INTRODUCTION
In hammer throw, it can be considered that the body weight affects the throwing distance, because the muscle volume is directly proportional to the body weight. The pulling force of hammer may also be affected by the body weight. The purpose of this study was to investigate the influence of the body weight on the pulling force during throwing motion in hammer throw.

METHODS
Throwing motions of the elite hammer throwers were recorded by 2 synchronized high-speed video cameras(100 ~ 250fps) in seven international athletic meets. Three-dimensional co-ordinates of the body segments and the hammer head were obtained with DLT techniques[1]. Initial conditions and maximum pulling force acting on hammer head during throwing motion(MPF) were calculated.

RESULTS AND DISCUSSION
Table 1 shows the results for typical 2 throwers. Their performances were almost the same (0.4%) although their body weights were quite different (24%). Throwing distance and initial velocities were similar in two throwers. However, maximum pulling forces per body weight were quite different. Therefore the relationship between the pulling force and body weight should be examined in detail.

The hammer throwing motion can be compared with two-body problem in mechanics between a thrower’s body and a hammer head. Therefore, it can be considered that body and hammer head rotate each other around the common center of gravity of these two bodies. In this study, the body weight of thrower-B was larger than that of thrower-A about 24%. Then radius of gyration from the common center of gravity to hammer head in thrower-B was longer than in thrower-A. As the velocity of the hammer head at release were almost the same in two throwers, maximum pulling force of thrower-A was larger than that of thrower-B because the centrifugal force (= the maximum pulling force) was inversely proportional to the radius of gyration.

Fig.1 shows relationship between throwing distance and maximum pulling force for all the throwers. Thrower's body weight was shown in frames. The multiple linear regression analysis was done by choosing MPF as dependent variable and throwing distance and body weight as independent variables.

As a result, a higher and significant correlation (r=0.897, P<0.001) and a high contribution as adjusted R-square (0.772) were obtained. Therefore, it became clear that maximum pulling force was increased by the throwing distance but decreased by athlete's body weight.

CONCLUSIONS
This study identified the influence of body weight on pulling force during the hammer throwing motion. It was concluded that the thrower with smaller body weight had a disadvantage, from the mechanical viewpoints as well as muscle volume.

REFERENCES

Table 1: Throwing distance, initial conditions, maximum pulling force and body weight for typical 2 throwers.

<table>
<thead>
<tr>
<th>Thrower</th>
<th>Throwing Distance (m)</th>
<th>Initial Velocity (m/s)</th>
<th>Release Angle (deg)</th>
<th>Release Height (m)</th>
<th>Maximum Pulling Force (kgw)</th>
<th>Maximum Pulling Force /Body Weight (kgw/kg)</th>
<th>Body Weight (kg)</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>76.37</td>
<td>28.4</td>
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<td>1.84</td>
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