Biomechanical Analysis of Trampoline Exercise

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INTRODUCTION

Recently a trampoline has been widely used for the purpose of recreation as well as competition. This has provided enjoyment for children and adults. In Japan, the trampoline is available from elementary school up, *through* university level. Some trampoline athletes are of the opinion that trampoline exercise can be a valuable tool for developing motor ability among children. According to personal communication with Miss REIKO HANDA, Japanese female elite trampoline athlete and World Champion in 1986, it was apparent that she does not Kick the bed with a conscious effort. It is known that with every bounce, the trampoline athlete needs to get upward force from the bed as an energy resource. It seemed necessary to analyze a trampoline exercise and obtain scientific data from physiological, anatomical and biomechanical points of view.

Investigations have been carried out in order to biomechanically analyze a trampoline exercise.

Vaughan (1980) performed a kinetic analysis of basic trampoline stunts and reported that the maximum upward force from a trampoline bed *when* performing a basic drop, was not particularly large.

Shimada and Yamamoto (1986) investigated the jumping movement pattern of an elite female athlete and reported that flexion of the knee is almost maximal on landing on the trampoline bed.

PURPOSE

The purpose of this study was to investigate the force exerted on a trampoline. The breathing pattern, and the heart rate during a trampoline exercise performed by an elite female Japanese trampoline athlete who won the World Championship in 1986.

METHOD

One female Japanese trampoline athlete who won the World Championship in Paris, France in 1986, and one female gymnastic athlete, who was a member of the Kanazawa University Gymnastics team were used as subjects. The physical characteristics of the subjects are shown in Table 1. Each subject performed a straight foot bounce on trampoline for 30 seconds with maximal effort.

TABLE 1
Physical characteristics of subjects for this experiment

Subject	Height (cm)	Weight (kg)	Weight (N)	Age (yrs)
R.H.	158.0	57.5	563.5	21.1
A.O.	168.0	61.5	602.7	23.4

The trampoline used in the study was a «Regulation, CA 2001» made by Senoh Ltd. of Japan. The france size was 4.25 m by 2.97 m and the bed size was 3.64 m by 1.80 m. All jumping movements were recorded by two VTRS (NAC and SONY). The SONY VTR was positioned at right angle to the plane of motion at a distance of 14 m; The NAC VTR was at distance of 15 m. The force plate was set at the bottom of one of the four trampoline legs for the purpose of recording ground reaction forces. Subjects attempted to jump as near as they could to the center of the bed. Radio telemetry was used to record the subjects heart rates and breathing patterns (Figure 1).

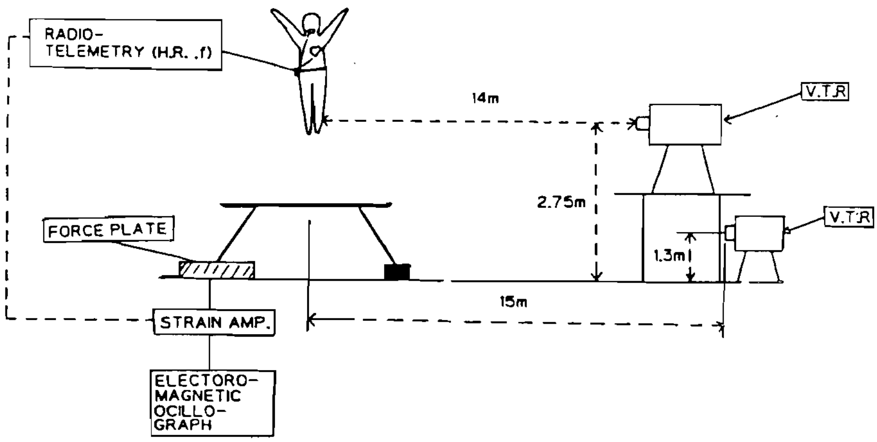

Fig. 1 Schematic diagram of experiment for a trampoline exercise.

