On Preliminary Research into Correlativity between Mechanical Characteristics of Sole of Foot and Upper Limb while Walking

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Abstract—In this paper, the walking capturing system so-called Simi Motion from Germany and the planta-pressure analyzing system so-called Footscan from Belgium are introduced. The above-mentioned systems make quantitative descriptions of all cases such as walking motions and plantar mechanical characteristics etc., and do a theoretical analysis of the relationship between swaying upper-limb and plantar mechanical characteristics in combination of limb motions with plantar pressure. The result of experimental research shows that there are significant differences in plantar mechanical characteristics that are related to the swaying upper limb both at same speed but different swaying posture and at different speed but same swaying posture. At the same time, it is found from the parametric statistics of the articulation points of upper limb that the correlativity in the articulation points is extremely notable during swaying upper limb. Therefore this study has laid a foundation for the individual and identical recognition by means of plantar mechanical characteristics and walking postures.

Index Terms—Simi Motion, Footscan, Plantar mechanical characteristics, Upper-limb motion, Correlativity

I. INTRODUCTION

In recent years, the personal analysis with the aid of walking posture has gradually become a new trend in the research of individual recognition. In some countries, the automatic recognition of walking posture is widely used in sensitive positions e.g. in airports and customs and plays a decisive role in the field of national public security. Based on the developing trend, this paper intends to utilize the two systems, namely Simi Motion for motion capture and Footscan for planta-pressure analysis, to analyze the relationship between upper-limb swinging and plantar mechanical characteristics, to combine the active limb motions with the footmark pressures and to look for the correlativity between them. Besides advanced instruments, the method of mathematical statistics is also applied to describe the limb motions and plantar mechanical characteristics so as to digitize these body’s motions and to further perfect the research system of individual recognition heading to a new extension. In company with the increasing demand for the individual recognition and the development of technology itself, it is foreseeable that the study of limb motions and plantar mechanical characteristics would develop in depth more and more.

According to its formation, the footmark is a kind of trace left behind by the interaction between feet and objects; but in the full meaning, it covers a series of motions, which can reflect the body’s function, walking habit and how to form his trace through the direction, magnitude and action point of acting force produced by feet in contact with ground. So in research into the footmark, it must be integrated with body’s motion. Because the walking motion is body-harmonious and complicated, and is in need of the intercoordination and regular movement of head, trunk and limb in a certain way, these actions will influence and restrict each other [1]. If there is any change in a certain part, it will result in the change of the integral structure and the centre of gravity, and the balanced lever system will be broken. Thus it can be seen that the organs of body’s parts can exert their crucial influences on the whole walking motion. Moreover, the obvious posture of body’s organs while walking can be reflected in plantar mechanical characteristics. Meanwhile, both walking postures and plantar mechanical characteristics all respectively have the nature of particularity and relative stability, which are the key that can be used in the individual and identical recognition and are also the prerequisite of research in this paper [2].

II. COLLECT PROCESSING

A. Experiment Subject

28 testees are selected in the experiment. The registration spheres are tied to the wrist joint, elbow joint, shoulder joint, hip joint, knee joint and ankle joint on the left side of their body respectively. They pass through the pressure test board of Footscan at the normal and quick walking speed. The parameters of their body height, age and body weight are shown in Table 1.

<table>
<thead>
<tr>
<th>No.</th>
<th>Body Height (cm)</th>
<th>Age</th>
<th>Body Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>174</td>
<td>20</td>
<td>74</td>
</tr>
<tr>
<td>2</td>
<td>168</td>
<td>25</td>
<td>69</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>27</td>
<td>176</td>
<td>49</td>
<td>80</td>
</tr>
<tr>
<td>28</td>
<td>172</td>
<td>21</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 1: Experiment Subject
B. Experimental Apparatus

Simi Motion 3D motion video analysis system: This system includes the desktop computer, two sets of Panasonic GS308 digital video cameras, calibration shelf, 20 labeling balls having a diameter of 25.4 mm (They are used for the automatic identification of mark point).

