A PORTABLE RUNWAY FOR COLLECTING TRIPLE JUMP GROUND REACTION FORCES

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INTRODUCTION

Very little is known about the characteristics of the ground reaction forces (GRFs) generated while triple jumping. Ramey & Williams (1985) lamented this fact when they stated "While such forces have been commonly assessed during running (Cavanagh & LaFortune, 1980; Plamondon & Roy, 1984) and some jumping activities (Bosco, Luhtanen, & Komi, 1976; Ramey, 1970), little is known concerning their magnitude during the triple jump" (p. 223). Eight years later, Hay (1993) commented on the same problem, "Collecting ground reaction force data during a triple jump competition is well-nigh impossible. As a result, the small amount of force data that are available have been collected under experimental conditions" (p. 18). The reason for the lack of information is clear: it is very difficult to collect GRFs for all three takeoffs in succession. There are a number of reasons for this. First, ode must acquire three force plates, which for most sport research facilities is not economically feasible. Second, the dimensions of a standard force plate is 400mm (w) by 600mm (1) by 70mm (ht) providing only a limited target. Third, most force plate companies strongly suggest that each plate be rigidly mounted to the takeoff surface which complicates the task and doesn't allow the plates to be easily repositioned to accommodate each individual athlete's unique style i.e., phase apportionment br the coaches training requirements. Because of these complications, researchers have not attempted to collect GRFs for each takeoff ,in succession.

Previous studies have used only one or two plates. Ramey & Williams (1985) used a single force plate to collect GRF data for four collegiate triple jumpers, two men and two women. The jumpers performed at 80 %-90% of their competition effort. The use of a single force plate required the subjects to execute three separate jumps to produce a single triple jump performance. Amadio (1985) recorded GRFs for four highly skilled male athletes; one was the German record holder and another was the German Junior record-holder. The jumpers performed 100% effort jumps off two force plates. This provided GRF data for two consecutive takeoffs. Similar to Ramey and Williams (1985) Amadio found that the largest vertical peak forces were generated during the step phase. However, the GRFs he measured ranged from 14.0-22.3 BW, almost twice the magnitude measured by Ramey and Williams. The purpose of this study was to design, build, and test a portable triple jump runway that could be used to collect GRF data for all three takeoffs in succession.

METHODOLOGY

Portable Runway Design

The portable runway was built out of compressed plywood and was designed to house three BERTEC 4060A force plates (400mm x 600mm x 70mm). The force plate housing compartments were spaced 3 meters (10 feet) apart which allows for a minimum hop-step ratio of 3m:3m (10ft:10ft). The runway was also designed so that the sections housing the force plates can be "telescoped" out in 30.48cm (1 foot) increments. Given these incremental increases, the maximum hop-step ratios possible are 4.52m:4.52m (15ft:15ft). An "approach section" was attached, which allows for an approach distance of 4 to 6 steps. Additional approach sections can be attached as needed. The data for three components of the GRFs and three moments were collected to an INTEL 386 PC at 500 Hz.

Validation of ProceduresBecause the force plates were not mounted to a surface, a number of precautions were taken to eliminate possible measurement errors. To eliminate sliding. the runway structure was precision built so that when the force plates were set into their housing, the bottom of the plates fit snugly against the walls of the structure while allowing the top plate to float freely. Also, to eliminate the possibility of rocking, a flat formica surface was placed under the plates. Both the floor and the formica surface were tested with a leveler and determined to be sufficiently flat to meet mounting specifications.

The precise design of the runway's housing compartment ensures that the force plates are clamped in the shear direction. It is also logical to assume that compressive forces generated by the athlete act as a vertical clamp during the time of foot contact with the plate. However, in order to support this assumption, testing was done by the researcherlcoach with the help of the Bertec Corporation to determine if the vertical forces measured in the portable runway are the same as when the force plates are mounted per the manufacturer's specifications. Using a sampling frequency of 10,000 Hz, a 16 lb indoor shot put was dropped nine times from a height of 7 in. onto a BERTEC force plate, mounted and then unmounted. The drop height was determined by trial and error to generate a peak vertical force of greater than 3,000 N. This value was chosen based on the GRF data collected for this study. Each trial was normalized with respect to its peak value. The normalized values (for each condition) were then averaged giving a single representative curve for the Mounted condition and the Unmounted condition. These data, as evident in Figure 1, support the assumption that the GRFs measured during the athlete to force plate contact are valid when using the portable triple jump runway.

Testing Procedures

In addition to testing the design of the runway and the accuracy of the measurements, another objective of this study was to determine if it could be used in an actual practice situation for the collegian female jumpers coached by the researcher. These practices consist of repetitions of four to eight step approach jumps for distance. If the portable runway is to be used successfully, a jumper must be able to hit the force plates while maintaining good technique.

