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# KINEMATICS AND KINETICS OF THE SWING LEG IN A RUMBA WALK

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This research investigated the kinematics and kinetics of the swing leg action in a Rumba walk (SLRW). The purpose of this study was to profile the SLRW in an attempt to distinguish a common movement pattern of the lower limb kinematics and kinetics in expert Latin dancers. Ten subjects (4 men and 6 women) all expert Latin Dancesport competitors volunteered to participate in this study. Kinematic data were collected using a Vicon Nexus system. Each participant completed the action 5 times. Calculations were made for angular velocity and acceleration, Coefficient of Multiple Correlation (CMC) and interactive moments. It was found that SLRW is a highly repeatable task in trained populations and that the execution of SLRW follows similar patterns of segmental interaction as those shown in walking and kicking.

**KEY WORDS:** segments interaction, dancers, ballroom.

**INTRODUCTION:** Ballroom dancing has surfaced worldwide in recent years as a highly competitive and popular sport, as demonstrated by the TV ratings in Europe, the United States and Australia during 2005 and 2006 for Dancing With the Stars, the name for a number of international television series based on the format of the British series Strictly Come Dancing (Tremayne & Ballinger, 2008). There are two forms of competitive ballroom dancing; the standard and the Latin styles. The kinematics and kinetics of the swing leg action in a Rumba walk (SLRW), a basic action used in Latin dancing were the focus of this study.

The review of the current scientific literature reveals that research into the mechanics of ballroom dancing is lacking, because of this limitation the primary aim of this study is to profile the expert execution of SLRW in regards to segment kinematics and the utilisation of motion dependant interactive moment to accomplish the task. In contrast numerous studies concerning lower limb kinematics and kinetics encompassing gait (Park, Choi, Kim, & Kim, , 2008), running (Okada & Ozaki, 1999), kicking (Dunn & Putnam, 1986) and martial arts (Sorensen, Zacho, Simonsen, Dyhre-Poulsen & Klausen, 1996) were performed. Given that a common sequencing of hip and knee motion exist between these tasks and SLRW; hip flexion accompanied by knee flexion-extension, data from this study were contrasted to those of other forms of movement.

**METHODS:** Male (4) and female (6) expert Latin Dancesport competitors volunteered to participate in this study. The dancer's sex, height and weight were recorded. Each participant was informed of the purpose and design of the study and signed a consent form. This study had ethical clearance from the ethical committee of the Australian Catholic University.

The task required the participants to perform a 'Rumba Walk' in a five step sequence. This consists of the left leg, initially placed behind the right leg, rapidly moving in front of the right leg. Six MX 3-D Vicon cameras sampling at 375 Hz were used to collect the position data of skin mounted spherical markers running in Vicon Nexus system. The lower limb plug in gait marker set was used to collect data. Participants were not instructed on how to execute the SLRW, but only notified of the time to initiate the movement.

Data post processing allowed the manual cropping the data from start to end of the sequence. The start of the action was defined as the point in time where the thigh segment shifted from negative (hip extension) to positive (hip flexion) angular velocity. The end of the action was defined as the point in which leg segment angular velocity shifted to extension into flexion after the leg segment had reached a peak positive angular velocity.

Position data were time normalised to 100 frames using a code written in Visual Basic. A coefficient of multiple correlations (CMC) for segments angular velocities was then obtained

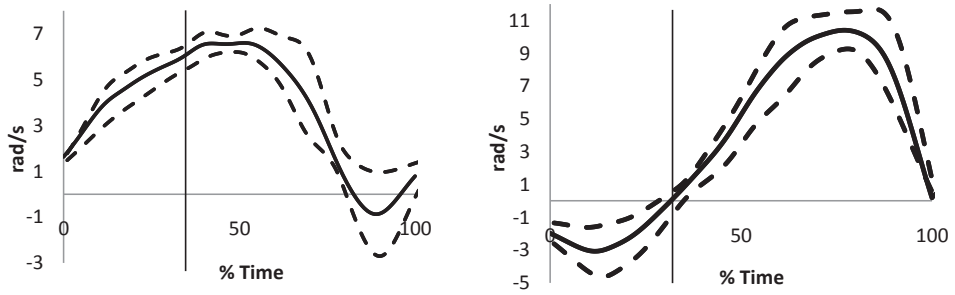
for each participant prior to the calculation of mean individual and group data. A CMC value of 0.7 was set to determine repeatability (Kabada, 1991). Thigh and leg segmental angular velocities and accelerations data were used as inputs to calculate motion dependant interactive moments (Putnam, 1991).

