KINETIC COMPONENTS OF ROPE SKIPPING: A PILOT STUDY

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Rope skipping has been a leisure-time activity of children for many generations. and is universally accepted as an activity with high aerobic demand Indeed, to emphasize and advertise its "keep fit" component, large numbers of young people have been engaged in demonstrations of complex skipping routines; e.g., Jump Rope for Heart in the United States. Recently, skipping has been recognized as a competitive sport and is supported by the Canadian Skipping Association.

The action of skipping can be described as a reoccurring stationary vertical jump whereby both feet lose contact with the ground to allow a rotating rope to pass beneath them. The height of each jump varies according to the individual's objective, for example, to jump at maximum speed.

Within the past few years, an interest in skipping as a competitive sport has developed. The events of competition are varied. An individual may choose to compete in single-rope or 'double dutch' events. These are further categorized as individual or paired, which may be classified as speed or freestyle skipping. The focus of this paper is on individual, single-rope style speed skipping.

Scientific data available on this event are limited since the *sport* is in its infancy as a competitive event. With the increased interest at the recreational level as well as the rapid development at the competitive level, the need for scientifically based instruction and coaching methods is apparent.

PURPOSE

It was the purpose of the present study to determine specific kinetic variables which may differentiate a novice from an advanced speed skipping performer. Kinetic parameters included the geometry (i.e., point of application and magnitude) of external forces at the instant of impact

REVIEW OF LITERATURE

No biomechanical data on rope skipping was found in the scientific literature. However, comparisons may be made between selected kinetic parameters of skipping and those of biomechanically similar events. Activities of relevance include walking, running and vertical jumping.

Analyses of the vertical component of ground reaction forces (GRF) of landing in walking, running and jumping have revealed characteristic double-peaked curves (Cavanagh & Lafortune, 1980; Miller & East, 1976; Nigg, 1983; Nigg, 1985a; Nigg, 1985b; Nigg et al, 1981; Valiant & Cavanagh, 1985). The initial peak, the passive force phase, represents the point of initial contact with the force recording device (Nigg, et al 1981). It has been suggested that this passive force phase provides a measure of the magnitude of the load on the human structure (Nigg, 1983). The second peak, the active force phase, occurs after impact when movement is entirely controlled by muscles (Nigg, 1983).

In an analysis of landing from a vertical jump, Valiant and Cavanagh (1985:119) noted two distinct landing styles which were characterized by two different vertical force time patterns. Forefoot landers were recognized by a distinct double-peaked curve. Flatfoot landers produced one large peak. Although they showed no sign of an initial peak, the magnitude of this large peak was 1.5 times greater than the magnitude of the active peak in the forefoot group.

METHODOLOGY

Five novice and five advanced caliber skippers participated in this study. All participants were members of a regional skipping team at the time of the study.

Ground reaction forces were measured throughout each participant's performance by means of an AMTI force plate.* AMTI's gait analysis software package was used for collection of data. Cinematographic recording by two LOCAM cameras positioned at right angles to each other, and operating at a film transport speed of 200 frames per second allowed for a simultaneous collection of kinematic data for reference purposes. A rotating drum placed in the visual field of both cameras provided a time reference to the nearest 0.04 seconds.

Hard copies of the kinetic data were obtained from the AMTI system by employing the gait analysis software package to drive a Hewlett-Packard plotter. The resulting plots provided an estimation of absolute magnitudes of vertical ground reaction forces (Fz) throughout each subject's performance. Components of horizontal shear forces (Fx and Fy) were also plotted. Mean magnitudes of vertical force, mean plate-time and mean air-time were calculated for each subject. Vertical force data were expressed as a percentage of body weight (%BW) for the purpose of comparison among subjects. As well, the velocity of skipping (skip steps per minute) was determined for each subject.

