DEVELOPMENT OF A PULLING-REAPING TRAINING & MEASUREMENT INSTRUMENT TO ENHANCE JUDO PERFORMANCE

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The purpose of this study was to develop a judo-doll *uke* (partner) for training and measurement applicable to pulling, pushing and sweeping in Judo. In Judo the most common techniques consist of the pulling, pushing and reaping which all need to be practiced with a partner. So research needs to develop a measurement system that can be used to evaluate the forces involved with these techniques. The Doll-Uke was developed so that Judoists can train alone. After the manufacture of Doll-Uke the strengths and weaknesses were recorded and evaluated. The height of a Doll-Uke is 170cm and has a weight of 70kg. Doll-Uke was developed with a trunk angle of 55° and the lower extremities of an angle of 45°. The Doll-Uke can also measure the forces developed during the pulling, pushing and reaping. Due to the ability of the system to measure the forces while performing Judo techniques, feedback can be provided to the Judoists to improve their performance during training.

KEY WORDS: judo, pulling, pushing, reaping, judo-doll

INTRODUCTION:

In 1992 the Japanese Judo Federation developed equipment for the practice and measurement of the shoulder throw (*Seoi-nage*). In 1994, Kim E.H. et al. developed a judo-doll that closely resembled the body of a Judoist. The effectiveness of tube training technique was measured by equipment developed by Kim et al. (2005). For the training of pulling techniques in Judo, high density elastic bands are used. In Judo, there are many Judoists that need training equipment to practice their basic techniques which comprise of pulling, pushing and reaping alone. With such equipment, Judoists will be able to practice at much as he/she desires the important techniques alone without a partner and through this they can improve their techniques substantially more. So the purpose of this research is to develop equipment that can be used instead of a partner while practicing Judo techniques. Also it needs to be able to measure the forces that would be experienced by a partner during training in order to provide feedback.

METHOD:

Understanding the characteristics and kinematics involved with basic Judo techniques
In this study the kinetic and kinematical analysis for 2 Judoist was recorded by force platforms and 7 MX13 Vicon cameras. 10 trials were captured but only 5 suitable trials of the *Osotogari* were analyzed. The important kinematic variables were the maximum knee joint flexion angle of 45°, the maximum extension of the trunk angle 52.2°, the maximum lateral flexion angle of the trunk 16.6°, and the maximum rotation angle of the trunk 49.1°.

Design of the judo training equipment and its scale: With the consideration of the physical characteristics surveyed previously (latest evaluation of the Judoist in international competition in 2007), i.e. size and weight of elite Judoist the Judo-doll was manufactured. basic judo training-doll that looks similar to a human with a skeletal muscle, body and lower extremities. In figure 1 the upper extremities, were attached and then the shoulder joints, knee joints and hip joints were manufactured and given the ability to move through their specific range of motion.

Latest Model: With the consideration of the strengths and weaknesses of the judo-doll in figure 2, the third judo-doll was manufactured. The multi-axial function of the shoulder joint

was re-manufactured and the knee and hip joints were fixed. For more realistic movement of the dolls trunk a spring was inserted and fixed into the trunks column and thus the trunk returns to its original posture. Also springs were inserted in the head and legs. For the measurement of the pulling, pushing and sweeping power a shift-sensor was attached inside the Judo-doll and covered by PRP which is a material used in the fashion industry on mannequins. As all Judoist are not the same height the third doll was manufactured with the ability to vary the height and wear a Judo uniform so that the players could practice more realistically i.e. they could grab the uniform and manipulate their opponent with the resistance to movement caused by the springs inside. With the addition of the shift sensors in various joints the Judoist physical strength can be measured.

RESULTS:

Functional Characteristics of Doll: With the surveyed information about the elite male (177.3 cm) and female (166.8 cm) Judo international Judoist height the doll was made with a height of 170cm. The height is controllable and can be increased or decreased by 15cm. As for the weight of the doll the middle weight for male (81 kg) and female (63 kg) was reflected on and the average of 70 kg was used for the manufactured doll with the option of and addition 50 kg of weight.

Calibration of the Quantitative Data: Through the connection of the sensor with the ADC board and the PC the force of the pushing, pulling and twisting can be measured through the variance of the voltage recorded. At the back of the knee and the shoulder joint a rope is attached and through the measurement of the rope's tension and the voltage of the shift sensor was simultaneously recorded. Via the data acquisition program in LabVIEW and the comparison of the voltage from the shift sensor and the actual tension in the rope a calibration formula was created.

Function: The doll can be used instead of a partner for the basic Judo techniques pulling, pushing and reaping. One of the strengths of this doll is that it can provide quantitative information about the player's physical strength.

Evaluation of the developed equipment through the biomechanical profile: To evaluate the usefulness of the judo doll, the *Osotogari* motion of 5 university students was recorded by the motion analysis system(Vicon) and then analyzed. For the analysis performed with Vicon's programs workstation, bodybuilder and polygon the movement, was divided into three phases through the definition of four events. For these events and phases the time, COM range and velocity, elbow angle and the kinetic variables were calculated and compared. For the standard deviation between the calculated variables the following formula 1 was used (Kim, 1995)

$$\text{diff}_{\text{rel}}(var) = \left| \frac{\text{var}_D}{\text{var}_M} - 1.0 \right| \times 100 \qquad (1)$$

Each, var_M, var_D = The standard variability between the levels; when the person receives and when the equipment receives.

