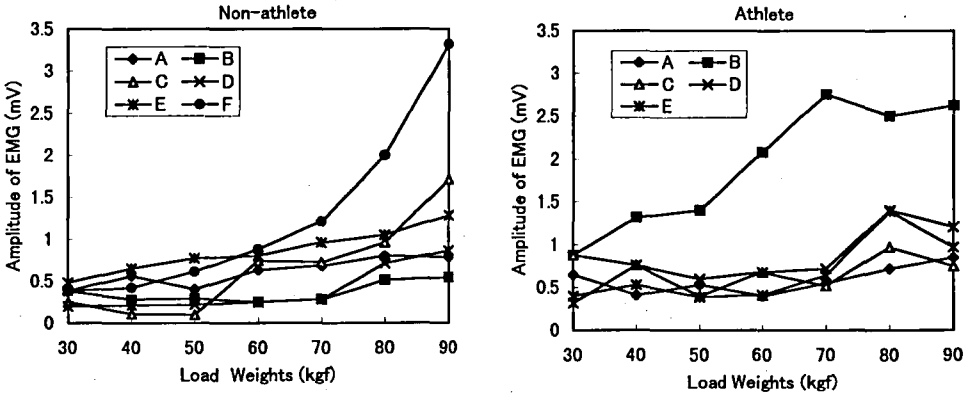


Fig. 5 Relationship between amplitude of EMG and load weight durung training

musculi biceps femoris more than the non-athlete, and the other muscles averagely within the limit of 70 kg's load weight, while the non-athlete had a big difference in a way of using each muscular strength, and this can be seen by the sudden rise of the amplitude signal in musculi tibialis anterior, musculi vastus medialis and tendo calcaneus(Achillis) from the point of 50 kg's load. Both of the subjects use each muscle more than usual. We recognize this fact as they showed their peak muscular strength; the non-athelete at 50kg's load weight point, and the athlete at over 80kg's point.

In addition, the athlete uses musculi biceps femoris and musculi gastrocnmius very well, and uses each of them almost equally. Judging from the results, we can make the most improvement in muscular strength. Especially, we can safely say that this phase is true of the athlete in using musculi biceps femori and musculi gastrocnmius the same as in running.

4. Conclusion

We analized the relationsip among various leg muscles mainly composed of musculi rectus femoris, musculi biceps femoris, musculi tibialis anterior, musculi gastrocnmius, musculi vastus medialis and tendo calcaneus (Achillis) by means of the electromyogram. In other words, We examined the difference of six kinds of muscular strength between an athlete and a non-athelete from the point of view of fundamental movements and training by using a load measuring instrument.

The result is as follows.

A. On the electromyogram of standing step, walking and running in fundamental actions between an athlete and a non-athelete

① Muscular strength was different in size, but about the same in pattern between them in walking.

② Muscular strength was different in size and in pattern instanding step and running.

③ Especially, in standing step, walking and running, an athlete had a larger amplitude signal of musculi biceps femoris(B), musculi tibialis anterior(C) and musculi gastrocnemius(D) and average muscular strength of each muscle.

④ On the other hand, non-athelete used muscles only a little in standing step and walking.

B. The relationship between the amplitude of the electromyogram and each muscle measured in the fundamental actions

⑤ Relatively looking over the comparison of each muscle, there was a difference of size twice to three times in amplitude between the athlete and the non-athelete. And they had a difference in the way of using each muscle. For example, the athlete used musculi biceps femoris(B) in standing step and walking, while the non-athelete used musculi tibialius anterior(C) in standing step, walking and running.

C. On the relationship between amplitude of electromyogram and load weight during training

⑥ The athlete used each muscle except musculi biceps femoris(B) averagely within 70kg's load.

⑦ The non-athlete had a big difference of ways of using each muscle.

⑧ We can conclude that we can develop our ability of standing step, walking and running by strengthening musculi femoris and musculi gastrocnemius through training.

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