RESULTS

The force-time curves obtained from kinetic data collection produced a series of sharp vertical force (Fz) peaks. Each peak rose quickly to a maximum of

*The Advanced Mechanical Technology Incorporated force plate is a multi-component measuring plate capable of detecting ground reaction forces in three mutually perpendicular planes.

approximately three times the subject's body weight, and fell back to zero within a time frame of approximately 200 ms. The impulse of each peak represented contact between one foot and the AMTI plate. The number of peaks varied according to the velocity of the skipping pattern.

A noticeable preliminary vertical force (Fz) peak was noted for four out of the five advanced performers. A large negative anterior-posterior (Fy) shear force was observed to accompany this occurrence. Results for the novice subjects did not show this trend (see Figure 1).

Results of an independent t-test performed on the mean magnitude of vertical force (expressed as %BW) showed no significant difference between groups ($p < .05$).

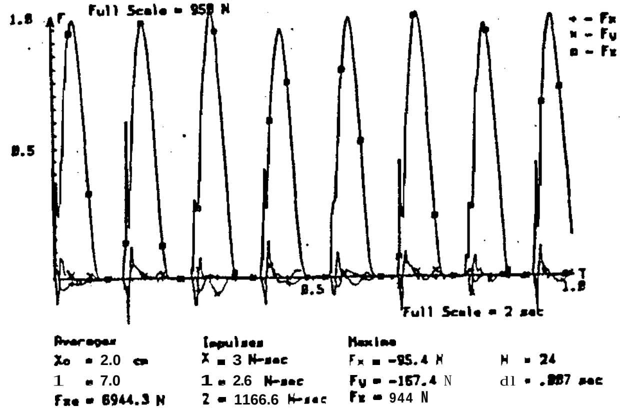

Figure 1. Sample force-time curve with preliminary peak.

Table 1. Results of Kinetic Analysis

PARAMETER	NOVICE	ADVANCED
Fz (%BW)	2.96 (s = .21)	2.86 (s = .11)
Plate-time (s)	0.19 (s = .02)	0.16 (s = .01)
Air-time (s)	0.09 (s = .01)	0.07 (s = .01)
Skip velocity (steps/min)	222 (s = 21.72)	260 (s = 19.52)

DISCUSSION

When comparing force-time curves of skipping with those produced during a vertical jump, some similarities as well as differences are evident For example, on the vertical jump, as suggested by Miller and East (1976). the force curves may be divided into three characteristic phases: preliminary unweighting (Fz<BW), weighting (Fz>BW), and final unweighting (Fz<BW). It appears that the vertical force curve for skipping has only two distinct phases, weighting and unweighting, and the first phase, preliminary unweighting, is absent during skipping.

The preliminary Fz peaks that were observed in the kinetic results of the advanced skippers bear striking similarity to the passive force peaks noted in the literature. Perhaps these peaks are representative of a passive force phase. The active phase would include the remainder of the force produced after this point when the movement is entirely controlled by muscle (Nigg, 1983).

The fact that passive forces occurred only in the performances of the advanced skippers is of particular interest. Cavanagh and Lafortune (1976) noted a high negative correlation between magnitude of passive force and time of contact with the ground. The results of the present study substantiated this relationship: an independent t-test indicated statistical significance for the mean time of plate contact between novice and advanced subjects (t = 2.63, df = 8, p<.05).

The irregularity of the passive force occurrences within each subject presented a complication. In each subject, flatfoot and forefoot landings occurred without any regularity. Also, curves with a passive force phase were accompanied by an unusually high anterior shear force (negative Fy) which is indicative of a forefoot landing style.

Valiant and Cavanagh (1985). in an analysis of landing from a vertical jump, noted that different landing styles are characterized by different vertical force curve patterns. Performances of forefoot landers were characterized by the occurrence of a passive force phase. Those of flatfoot landers showed no evidence of passive force peaks in their Fz curves.

It is reasonable to conclude that the occurrence of a passive force phase is related to the style of landing. Further study in this area is required to validate this hypothesis. Such a relationship would suggest important implications for the design of footwear specific to the sport of skipping. As suggested by Nigg (1983). the magnitude of passive force provides a measure of the load repeatedly imposed on the human structure. In such an activity, proper footwear becomes essential.

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