Footscan analysis system for pressure of Sole of Foot: This system includes the notebook computer, PC interface board, pressure transducer, flat plate sensor (2 M × 40 cm) and cables and wires.

C. Experimental Procedure

a. To Calibrate The Frame And To Edit The Joint Point Of Human Body

Place the calibration shelf in the laboratory, run the software of SIMI Motion, and two video cameras on the left side and right side record the certain calibrated video at the same time. And then utilize the software to calibrate the frame of space of the laboratory, establish the three dimensional coordinate axis, and make preparations for the data processing after collecting the human body characteristics, which is shown in Figure 1. At the same time, utilize the software of SIMI Motion to edit and connect the joint point of human body. The joint point utilized mainly in this experiment includes the wrist joint, elbow joint and so on [3].

b. Data Acquisition And Processing

Let the testees carry the labeling balls on their joint points respectively to walk in the way of normal walking and quick walking for five round trips on the pressure test board, among of them, the two video cameras capture the video of the walking postures respectively at the different angle, the mechanical characteristics such as the pressure of Sole of Foot and so on are collected through the Footscan pressure board, which is shown in Figure 2. Send the video that is needed to process into the software of SIMI Motion, calibrate the walking postures of human body video frame by frame according to the previously edited joint points, there are about 150 frames per video, which is shown in Figure 3. After calibrating the video of walking postures frame by frame, the software of SIMI Motion can process the data. There are many function of data processing in this software. The software can make the stick shape diagram and curve diagram and calculate the centre of gravity of human body, angle, the length of X, Y and Z axis, speed and acceleration and so on [4].

c. Output Of Data

The software of SIMI Motion can also send out and save the curve diagram of the raw data, the amplitude of swing of X, Y and Z axis of every joint point, speed, acceleration that are collected, and also can send out the whole section of processed stick shape diagram, three-dimensional diagram in the mode of video, which is shown in Figure 4 and Figure 5.

III. EXPERIMENTAL DATA ANALYSIS

A. Analysis Of Correlativity Between The Different Arm-Swinging Posture And Mechanical Characteristics Of Sole Of Foot

Because of the influence of the factors such as the swinging postures of other positions of human body and the body height, age, body weight and so on, the general analysis result of correlativity between the upper limb swinging and mechanical characteristics of Sole of Foot is not ideal. We attempt to compare and analyze the two different kinds of swinging postures of upper limb of each testing object under the condition of the same and similar other factors [5].
B. Comparison Between The Swinging Of Arm To The Left And Right And The Swinging Of Arm To The Front And Behind

Let the testees walk normally at the walking speed of about 1.5 m/s. Their arm-swinging postures are the swinging of arms to the left and right and swinging of arms to the front and behind respectively when they are walking. And then compare the difference between their swinging posture and the peak values of pressure of every position of Sole of Foot. In the comparison, the number of swinging the arms to left and right is No. 1, and the number of swinging the arms to front and behind is No. 2. The walking postures and 3D stick shape diagram under the two kinds of conditions are shown in Figure 6 and Figure 7.

![Figure 6: 3D Stick Shape Diagram of Walking Postures of No. 1](image)

![Figure 7: 3D Stick Shape Diagram of Walking Postures of No. 2](image)

a. Comparison Between Acceleration Of Wrist Joint

By comparing the peak acceleration of wrist joint in every direction in Table 2, it can be found: the peak acceleration of wrist joint in every direction of swinging the arms to the left and right is higher than that of swinging the arms to the front and behind, the peak acceleration of wrist joint in every direction of swinging the arms to the up and down is lower than that of swinging the arms to the front and behind. The curve diagram of acceleration is shown in Figure 8 and Figure 9.

