Knee Joint Angle at the Time of Adjustment to Submaximal Jumping in Healthy Men

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Abstract. We examined the correlation between jump distance and the maximum flexion angle of the knee joint during jumping to evaluate whether healthy men adjust to jump distance by changing the angle of the knee joint. Fourteen subjects jumped 3 times with their eyes closed to each of what they thought was 25%, 50%, and 75% of their maximum jump distance, a total of 9 jumps for both the vertical and standing broad jump. We measured the knee joint flexion angle at the time of the motion and examined the correlation between jump distance and knee joint flexion angle. The results show a relationship between jump distance and knee joint flexion angle for both the vertical and standing broad jump. We determined that jump distance is controlled by knee joint flexion angle in healthy men. Thus, a factor of jump control was clarified in this study.

Key words: Jump distance, Knee joint angle, Motion control

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INTRODUCTION

Factors related to jump motion control have been researched by Kawahara1) and Sadamoto et al.2). Kawahara1) examined control of distance and correct jump motion in the standing broad jump. Sadamoto et al.2) reported a relationship between grading jump ability and adjusting knee joint angle in the vertical and standing broad jump with the eyes open and closed. As a result, the means by which individuals control jump distance and the importance of adjusting the knee joint angle were clarified. Also, Vanrenterghem et al.3) recently asserted that subjects do not change the knee and foot joint angles but instead change the ratio of muscle output when adjusting for distance in the vertical jump. Kai et al.4) reported on the relevance of jump distance adjustment and the ability to reproduce knee joint angles. We examined the correlation between jump distance and the maximum flexion angle of the knee joint during jumping to determine whether healthy men control jump distance by changing the knee joint angle. The correlation between jump distance adjustment and knee joint angle reproduction ability becomes more reliable when this relevance is taken into consideration.

METHODS

Subjects

Fourteen healthy men participated in this experiment. The characteristics of the subjects were as follows: mean age 24.8 ± 4.5 years (SD), mean height 168.5 ± 6.0 cm (SD), mean weight 63.4 ± 10.4 kg (SD). All subjects were right-handed and...
right-footed (the preferred foot when kicking a ball). Approval for the study was obtained from the ethics committee of our university. All subjects gave their informed consent before participation in this study.

Subjects were clothed in shorts and removed their footwear. Subjects were marked with seals on the skin surface over the greater trochanter, lateral knee joint, and lateral malleolus as body landmarks. Each seal, red in color, was 2 cm in diameter and was mounted on a contrasting background, which was a 2.5 cm square white seal placed on the landmarks.

Jump

Jump was measured by the vertical jump and the standing broad jump (Fig. 1). Each maximum jump was performed twice, and the greater value was adopted. Each subject jumped 3 times to what they thought was 25% of their maximum jump, then 3 times to 50%, and 3 times to 75% of the same, for a total of 9 jumps with their eyes closed. The order of the trial for each percent value was random. The details were as described in Kai et al.\(^4\). Jump motion was recorded using a video camera, and subjects’ knee joint angles in the digital stills photographs were measured on a computer running Scion Image software.

Statistical analyses were performed using SPSS 11.5 J for Windows. Spearman’s correlation coefficients were used for statistical analysis of correlation between jump distance and knee joint flexion angle in the vertical and standing broad jumps. A p-value of less than 0.01 was considered statistically significant. Values are shown as the average ± 1 standard deviation.

RESULTS

The average maximum vertical jump of the 14 subjects was 53.9 ± 5.7 cm, and the range of the maximum was 45.0–63.0 cm. The average maximum standing broad jump of the subjects was 218.4 ± 27.1 cm, and the range of the maximum was 161.0–257.0 cm.

In the vertical jump, the correlation between the jump distance and the knee joint flexion angle was \(r=0.238\) (\(p<0.01\)). Figure 2 shows a scatter plot of the relationship between jump distance in the vertical jump and knee joint flexion angle. In the standing broad jump, the correlation between the jump distance and the knee joint flexion angle was \(r=0.584\) (\(p<0.01\)). Figure 3 shows a scatter plot of the relationship between jump distance and knee joint flexion angle.

![Fig. 1. Measurements of jump distance and knee joint flexion angle. θ: knee joint flexion angle. Top: vertical jump, Bottom: standing broad jump.](image)

![Fig. 2. Correlation between jump distance and knee joint flexion angle in the vertical jump.](image)
DISCUSSION

In a previous study\(^5\) of the vertical jump, the average maximum distance was 54.0 ± 7.1 cm with Japanese subjects of the same age as the subjects of this study; in the standing broad jump, the average maximum was 227.0 ± 19.2 cm. In this study, the maximum distance was 53.9 ± 5.7 cm in the vertical jump, and 218.4 ± 27.1 cm in the standing broad jump. Thus, we concluded that the subjects of this study had the same jump ability as normal Japanese adult men. Coefficients of correlation were calculated for the jump distance and the knee joint flexion angle in both the vertical and standing broad jump. The coefficient of correlation was \(r=0.238\) (p<0.01) between the jump distance in the vertical jump and the knee joint flexion angle. The coefficient of correlation was \(r=0.584\) (p<0.01) between the jump distance in the standing broad jump and the knee joint flexion angle. We thought that the reason why the coefficients of correlation differed between the vertical and standing broad jumps was due to different muscle strength ratios of each lower extremity in the maximal jump\(^6\), and to increase of the muscle strength ratio of the ankle joint as the jump distance becomes shorter\(^3\). As a result, we concluded that jump distance depends on the angle of the knee joint, and that the jump distance was adjusted by changing the angle of the knee joint. We believe that changing the knee joint angle allows for control of sub-maximum jump distances because the knee joint flexion angle depends on jump distance. These results show why knee joint reproduction ability was related to jump distance adjustment ability in our previous study\(^4\); that is, the subjects who had a high ability to reproduce knee joint angles were able to control jump distance more precisely, because the jump distance is controlled by the knee joint angle. These findings suggest the control ability of sub-maximum jump distances may be increased by training the adjustment of the knee joint flexion angle, because the knee joint flexion angle depends on sub-maximum jump distance. Sadamoto’s report\(^2\) differs from Vanrenterghem’s report\(^3\) regarding the importance of knee joint angle adjustment during jumping. This may be due to subject differences, as Sadamoto’s subjects were female college students and Vanrenterghem’s subjects were male volleyball players. We think that in healthy male subjects, as in this study, jump distance is adjusted by controlling the knee joint angle. Future studies should address jump control attained by adjustment of the muscle output of the ankle and knee joints in healthy men.

REFERENCES