RESULTS AND DISCUSSION

The vertical and horizontal *components* of ground reaction forces are shown in Table 2. The forces in both the horizontal and vertical directions were larger for the *experienced* athlete, although the athlete was lighter (i.e., less mass) than the university gymnast. The video image showed minimal kick motion in the athlete and large motion in the non-athlete. Apparently the athlete took advantage of the *stretch* produced by the knee action on landing.

TABLE 2

Horizontal direction and vertical directions of ground reaction in trampoline exercise with maximal effort for athlete (subj. R.H.) and non-athlete (subj. A.O.)

	Vertical Force		Horizontal Force (A-P plane)	
	P.F. (N)	P.F./W	P.F. (N)	P.F./W
Athlete	1399.4	2.48	442.7	0.78
Non-Athlete	1298.4	2.15	337.6	0.56

Polar curves of vertical and horizontal ground reaction forces are shown in Figures 2, 3 and 4. Figure 2 is a display of the starting phase for the athlete while Figure 3 shows the intermediate steady phase of the 30-second exercise. Both curves have been two downward peaks with the second one being larger. The first peak was representative of the subjects weight on the bed and the second peak shows the subjects kick of the bed. Figure 4 shows the steady phase for the non-athlete and it is apparent there are not two peaks. For athlete, the first force was downward while it was forward for the non-athlete and accounts for the unstable jumping movement of the non-athlete.

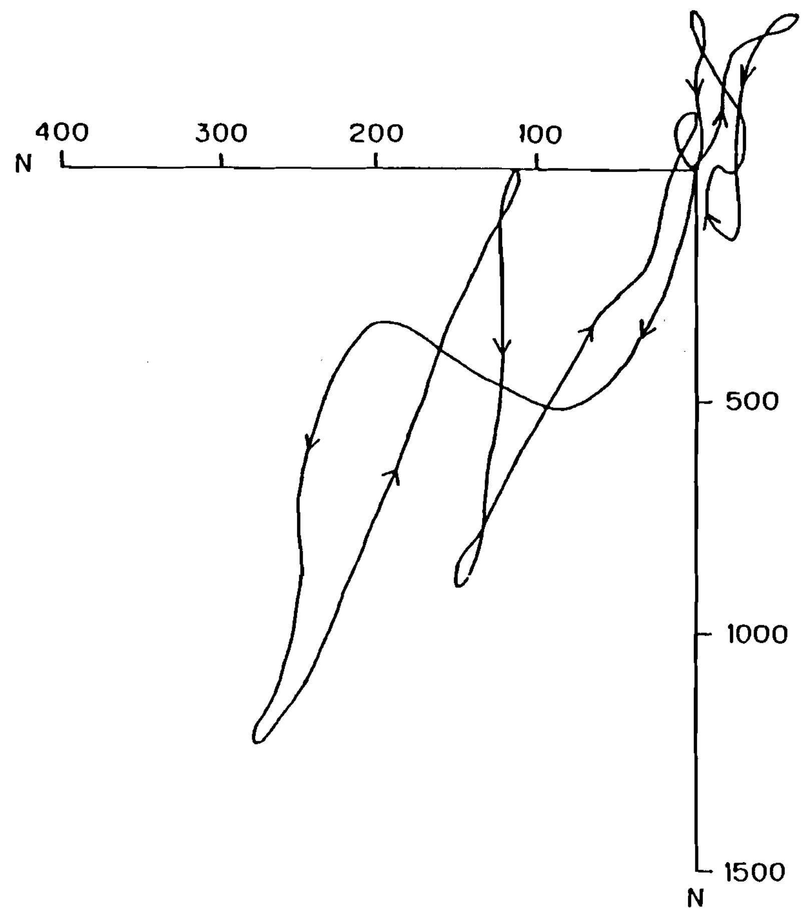

Fig. 2 Polar curve of horizontal and vertical forces for ground reaction during first starting phase of 30 seconds trampoline exercise for athlete (subj. R.H.).