![Figure 8: Acceleration of X, Y and Z Axis of Wrist Joint of No. 1](image)

![Figure 9: Acceleration of X, Y and Z Axis of Wrist Joint of No. 2](image)

Table 2: Peak Acceleration of X, Y and Z Axis of Wrist Joint (m/s²)

<table>
<thead>
<tr>
<th>No.</th>
<th>ax</th>
<th>ay</th>
<th>az</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13.772</td>
<td>28.403</td>
<td>8.143</td>
</tr>
<tr>
<td>2</td>
<td>7.841</td>
<td>18.174</td>
<td>16.552</td>
</tr>
</tbody>
</table>

b. Comparison Between The Point Of Raising The Foot And The Point Of Planting The Foot

FOOTSCAN analysis system of pressure of Sole of Foot can draw a central line of pressure of footmark automatically according to the change of pressure of Sole of Foot when walking, and can send out the value of pressure central line to deviate from the central line of footmark every time. The central line of pressure here refers to the curve that when a person is walking, the motion of seven supporting positions (1-Planting of Foot, 2-Heel, 3-Arch Area, 4-Sole of Foot, 5-Palma and Soles, 6-Toe Area, 7-Raising of Foot) of the supporting foot beginning from the planting of foot to using the foot to pedal the ground to raise the foot to interact with the ground is the continuous motion from the behind to the front, when he pass through the pressure test board, the central points of pressure are connected to a curve of trend of shape of the pressure surface of every position of the foot to the raising of the foot. Because of the limit of condition of anatomy shape and bearing face of foot and the difference of characteristic of walking motion of individual, the central line of pressure of footmark formed in reality is an intermittent curve, and the intermittent distance and position, and degree and position of bending vary with each individual, which is shown in Figure 10. By comparing the degree of central point of pressure of Sole of Foot to deviate from the central line of footmark at the time of raising and planting the foot under the both 1 and 2 conditions, it can be found that the swinging postures influences the position of central point of pressure of Sole of Foot [6].

![Figure 10: Central Line of Pressure](image)
footmark is. By means of statistics of the values of central line of pressure that deviate from the central line of footmark at this point at the time of planting the foot and raising the foot, it can be reflected that the walking postures influences the swinging to the left and right of pressure of Sole of Foot. The reached conclusion is shown in Table 3.

<table>
<thead>
<tr>
<th>No.</th>
<th>Plant</th>
<th>Raise</th>
<th>Plant</th>
<th>Raise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-4.6</td>
<td>25</td>
<td>-2.4</td>
<td>22.7</td>
</tr>
<tr>
<td>2</td>
<td>-4.1</td>
<td>24.4</td>
<td>-2.6</td>
<td>18.5</td>
</tr>
<tr>
<td></td>
<td>-5.6</td>
<td>21.6</td>
<td>-3.8</td>
<td>18.7</td>
</tr>
<tr>
<td></td>
<td>-4.7</td>
<td>19.4</td>
<td>-3.2</td>
<td>19.9</td>
</tr>
<tr>
<td></td>
<td>-8</td>
<td>18.1</td>
<td>-5.6</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>-5.4</td>
<td>21.7</td>
<td>-3.52</td>
<td>20.16</td>
</tr>
</tbody>
</table>

Table 3: Distance of Central Point of Pressure

By comparing the absolute values of central point of pressure of Sole of Foot at the time of raising the foot and planting the foot in the table, it is found: the planting of foot of No.1 > the planting of foot of No.2, and the foot raising of No.1 > the foot raising of No.2. It is obvious that the distance of central point of pressure from the central line of footmark when swinging the upper limbs to the left and right in the stage of raising the foot and planting the foot in the walking course is longer; the distance of central point of pressure from the central line of footmark when swinging the upper limbs to the left and right in the stage of raising the foot and planting the foot in the walking course is shorter. Comparing the swinging of upper limbs to the left and right with the swinging of upper limbs to the front and behind, the swinging to the left and right more obvious in the aspect of mechanical characteristics of Sole of foot.

C. Comparison Between The Peak Values of Pressure of Every Area of Sole of Foot

By comparing the peak values of pressure of every position in Table 4, it can be found: the peak values of pressure of Meta 1 and Meta 5 of No. 1 is higher than that of No. 2, which indicates that under the condition of swinging to the left and right, the higher pressure of Sole of Foot is distributed on the inside and outside of footmark, in order to maintain the balance of the body. The peak values of pressure of Toe 1, Meta 2, Meta 3, Meta 4 and Heel of No. 1 are less than that of No. 2, which indicates that under the condition of swinging to the front and behind, the higher pressure of Sole of Foot is distributed in the positions of raising the foot, planting the foot and the position of center of metatarsus area. The curve of peak value pressure of Sole of Foot under the condition of swinging to the left, right and front and behind is shown in Figure 11 and Figure 12.