**RESULTS:** Individual CMC values for the thigh and leg angular velocities data are displayed in Table 1. Data from two participants were excluded from the study as their CMC values fell below 0.7. A mean (SD) of the remaining CMC values was also calculated and displayed in Table 1. The execution of the SLRW was divided into phases: concurrent and counter current phases. The concurrent phase was characterised by the simultaneous flexion of the hip and knee joints and occurred in the early stages of the action, while counter current phase was distinguished by simultaneous flexion of the hip and extension of the knee joints, which occurred towards the end of the skill. These are indicated by a vertical line in Figure 1 where the mean (SD) of the normalised angular velocities of the thigh and leg segments are presented.

**Table 1**
**Segments angular velocities' coefficient of multiple correlations (CMC) during a SWRL skill.**

| Participant | Thigh | Leg |
|---|---|---|
| 1 | 0.74 | 0.82 |
| 2 | 0.79 | 0.82 |
| 3 (*) | 0.41 | 0.53 |
| 4 | 0.79 | 0.84 |
| 5 | 0.78 | 0.82 |
| 6 | 0.77 | 0.85 |
| 7 | 0.73 | 0.8 |
| 8 (*) | 0.37 | 0.53 |
| 9 | 0.79 | 0.82 |
| 10 | 0.81 | 0.83 |
| **Mean** | **0.78** | **0.83** |
| **SD** | **0.03** | **0.02** |

(*) excluded from database, since CMC < 0.7




**(a)** **(b)**

**Figure 1: Mean (SD) angular velocity of the thigh (a) and leg (b) segments in a rumba walk. Vertical line separates the skill into its two phases; concurrent (left) and counter current (right) stages.**

The contribution of each interactive moment for both thigh and leg segments during the concurrent and counter current phases of the action are displayed in Table 2. Following Putnam's criteria (1991); a positive value indicates a contribution, while a negative value indicates a hindering effect to the segment's net moment by the interactive moment.

**Table 2**
**Mean (SD) interactive moments acting on the thigh and leg segments during the execution of a SRWL. Values on this table represent the percentage contribution of each interactive to task execution.**

| Moments acting on the thigh | | | Moments acting on the leg | | |
|---|---|---|---|---|---|
| | Concurrent | Counter current | | Concurrent | Counter current |
| **MωpP** | 19 (5) | 22 (7) | **MωpD** | -45(6) | 78(10) |
| **MαpP** | -81 (7) | -15(4) | **MαpD** | 91(9) | -7(4) |
| **MωdP** | 16 (10) | 79 (7) | | | |
| **MαdP** | 7(5) | 5(3) | | | |

- **MωpD:** is the moment applied to the centre of mass of the distal segment due to the angular velocity of the proximal segment
- **MαpD:** is the moment applied to the centre of mass of the distal segment due to the angular acceleration of the proximal segment
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- **MωdP:** is the moment applied to the centre of mass of the proximal segment due to the angular velocity of the distal segment
- **MαdP:** is the moment applied to the centre of mass of the proximal segment due to the angular acceleration of the distal segment

**DISCUSSION:** In general SLRW was highly repeatable with eight out of the ten participants receiving CMC scores greater than 0.7 for both the thigh and the lower leg. This shows that it is likely that SLRW is a learnt skill and not a stereotypical action, as two out of ten participants showed low repeatability to their movements.
The SLRW can be defined as an open kinetic chain action displaying similar joint actions as those of kicking and walking. These similarities are evidenced by the patterns of thigh and leg angular velocities, which show a sequential segment action. Competitive dancers typically spend more time in knee extension than on knee flexion (Fig 1). Given that higher extension velocities are identified it is plausible to assume that the observed knee flexion may not be a purposeful action but a result of hip flexion and that as such the first phase of the skill may be dominated by hip flexion moment. The motion dependant interactive moments confirm this view. The moments arising from the angular acceleration of the thigh acting on the leg during the concurrent phase suggest that most of the flexion of the knee joint during this phase results from the acceleration of the thigh, thus moments arising from the flexion of the hip assist the flexion of the knee joint. This is in contrast with what was reported to occur in Taekwondo kicking (Landeo, 2009), where the flexion of the knee assist that of the hip. The remaining of motion dependant interactive moment follow similar trends to those showed in kicking and during gait (Putnam, 1991, Dunn and Putnam, 1986).

**CONCLUSION:** The findings suggest that the SLRW is a learnt skill and not a stereotypical action and that the expert performer essentially performs the action in a similar temporal and spatial kinematic arrangement. Through the verification of the data's repeatability, normative kinematic information has been obtained. This study hopes that this information will provide a template for future reference in order for coaches and trainers to assess the development of their dancers in a more objective way. However more research is needed as this study did not take into account variables such as the interplay of music, partner and competitors, as well as the effect of footwear and surface of the dance floor and other environmental conditions. There are also tremendous variations of movements that are encompassed within ballroom dancing and each of these various actions and skills need to be reviewed. This

study has helped to establish a body of knowledge into the area of competitive ballroom dancing that can be built upon to enrich this artistic and enjoyable activity.

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