The Pushing or Pulling Force Exertion Under Unbalanced Conditions

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Abstract:

Purpose

It is important to understand "Kuzushi", an underlying throwing technique of Judo. The purpose of this research was to clarify the relationship between body balance and force exertions. It is written in instruction books of Judo that if a person is made off balance, he can not exert any muscular force and move.

Methods

The subjects were seven university students. The subjects pushed or pulled a handle in both the forward and backward off balance posture. Center of mass (COM) and pushing/pulling force were measured. COM was calculated from three-dimensional kinematic analysis. The point of COM was projected vertically onto the floor. A distance of a toe-heel was standardized by percentage, the projected COM was expressed by the rate as 0% at the toe through 100% at the heel. Isometric muscular forces of pushing and pulling forces were measured by load cell dynamometer (100kgf). The experiment was conducted in both natural and defending postures. We analyzed the difference of force exertion between those postures and the relationship between the vertical projection of COM and pushing/pulling force.

Results and Discussion

The closer the projected COM goes to the toe line, the pushing force becomes stronger. The closer it goes to the heel line, the pushing force becomes weaker. On the contrary, if the projected COM was closer to the toe, the pulling force becomes stronger. If it was closer to the heel, the pushing force was weaker. The results were a similar trend in both the natural and defending postures. However, the pushing and pulling force in defending posture were stronger than those in natural posture. The defending posture was more stable compared with the natural posture, because the COM was lower and the base of support was larger. In this study, if COM drifts outside from toe line of the base of support, the subjects could exert slight pulling force (4 kgf) in the natural posture. Even if a subject is off balance in the forward direction, he can use the opponent as a support while leaning to maintain his own balance. Therefore, he was able to exert a force in this state (posture).

Conclusion

In conclusion, (1) the closer the projected COM goes to the toe line, the pulling force becomes weaker. (2) If the projected COM was closer to the heel, the pushing force was weaker. (3) The pushing and pulling force in defending posture were stronger than those in natural posture. (4) If COM drifts outside from toe line of the base of support, the subjects could exert slight pulling force (4 kgf) in the natural posture.