From the comparison between all the parameters mentioned above, it can be found: when swinging the arms to the left and right, the peak acceleration of wrist joint in the left, right, front and behind direction is higher, the peak acceleration in the up and down direction is lower, the peak value of pressure of Sole of Foot of Meta 1 and Meta 5 is higher, the positions of raising the foot and planting the foot deviate from the central line of footmark, and the swinging to the left and right is more obvious. When swinging the arms to the left and right, the peak acceleration of wrist joint in the up and down direction is higher, and the peak acceleration in other two directions is lower, the pressure of Sole of Foot of Heel, Toe 1, Meta 2, Meta 3 and Meta 4 areas is higher, and the position of raising the foot and planting the foot is close to the central line of footmark [7].

C. Comparison Between The Swinging Of Forearm And The Swinging Of Upper Arms

Let every testee walk normally at the walking speed of about 1.5 m/s. When walking, the arms swinging posture is to swing the arms to the front and behind, and there is a difference in the aspect of swinging the arm: to swing the forearm in one walk and swing the upper arms in other walk. Compare the difference between the two kinds of arms swinging posture and the pressure of Sole of Foot. The number of swinging the forearm is No. 3, and the number of swinging the upper arms is No. 4. Two kinds of walking postures and 3D stick shape diagram are shown in Figure 13 and Figure 14 [8].
a. Comparison Between The Acceleration Of Wrist Joint

By comparing the acceleration of wrist joint in every direction in Table 5, it can be found that the acceleration of X axis is similar to each other, the acceleration of Y axis and Z axis when swinging the forearm is higher than that when swinging the upper arms. The curve diagram of acceleration is shown in Figure 15 and Figure 16.

![Figure 15: Acceleration of X, Y and Z Axis of Wrist Joint of No. 3](image)

![Figure 16: Acceleration of X, Y and Z Axis of Wrist Joint of No. 4](image)

**Table 5:** Peak Acceleration of X, Y and Z Axis of Wrist Joint (m/s²)

<table>
<thead>
<tr>
<th>No.</th>
<th>ax</th>
<th>ay</th>
<th>az</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4.568</td>
<td>12.147</td>
<td>6.214</td>
</tr>
<tr>
<td>4</td>
<td>4.430</td>
<td>7.368</td>
<td>4.574</td>
</tr>
</tbody>
</table>

b. Comparison Between The Angles Of Elbow Joint

By comparing the maximum bending angle of elbow joint in Table 6, it can be found: the maximum bending angle of swinging the forearm is obviously greater than the maximum bending angle of swinging the upper arms. The curve diagram of angle of elbow joint is shown in Figure 17 and Figure 18.

![Figure 17: Curve of Bending Angle of Elbow Joint of No. 3](image)

![Figure 18: Curve of Bending Angle of Elbow Joint of No. 4](image)

**Table 6:** Maximum Bending Angle of Elbow Joint (Degree)

<table>
<thead>
<tr>
<th>No.</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>66.294</td>
</tr>
<tr>
<td>4</td>
<td>25.251</td>
</tr>
</tbody>
</table>

c. Comparison Between The Peak Values Of Pressure Of Every Area Of Sole Of Foot

By comparing the peak values of pressure of every position of Sole of Foot in Table 7, it can be found: the peak values of pressure of Toe 1 and Meta 1 when swinging the forearm are more than that when swinging the upper arms, the peak values of pressure of all the other positions when swinging the forearm are less than that when swinging the upper arms, which indicates that when swinging the forearm, the higher pressure of Sole of Foot is distributed on the of Toe 1 and Meta 1, the pressure of Sole of Foot in the stage of using the metatarsus to pedal the ground and raising the foot is higher. And when swinging the upper arms, the higher pressure is distributed on the Meta 2 and Meta 3, that is, on the position of center of metatarsus area. The curve diagram of peak value of pressure of Sole of Foot is shown in Figure 19 and Figure 20.