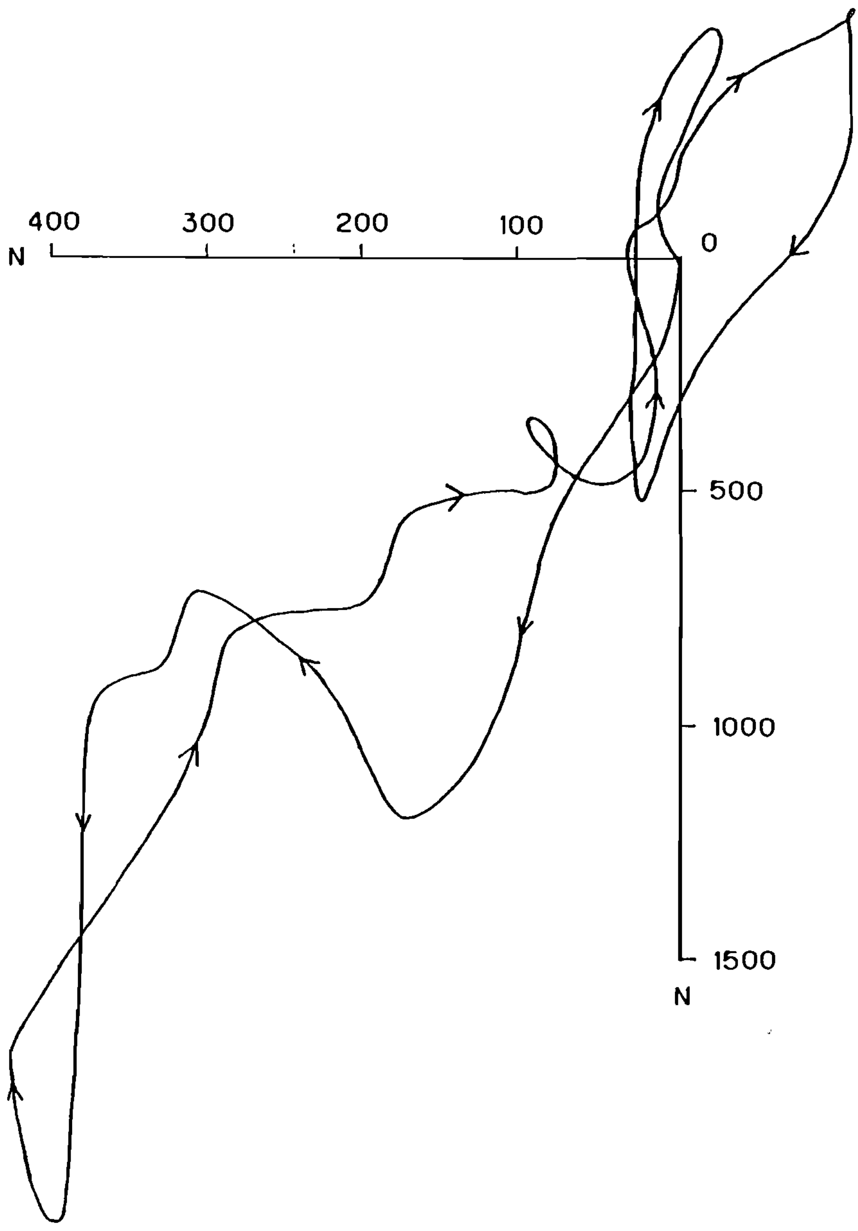

Fig. 3 Polar curve of horizontal and vertical forces for ground reaction during a consistently steady phase of 30 seconds trampoline exercise for athlete (subj. R.H.).