For this study, done in a gymnasium, one subject performed 15 triple jumps using an approach distance of four steps. Because the researcherlcoach is a former triple jumper with reasonably good technique and a best jump of 15.4m, he acted as the test subject for this preliminary study. Each jump was 9 meters (30 feet) total distance (3m:3m:3m) with the final landing onto gymnastics mats.

Sample # (10,000 Hz Sample Rate)

RESULTS AND DISCUSSION

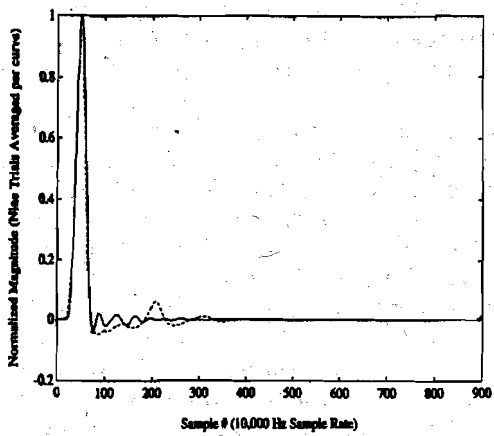

Figure 1 A comparison of Mounted and Unmounted BERTEC force plates using repeated drops of a 16 pound shot put from a constant height.

Figure 2 shows plots of the data collected using the portable triple jump runway. These plots show the Fy and Fz curves for one representative jump. Positive Fz values represent the GRFs when the athlete applies force downward in the vertical direction and positive Fy values occur when the athlete applies force backward in the anterior-posterior direction. Negative values for Fy represent braking forces.
With few exceptions. the plots of the GRFs for all 15 trials resemble those in Figure 2. When comparing the three phases, however, the curves vary markedly. Each phase, therefore, appears to have its own dist inctive force time characteristic. For example, the vertical force time curve for the hop takeoff resembles a normal curve slightly skewed to the left. The step phase, on the other hand, had two distinct peaks: the first sharply increasing to 2500N and the second increasing more slowly to 1500N. The jump takeoff, in contrast to both the hop and the step takeoffs, was characterized by one initial peak in which the curve rose rapidly to 2500N.

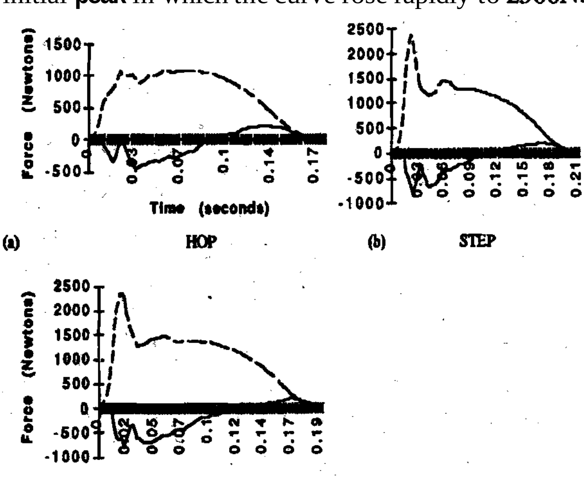

Figure 2 - Typical vertical GRFs (dashed lines) and anteriorposterior GRFs (solid lines) for the hop, step, and jump for one subject.

CONCLUSION

Previous studies have used only one or two plates to measure ground reaction forces in the triple jump. The purpose of this study was to design, build, and test a portable triple jump runway that could be used to collect GRF data for all three takeoffs in succession.

It should be noted, however, that this runway was not designed to be used during competition or even during full approach jumps. Its use is based upon the assumption that, except for the magnitude of the forces, the characteristics of the force-time curves for a four step, six step, or eight step approach jump will be very similar to those generated in competition. During training sessions, I have found that my jumpers can reach 90ü of their best competition distance using only a 6 step approach. Therefore, it is logical to assume that the characteristics of the force time-curve will be identical.

A measurement system of this type would be useful to both researchers and coaches. The researcher could determine the force-time characteristics for each individual athlete. This is an important consideration because judging from the data collected in this study it is clear that each phase has its own force-time characteristic and it is logical to assume that each athlete will generate his or her own unique curves. It would also provide input data for computer models of the triple jump enabling researchers to model the optimum force-time characteristics for each phase as well as for each individual. In addition,- scientifically oriented coaches could use the data to individualize training methods and to determine the effect of training on the GRFs. This study showed that a portable runway can be used to obtain accurate and useful ground reaction force data for all three takeoffs in succession.

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