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RELATIONSHIP BETWEEN PLANTAR LOAD DISTRIBUTION AND LOWER JOINT KINETICS DURING TAKE-OFF PHASE IN VERTICAL JUMP

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INTRODUCTION

Plantar, the final body segment for transmitting internal force to the outside body, plays an important role so as to get a high performance by controlling vector of ground reaction force (GRF). In vertical jump, GRF is main factor to determine take-off velocity of center of body mass resulting jump height. In the interaction between plantar and surface such as ground, reasonable plantar load distribution pattern may be exist in order to get effective vector of GRF in vertical jump.

Purposes of this study were to develop the quantification of plantar load distribution and apply it to performance assessment related to height and joint kinetics during take-off phase in vertical jump.

METHODS

In order to define sub-areas from foot anatomical measurement points, Foot scan (Rs Scan international, Balance 2nd Generation 7.7, 0.5m plate, with 4096 resistive sensors, 200Hz : Belgium), VICON MX20 Camera×8 (Oxford Metric Ltd. 200Hz) and Force plate (Kistler type9287C 0.6m×0.9m, 1kHz: Switzerland) were systematically synchronized as to acquire the data. Subjects were attached whole body 35 point (plugin-gait model) and bilateral foot segment 16 point. Each foot sub-area was determined using methods of J.A.Stebbins,et al. (2005) [1] including 5 sub-areas (MF: medial forefoot, LF: lateral forefoot, MiF: midfoot, MH: medial heel, LH: lateral heel). Plantar load matrix data were exported every 5ms into each worksheet and each 5 sub-area plantar load (N/BW), plantar impulses(N・sec/BW) were calculated.

Twenty one male subjects performed counter movement jumps on pressure plate and force plate. Subjects were divided into good and poor groups (Good: n = 7, Age: 22.6 ± 2.4 yrs, BH: 174.1 ± 4.8cm, BW: 72.5 ± 4.5kg, Poor: n=6, Age: 23.5 ± 3.5yrs, BH: 169.8 ± 4.3cm, BW: 72.2 ± 5.8kg) according to performance (Jump height: Poor < mean ± 0.5 < Good). Inverse dynamic method was used to calculate the net joint torque (Nm) at the ankle, knee and hip in sagittal plane. Joint power (W) and work (J) were calculated from the net joint torque product joint angular velocity and the time integral of power production at joint. Each data was presented along with normalization time of weighting phase. All statistics analysis were used by student's t-test (welch) performed on selected means to detect significant differences (effective $p < 0.05$) between good and poor groups (JMP ver. 8.0 : SAS inc.). Relationships among plantar load, impulse and kinetics data were used as correlation coefficient of Pearson (effective $p < 0.05$).

RESULTS AND DISCUSSION

Plantar load distribution pattern change from heel to LF and MF. The difference in weighting phase time (sec) and normalize time (%) of was not observed between both groups. Good group exhibited larger both total plantar load impulse and MF plantar load impulse compared to Poor group[Total impulse (N・sec/BW) 0.59 ± 0.02 V.S. 0.56 ± 0.03, $p < 0.05$, MF impulse (N・sec/BW): 0.34 ± 0.04 V.S. 0.24 ± 0.05, $p < 0.001$]. As for the shift of weighting time (%) from LF to MF, good group were faster in comparison with poor group (49.0 ± 12.0 V.S. 73.9 ± 8.9, $p < 0.001$, Figure 1). It is indicated good group change plantar load shift early from LF to MF in the lowest squatting position.

Hip joint peak torque and work were significantly different between good and poor groups [Hip torque (Nm/kg): 6.95 ± 0.36 V.S. 5.76 ± 0.53, $p < 0.01$, Hip work (J/kg): 4.26 ± 0.36 V.S. 3.76 ± 0.58, $p < 0.05$]. Good jumper tended to have a short temporal difference of plantar load shift time and hip peak torque than poor jumper (Figure 1).

MF impulse was significant by correlated with hip joint peak torque and work (r = 0.541, r = 0.561, respectively). Lateral-medial change shift time indicated significant negative correlation with MF impulse and hip joint peak torque (r = -0.809, r = -0.453, respectively).

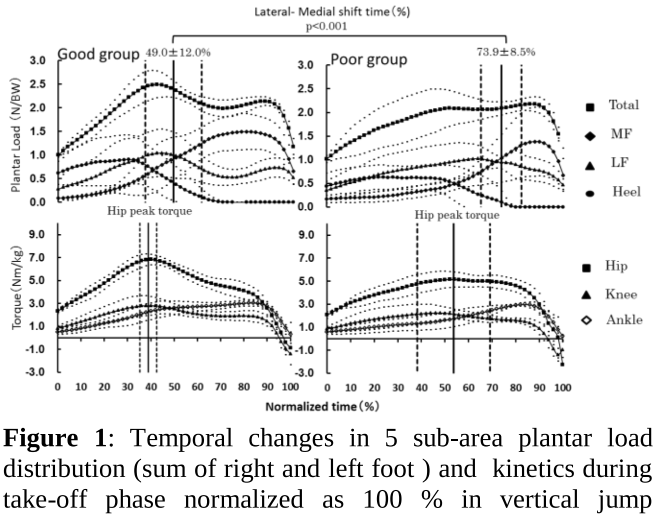

Figure 1: Temporal changes in 5 sub-area plantar load distribution (sum of right and left foot) and kinetics during take-off phase normalized as 100 % in vertical jump (upper : Plantar load, lower : Joint torque).

CONCLUSIONS

Earlier lateral-medial planter load shift time might influence on GRF vector as to result greater MF plantar load impulse as well as greater hip joint torque/work. Plantar load pattern in good group would be effective to joint kinetics as to get high performance.

REFERENCES

1. Stebbins J.A. et al., *Gait & Posture*,**22**: 372-376, 2005.