Differences in vertical ground reaction force and lower limb angle according to the use of insoles for vertical jumps in Rhythmic Gymnastics

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INTRODUCTION

The purpose of this study was to identify kinematics and kinetic factors for optimal performance of vertical jumps for Rhythm Gymnastics through the analysis of ground reaction force, lower limb angle, and the use of insoles. First, the differences between ground reaction force and lower limb angle (hip, knee and ankle joint angle) according to the use of insoles was analyzed. Second, the relationship between and within vertical ground reaction force variables and lower limb angles was investigated.

METHODS

Subjects for this study were ten members of the Korean National Rhythmic Gymnastics Team. A 6mm Video camera was used to capture the angle of the lower extremities (hip, knee and ankle) upon landing. The camera was also used to perform a qualitative analysis of the gymnast's movements. Gymnasts performed vertical jumps in bare feet, with shoes, and with shoes with insoles. The Kistler 9281B Force Platform was used to analyze the three stages of vertical jumps: take-off, flight, and landing. Impulse was measured during, take-off, while flight time was recorded for flight, and both impact variables and active force variables were measured for landing. Impact variables included maximum passive peak value, number of passive peaks, maximum passive loading rate, and passive impulse. Active force variables included number of active peaks, maximum active peak value, maximum active loading rate and active impulse. In order to statistically determine the differences in ground reaction force and lower limb angle according to the use of shoes or insoles one-way ANOVA analysis was used. Tukey was used for follow-up analysis. Finally the relationship between ground reaction force and lower limb angle was analyzed through Pearson's correlation.

RESULTS and DISCUSSION

A. Amongst the ten variables for ground reaction force during vertical jumps, there was a significant difference according to the use insoles in only one variable, the number of passive peaks. The number of passive peaks was reduced when forefoot insoles were worn.

B. There was a correlation between the take-off impulse and the maximum active force peak ($r=0.584$, $p < 0.01$) and active impulse ($r=0.543$, $p < 0.01$) during landing.

C. There was a correlation between flight time and maximum passive loading rate ($r=0.429$, $p<0.05$,).

D. There was a correlation between all impact variables ($r=0.4$ to $r=0.9$, $p<0.05$, $p<0.01$). Because of the inter-related nature of impact variables, analysis of any single variable can provide adequate information about impact phenomena.

E. There was a correlation between all active force variables during landing (r=0.4 to 0.8, $p<0.01$). Thus, analysis of any single variable can provide adequate information about active force phenomena.

F. There was a correlation between knee and ankle angle and maximum active loading rate from toe landing to heel-landing (r=0.37, $p<0.05$, r=0.61, $p<0.01$).

G. There was a negative correlation between hip joint and impact variables (r=-0.4, $p<0.01$)

H. There were negative correlations between ankle / knee angle and both active loading rate and active impulse (r=-0.6, r=-0.5, $p<0.01$)

I. Gymnasts who landed with quick, sharp movements possessed high values for maximum loading rate.

CONCLUSIONS

The use of forefoot insoles reduced the number of passive peaks during landing. Since Rhythmic Gymnasts subject their bodies to large amounts of stress, it is recommended that all Rhythmic Gymnasts use forefoot insole to reduce impact forces on the body during landing.

Furthermore, bending at the hips, knees and ankles proved to be important. During landing, there was a negative correlation between hip joint angle and impact force. Thus, as hip angle increases, impact force is reduced. Therefore, it can be concluded that Rhythmic Gymnasts can reduce impact force on their bodies by increasing hip angle during landing. In the knee and ankle, as angle decreases active loading rate increase. An increasing active loading rate signifies rapid, energetic movement both downward and upwards during landing. These quick, sharp landings not only showed high values for maximum active loading rate, but also displayed a nearly symmetrical rate of decay for active force. This might indicate a relationship between both active rate values and active decay rate values. This relationship, as well as angular velocity during these time periods should be investigated further in future studies.

Although the aesthetics of Rhythmic Gymnasts emphasize upright body position after landing, it is critically important for gymnasts to bend at the hips, knees and ankles. While these movements seem contrary to the aesthetics of the sport, when performed rapidly with an equally rapid return to an upright position, the gymnasts are able make their landings seem light and effortless. Analysis of ground reaction forces can help gymnasts balance the reduction impact forces, while preserving the aesthetics of their performances. Furthermore, continued analysis of ground reaction force should focus on helping Rhythmic Gymnasts optimize their performance of vertical jumps. For example, studying the correlation between active loading rate and active decay rates, as well as studying joint angle during these two different periods can provide a great deal of useful information for future analysis. Finally, future studies should also include a much larger sample size in order to increase the validity of the results.

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