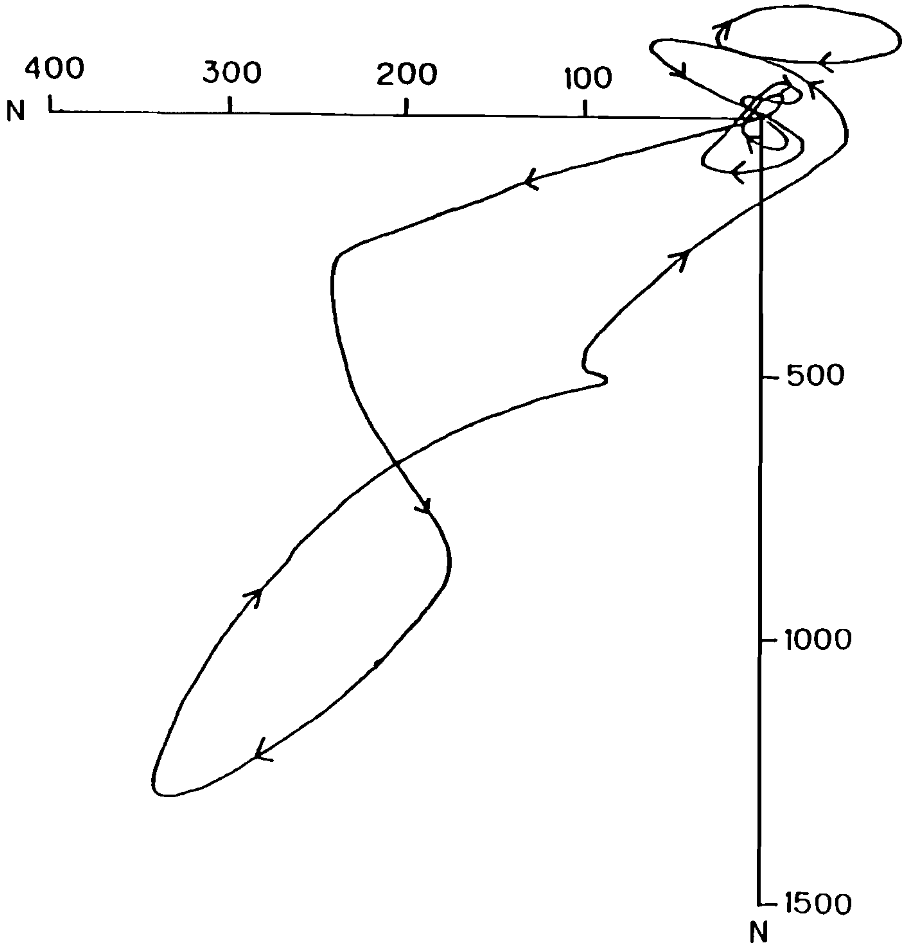

Fig. 4 Polar curve of horizontal and vertical forces for ground reaction during a consistently steady phase of 30 seconds trampoline exercise for non-athlete (subj. A.O.).

Heart rate, breathing frequency, jumping height and jumping frequency are shown in Table 3. Although heart rate does not differe *appreciably* breathing frequency, jumping height and jumping frequency are very different.

Breathing pattern almost coincided with the jumping pattern of the athlete with the inhalation phase while airborne. The breathing pattern of the non-athlete did not coincide with the jumping pattern. It is clear from these results that the athletes motion was more stable than the non-athlete.

TABLE 3

H.R., Breathing Frequency, Jumping Height and Jumping Frequency of trampoline exercise with maximal effort for athlete (subj. R.H.) and non-athlete (subj. A.O.)

	H.R. (b/m)	Breathing Frequency (times/min)	Jumping Height (cm)	Jumping Frequency (times/min)
Athlete	160	36	170	40
Non-Athlete	166	52	90	48

CONCLUSIONS

1. The trampoline athlete in order to take advantage of the spring reaction effectively, kicked after applying weight to the bed.
2. The trampoline athlete inhaled when landing on the bed and exhaled when in the air, which almost coincided with the jumping pattern.
3. The heart rates of both subjects increased to about 160 beats per minute during the exercise.

REFERENCES

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