![Figure 19: Pressure of Every Area of Sole of Foot of No. 3](image)

![Figure 20: Pressure of Every Area of Sole of Foot of No. 4](image)

**Table 7:** Maximum Peak Value of Pressure of Sole of Foot (N/cm²)

<table>
<thead>
<tr>
<th>No.</th>
<th>Toe 1</th>
<th>Meta 1</th>
<th>Meta 2</th>
<th>Meta 3</th>
<th>Meta 4</th>
<th>Meta 5</th>
<th>Heel</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>11.66</td>
<td>11.60</td>
<td>13.84</td>
<td>17.54</td>
<td>10.18</td>
<td>2.2</td>
<td>13.52</td>
</tr>
<tr>
<td>4</td>
<td>4.44</td>
<td>7.24</td>
<td>22.68</td>
<td>21.84</td>
<td>10.92</td>
<td>2.5</td>
<td>14.78</td>
</tr>
</tbody>
</table>

It can be found from the comparison between all the parameters mentioned above that under the condition of the postures of swinging the upper limb to the front and behind when walking, when swinging the forearm, the peak acceleration of wrist joint in the front, behind, up and down direction is higher, and the maximum bending angle of elbow joint is also greater, the peak values of pressure of Sole of Foot in the stage of raising the foot is larger. When only swinging the upper arms, the peak acceleration of wrist joint in the front, behind, up and down direction is lower, and the maximum bending angle of elbow joint is also smaller, the peak values of pressure of Sole of Foot in the stage of raising the foot is smaller, the peak values of pressure of Sole of Foot of Meta 2 and Meta 3 areas is larger.

D. Comparison Between Different Walking Speeds

Test the relationship between the upper limb swinging postures and pressure of Sole of Foot of every testee.
under the condition of different walking speed. The slow walking speed is 1.5 m/s and the quick walking speed is 2.5 m/s. The walking postures at the different speed and 3D stick shape diagram are shown in Figure 21 and Figure 22 [9].

Figure 21: 3D Stick Shape Diagram When Walking Slowly

Figure 22: 3D Stick Shape Diagram When Walking Quickly

a. Comparison Between The Acceleration Of Wrist Joint

By comparing the peak acceleration of wrist joint in every direction Table 8, it can be found: when the walking speed is increased, the peak acceleration in every direction is increased obviously. The curve diagram of acceleration is shown in Figure 23 and Figure 24.

Figure 23: Acceleration of X, Y and Z Axis of Walking Slowly

Figure 24: Acceleration of X, Y and Z Axis of When Walking Quickly

Table 8: Peak Acceleration of X, Y, Z Axis of Wrist Joint (m/s²)

<table>
<thead>
<tr>
<th>Walking Speed</th>
<th>ax</th>
<th>ay</th>
<th>az</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk Slowly</td>
<td>4.568</td>
<td>12.147</td>
<td>6.214</td>
</tr>
<tr>
<td>Walk Quickly</td>
<td>7.841</td>
<td>18.174</td>
<td>16.552</td>
</tr>
</tbody>
</table>

b. Comparison Between Angle Of Elbow Joint

By comparing the maximum bending angle of elbow joint in Table 9, it can be found: when the walking speed is increased, the maximum bending angle of elbow joint is increased obviously. The curve diagram of angle of elbow joint is shown in Figure 25 and Figure 26.

Figure 25: Curve of Bending Angle of Walking Slowly

Figure 26: Curve of Bending Angle of Walking Quickly

Table 9: Maximum Bending Angle of Elbow Joint Unit: Degree

<table>
<thead>
<tr>
<th>Walking Speed</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk Slowly</td>
<td>66.294</td>
</tr>
<tr>
<td>Walk Quickly</td>
<td>83.774</td>
</tr>
</tbody>
</table>

c. Comparison Between The Central Points Of Pressure When Raising The Foot And Planting The Foot

By comparing the absolute values of distance of central point of pressure from the central line of footmark at the time of raising and planting the foot in Table 10, it can be found: all the difference values between the central points of pressure of raising and planting the foot when quickly walking and slowly walking are less than 0.5, which indicates that the difference between the vertical distances of point of force application of the same person from the central line of footmark in the stage of planting and raising the foot in the walking at the quick speed is not obvious, the distance of position of raising the foot and planting the foot is not increased along with the increase of speed.

