INTRODUCTION

Kicking is the most fundamental activity in the sport of soccer. Information concerning kicking biomechanics is necessary to develop strategies that optimize performance. Previous studies evaluating soccer kicking have been limited in that they have focused solely on swing limb kinematics and kinetics. (Kellis et al. 2006; Nunome et al. 2006; Apriantono et al. 2006). Evaluation of the swing limb provides only partial insight into this activity as stance limb mechanics can have an influence on swing limb dynamics. Furthermore, evaluation of younger soccer players at different stages of maturation may provide insight into the developmental aspects of kicking.

The purposes of this study were to 1) compare the swing and stance limb kinetics of pre-pubertal and post-pubertal female soccer players during kicking, and 2) identify predictors of peak swing limb foot velocity. Peak foot velocity of the swing leg was chosen as the dependent variable of interest as this parameter has been shown to be related to ball velocity following foot contact. (Kellis et al. 2006; Nunome et al. 2006; Apriantono et al. 2006)

METHODS

Twenty healthy female soccer players participated in this study. The Pubertal Maturation Observational Scale (Davies et al. 2000) and a self-report of Tanner stages (Schlossberger et al. 1992) were used to classify subjects as pre-pubertal (n=10) or post-pubertal (n=10).

Bilateral three-dimensional kinematics (eight camera Vicon motion analysis system, 250 Hz) and ground reaction forces (AMTI force platform, 1500 Hz) were collected while each subject kicked a soccer ball into a net. Each subject was allowed a two step approach and kicked with their preferred foot. Four kicking trials were obtained. Net joint moments at the knee and hip (normalized by body mass) were calculated using inverse dynamics equations.

Variables of interest during the kicking cycle included peak foot velocity of the swing limb, peak hip extensor, peak knee flexor and peak knee extensor moments of the stance limb, as well as peak hip flexor, peak hip adductor and peak knee extensor moments of the swing limb. The start of the kicking cycle was defined by initial contact of the stance limb on the force plate while the end of the kicking cycle was determined when maximum vertical displacement of the swing limb foot was achieved following ball contact (i.e. follow-through).

Independent samples t-tests were used to evaluate group differences for each of the kinetic and kinematic variables noted above. Stepwise regression analysis using a forward stepping approach was used to determine which of the kinetic variables were
predictive of peak swing limb foot velocity (both groups combined). For all analyses, the P-value was set at 0.05.

RESULTS AND DISCUSSION

Peak foot velocity was 16% greater in the post-pubertal group when compared to the pre-pubertal group (p=0.006; Table 1). Additionally, the post-pubertal group demonstrated significantly greater peak knee extensor moments of the stance limb as well as significantly greater swing limb kinetic variables (peak hip flexor, hip adductor, and knee extensor moments; Table 1).

Stepwise regression revealed that the peak swing hip flexor moment was the best predictor of peak foot velocity of the swing limb (R=0.82, P<0.001). No other kinetic variables entered the regression equation.

Both swing and stance limb kinetics likely contributed to the observed differences in peak foot velocity between pre-pubertal and post-pubertal soccer players. The fact that all swing limb variables were greater in the post-pubertal group suggests that increases in swing limb foot velocity are primarily achieved through forward acceleration of the swing limb. The stance limb knee extensors appear to assist in swing limb acceleration and may contribute to the transfer of energy from the stance to swing limb.

Peak hip flexor moment explained 67% of the variance in peak foot velocity during kicking. This finding suggests that dynamic hip flexor strengthening may improve kicking performance in young female soccer players. However, a training study would be needed to confirm this hypothesis.

SUMMARY/CONCLUSIONS

Post-pubertal female soccer players demonstrate greater swing limb foot velocities during kicking compared to pre-pubertal athletes. More mature athletes achieve greater foot velocities through a combination of higher swing and stance limb moments. The ability to generate a large hip flexor moment appears to be an important factor with respect to improving kicking performance.

REFERENCES


ACKNOWLEDGEMENTS

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Table 1: Group comparisons of kinetic variables (mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Pre-Pubertal</th>
<th>Post-Pubertal</th>
<th>P value</th>
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<tbody>
<tr>
<td>Peak Foot Velocity (swing limb)</td>
<td>11.6 ± 0.8</td>
<td>13.4 ± 1.4</td>
<td>0.006</td>
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<tr>
<td>Peak Knee Extensor Moment (stance limb)</td>
<td>1.6 ± 0.3</td>
<td>2.0 ± 0.3</td>
<td>0.014</td>
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<tr>
<td>Peak Knee Flexor Moment (stance limb)</td>
<td>1.0 ± 0.2</td>
<td>1.0 ± 0.3</td>
<td>0.9</td>
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<tr>
<td>Peak Hip Extensor Moment (stance limb)</td>
<td>3.7 ± 0.7</td>
<td>4.3 ± 0.9</td>
<td>0.1</td>
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<tr>
<td>Peak Hip Flexor Moment (swing limb)</td>
<td>1.5 ± 0.2</td>
<td>1.9 ± 0.3</td>
<td>0.001</td>
</tr>
<tr>
<td>Peak Hip Adductor Moment (swing limb)</td>
<td>0.9 ± 0.4</td>
<td>1.1 ± 0.4</td>
<td>0.04</td>
</tr>
<tr>
<td>Peak Knee Extensor Moment (swing limb)</td>
<td>0.5 ± 0.1</td>
<td>0.6 ± 0.2</td>
<td>0.04</td>
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