1. For the comparison of the 4 time variables, with the relative tolerance level of 5% for the relative level difference, the reappearance rate was 50%. For a high tolerance level of 10% and 15% , the reappearance rate increased to 75% and 100%.
2. With the comparison of the 12 ranges of COM, and the relative tolerance level of 5% the reappearance rate was 58.8% was observed. For the tolerance levels of 10% and 15% the reappearance rate increased to 75% and 91.7%.
3. With the comparison of the 12 COM velocities and the relative tolerance level of 5% the reappearance level was 8.3%. For the tolerance level of 10% there was a low reappearance level of 16.7% compared to the other variables was observed.

4. For the comparisons of the posture variable of the elbow angle the relative tolerance level of 5% the reappearance rate was 25% and for the tolerance level of 10% the reappearance rate increased to 62.5%.

Evaluation of the pulling and sweep of the equipment: Two judo players pulling strength size and pattern and sweep strength size and pattern was measured. Here are the detailed results. For the measurement of the pulling power and pattern analysis the subject was asked to pull at maximum strength 10 times then rest for 10 seconds the repeat for a total of 4 sets. It was observed that there was a consistent pattern for all of the subjects. While subject A pulled at maximum strength 40 times it was observed that the more times he/she pulled the muscle strength was deemed weakier and thus the pattern of reduction was observed. Whereas for the subjects B with a good muscle strength there was a constant pattern of strength observed. For the *Osotogari*'s elevation angle after 10 trials the A subject's upper body force was consistent while for the legs strength there was a slightly different pattern observed. There was a consistant force pattern for both the upper body and lower body strength while performing the *Gari*

Evaluation of the equipment by a survey: A survey of 20 international judo players, 5 judo instructors using the equipment were asked to fill out a survey. The conclusions of the survey are as follows. 72% replied that there was a need for the equipment, above 80% stated that they were satisfied with the equipment. 80% agreed that the *Osotogari* motion was similar. 72% agreed that it was similar for the pulling motion. 84% had a positive response to the equipment. 64% stated that they would like to continue the use of the equipment. The strengths of the equipment was the improvement of elevation speed, increase of muscle strength (20%) and 36% of players replied that in needed to be improved while 8% of instructors stated it needed to be improved.

Table 1 biomechanical evaluation Doll-*Uke* relative level difference

$diff_{rel}$(var)(%) Variable	N	<5%	5~10%	10~15%	>15%
Time	4	2	1	1	-
sum	4(100%)	2(50%)	1(25%)	1(25%)	-
COM displacement	12	7	2	2	1
COM velocity	12	1	1	-	10
sum	24(100%)	8(33.3%)	3(12.5%)	2(8.3%)	11(45.8%)
Elbow angle	8	2	3	-	3
sum	8(100%)	2(25%)	3(37.5%)	-	3(37.5%)
Total sum	36(100%)	12(33.3%)	7(19.4%)	3(8.3%)	14(39%)

CONCLUSION:

Practical Application: While training with the doll the quantification of pulling, pushing and *Gari* strength is provided and can be analyzed.

Data Acquisition: The doll's force measuring system is shown in figure 3 while a player is pulling the doll. As shown in figure 3 the number and graph of the pushing, pulling and *Gari* can be displayed and analyzed. With the classification of the periods detailed, analysis is possible through observation of the outputted graphs.

Expected Effect: Through the practical application of the doll in Judo halls the scientific objective data supplied is expected to help instructors and players alike. The quantification of the player's strength is provided in real time and thus while training useful feedback is provided. Lee Won-Hee, a Judo gold medalist in the men's under-73 kg category at the 2004 Olympics in Athens (Figure 3).

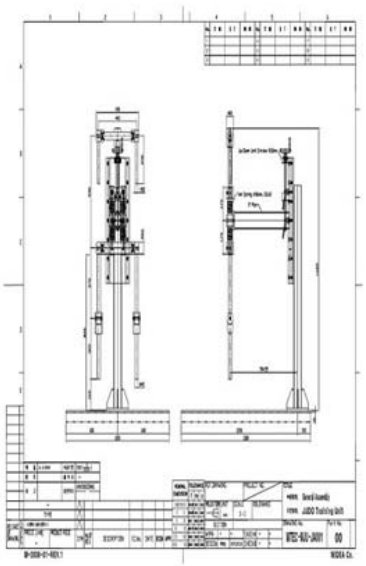

Figure 1 design of the Judo training equipment

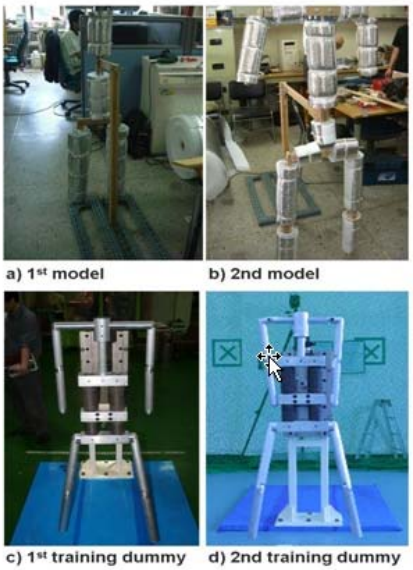

Figure 2 1st and 2nd training equipment model

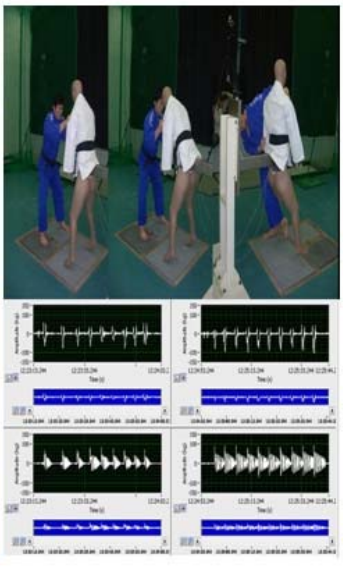

Figure 3 data acquisition

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