Table 10: Distances between the Central Point of Pressure and Central Line of Footmark at the Time of Raising and Planting the Foot (mm)

<table>
<thead>
<tr>
<th>Walking Speed</th>
<th>Plant Foot</th>
<th>Raise Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk Slowly</td>
<td>-3.42</td>
<td>20.16</td>
</tr>
<tr>
<td>Walk Quickly</td>
<td>-2.98</td>
<td>20.36</td>
</tr>
</tbody>
</table>

d. Comparison Between The Peak Values Of Pressure Of Every Area Of Sole Of Foot

By comparing the peak values of pressure of every area of Sole of Foot in Table 11, it can be found: the peak values of pressure of Toe 1 and Meta 1 when walking slowly are more than that when walking quickly, the peak value of pressure of all other positions when walking slowly are less than that when walking quickly. It indicates that the higher pressure of Sole of Foot when walking slowly is distributed on the Toe 1 and Meta 1, that is to say, the pressure of Sole of Foot in the stage of pressing down the Meta 1 and raising the foot is higher. And the higher pressure when walking quickly is distributed on the heel, Meta 2, Meta 3, Meta 4 and Meta 5 areas. The curve diagram of peak value of pressure of Sole of Foot is shown in Figure 27 and Figure 28.
lower the peak acceleration of wrist joint is, the smaller
the peak acceleration of wrist joint is, the larger
the wrist joint and the movement of elbow joint. The larger
is a remarkable correlativity between the movement of
when swinging the upper limbs as the people walks, there
is a remarkable correlativity between the movement of
wrist joint of upper limbs, it is found that when the upper
limbs and the mechanical characteristics of Sole of Foot
joint point of upper limbs, it is found that when the upper
limbs and the mechanical characteristics of Sole of Foot,
shape, the pressure when planting the foot is increased,
and the different body height, age, body weight and
change of speed. The main reason is that the walking
motion of human body is very complicated, besides the
swinging of the upper limbs, the motion of head, trunk
and lower limbs of human body jointly influence the
formation of mechanical characteristics of Sole of Foot,
and the different body height, age, body weight and
walking speed also influence the mechanical
characteristics of Sole of Foot.

Table 11: Maximum Peak Value of Pressure of Foot (N/cm²)

<table>
<thead>
<tr>
<th>Walking Speed</th>
<th>Toe 1</th>
<th>Meta1</th>
<th>Meta2</th>
<th>Meta3</th>
<th>Meta4</th>
<th>Meta5</th>
<th>Heel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk Slowly</td>
<td>11.66</td>
<td>11.6</td>
<td>13.84</td>
<td>17.54</td>
<td>10.18</td>
<td>2.2</td>
<td>13.52</td>
</tr>
</tbody>
</table>

It can be found from the comparison between all the
parameters mentioned above that when the walking speed
of the same person is increased, the peak acceleration of
motion of wrist joint in every direction is increased, the
maximum bending angle of elbow joint is increased, the
step angle becomes smaller, the pressure of the heel,
Meta 2, Meta 3, Meta 4 and Meta 5 areas is increased, the
pressure of Toe 1 and Meta 1 areas is reduced, that is to
say, the pressure when planting the foot is increased,
and the pressure when raising the foot is reduced. The
influence of change of walking speed on the position of
raising the foot and planting the foot is smaller, the
position of point of raising and planting the foot will not
change because of the change of the speed.

IV. RESULT AND DISCUSSION OF EXPERIMENT

By analyzing the general sample, it is found that
swinging the upper arms as the people walks, there
is a remarkable correlativity between the movement of
wrist joint and the movement of elbow joint. The lager
the peak acceleration of wrist joint is, the lager the
maximum bending angle of elbow joint is, whereas, the
lower the peak acceleration of wrist joint is, the smaller
the maximum bending angle of elbow joint is.

