Biomechanics of Jumping Rope

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Introduction

- Jump Rope as Exercise
  - Method of Cardiovascular Exercise
  - Injury Rehabilitation

- Jump Rope as a Competitive Sport
  - 2 Main Events
    - Speed
    - Freestyle—Power

3 Phases in Jump Rope

- Load Phase
  - Requires the balance of the body on the feet
- Flight Phase
  - Propulsion
  - Airborne
- Landing Phase
  - Body weight should rebalance on the balls of the feet
Background Muscular Information

Load Phase

Landing Phase

3 Phases Continued

Flight Phase

Question and Motivation

- How does the technique of jumping rope influence the flight phase?
- Determine which method is most effective for exercise
- Hypothesis: Crossover jump will generate the greatest jump height. The run-step will have the greatest foot velocity.
Methods

- Camera
  - Sony Cybershot RX10 II
    - 480fps

- 3 techniques with 2 trials of each technique

- Markers on foot, knee, hip, wrist, elbow, shoulder

- Data analyzed with Logger Pro and Excel

- Tape Measure Used to Measure Height
Forward Jump
Run-Step Jump
Crossover Jump
Analysis

- Velocity
  - Foot
  - Knee
  - Hip

- Jump Details
  - Duration of Jump
  - Jump Height

- Kinetic Energy and Power
Velocity for the Foot

- **Forward**
  - Maximum Velocity = 2.969 m/s

- **Step**
  - Maximum Velocity = 3.828 m/s
Velocity for Foot Crossover Jump

Maximum Velocity = 8.551 m/s
Additional Kinetics—Forward Jump

Movement over Time

Velocity vs. Time
Additional Kinetics-Run-Step Jump

**Movement over Time**

**Velocity vs. Time**
Additional Kinetics—Crossover Jump

Movement over Time

- VideoAnalysis | Knee
- VideoAnalysis | Elbow
- VideoAnalysis | Hip

Velocity vs. Time

- VideoAnalysis | Knee Velocity
- VideoAnalysis | Elbow Velocity
- VideoAnalysis | Hip Velocity
Kinetic Energy

- Kinetic Energy of Leg: Use body mass percentage of foot and then of the thigh and leg
- Foot: 1.33% of Total Body Weight
- Thigh and Leg: 17.1% of Total Body Weight
  - Forward Jump = 40.151 J
  - Run Step Jump = 22.623 J
  - Cross Over Jump = 88.204 J

- Hypothesis: REJECTED
## Jump Details

<table>
<thead>
<tr>
<th>Jump Technique</th>
<th>Max. Jump Height (m)</th>
<th>Duration of Jump (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Jump</td>
<td>0.254</td>
<td>0.1146</td>
</tr>
<tr>
<td>Run-Step</td>
<td>0.380</td>
<td>0.1538</td>
</tr>
<tr>
<td>Crossover</td>
<td>0.580</td>
<td>0.1687</td>
</tr>
</tbody>
</table>

- **Hypothesis:**
  - ACCEPTED
Calculations

- Maximum Kinetic Energy: Based on Center of Mass
  - Forward Jump= 605.415 J → 8.676 kcal/min
  - Run-Step Jump= 833.299 J → 11.924 kcal/min
  - Crossover Jump= 1,234.045 J → 17.699 kcal/min

- Average Power: Calculated using Harman formula
  - Forward Jump= 1,065.40 W
  - Run-Step Jump= 1,109.73 W
  - Crossover Jump= 1,652.63 W

- Harman formula: Average power (W) = 21.2 · jump height (cm) + 23.0 · body mass (kg) – 1,393
Conclusions

- Maximum Velocity: Crossover
- Greatest Jump Height: Crossover
- Greatest Maximum Kinetic Energy: Crossover
- Greatest Power: Crossover

The crossover jump seems to be most effective jump in terms of maximizing jump height and kinetic energy. The run-step is the second-best option.
Future Directions

- Comparison to professionals
- Introduce more techniques
  - Weighted Jump Rope
  - Different Types of Rope
- Look at angles of the knee and elbow
- How does the impact of landing differ?
  - Effect on different surfaces
References


Acknowledgments

- Dr. Rome
- Dr. Nelson
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QUESTIONS?