By comparing and analyzing the testees who walk at
the same speed in the way of different walking postures,
it is found: first, when swing the arms to the left and
right, the peak acceleration of wrist joint in the left, right,
front and behind directions is higher, the peak
acceleration in the up and up and down direction is lower,
the pressure on the inside and outside of Sole of Foot is
higher. When swinging the arms to the front and behind,
the peak acceleration of wrist joint in the left, right, front
and behind directions is lower, the peak acceleration in
the up and down direction is higher, the pressure of
central area of Sole of Foot is higher. Second, when
swinging the forearm, the peak acceleration of wrist joint
in the front, behind, up and down direction is higher, the
maximum bending angle of elbow joint is also greater,
the peak values of pressure of Sole of Foot in the stage
of raising the foot is larger, the peak values of pressure
of Sole of Foot in the Meta 2 and Meta 3 areas is smaller.
When only swinging the upper arms, the peak
acceleration of wrist joint in the front, behind, up and
down direction is lower, the maximum bending angle of
elevator joint is also smaller, the peak values of pressure
of Sole of Foot in the stage of raising the foot is smaller,
the peak values of pressure of Sole of Foot in the Meta 2 and
Meta 2 areas is larger [10].

By comparing and analyzing the same walking
postures and different walking speed of the same person,
it is found: when the walking speed is increased, the peak
acceleration of movement of wrist joint in every direction
is increased, the maximum bending angle of elbow joint
is increased, the step angle becomes smaller, the pressure
in the heel area, Meta 2, Meta 3, Meta 4 and Meta 5 areas
is increased, the pressure in the Toe 1 and Meta 1 areas is
reduced, that is to say, the pressure of planting the foot is
increased, the pressure of raising the foot is reduced. The
influence of change of walking speed on the position of
the point of raising the foot and point of planting the foot
is smaller; the position of the point of raising the foot and
point of planting the foot does not change because of the

When analyzing the characteristics of motion of upper
limbs and the mechanical characteristics of Sole of Foot
of test sample, we find that the correlativity between the
both will be unstable. The main reason is that the walking
motion of human body is very complicated, besides the
swinging of the upper limbs, the motion of head, trunk
and lower limbs of human body jointly influence the
formation of mechanical characteristics of Sole of Foot,
and the different body height, age, body weight and
walking speed also influence the mechanical
characteristics of Sole of Foot.

V. CONCLUSION AND PROSPECTS

In the study described by this paper, the advanced
analysis system for pressure of Sole of Foot and motion
capture system in this country are introduced to analyze
the relevant data of motion characteristics of upper limb
of human body and the mechanical characteristics of Sole
of Foot, and then the data are compared and analyzed,
which makes the description of characteristics more
standardized and quantized. The research achievements
made by this paper are mainly as follows:

(1) To change the traditional and empirical
description of walking postures, and to use the foreign
advanced apparatus to quantize the description of walking
postures [12].

(2) By means of statistics of every parameters of
joint point of upper limbs, it is found that when the upper
limbs of human body swing, there is the correlativity
between all the joint points.

(3) To combine the walking postures with the
mechanical characteristics of Sole of Foot, to find the
correlativity between them, to summarize the mechanical characteristics of Sole of Foot that is corresponding to the four kinds of different walking postures of swinging the arms to the left and right, front and behind, and swinging the forearm and upper arms, and to provide the new basis for the identification and analysis of individual.

(4) To analyze the motion characteristics of upper limb and mechanical characteristics of Sole of Foot of same person at the different speed, to use the quantified data to describe the qualitative analysis of different-speed walking motions, and find the stability and discrepancy of all kinds of characteristics at the different speed.

The study in this stage has achieved the certain positive result on the collection of characteristics of motion of upper limb of human body and mechanical characteristics of Sole of Foot. In the course of future data acquisition, it is necessary to establish the strict standard and for the testee and experiment environment, to reduce the human error, and through the work of data collection in the previous period, we hope to establish the data base of walking postures of human body, and to lay the foundations for the identification of walking postures.

REFERENCE


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