KINEMATIC COMPARISON OF GRAB AND TRACK STARTS IN SWIMMING

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The purpose of this study was to compare takeoff and entry characteristics of track starts performed with normal and restricted spacing of the feet to grab starts. Track starts produced a faster ($p = 0.06$) and steeper ($p = 0.07$) entry further from the block ($p = 0.18$) than grab starts despite similar takeoff speeds and angles. Differences contributing to the improved entry characteristics included increased takeoff height ($p = 0.01$) and lowered entry height ($p = 0.2$). Little difference was found in takeoff and entry trunk orientation. These data suggest that track starts offer performance advantages over the grab start. Furthermore, these advantages were not diminished by restricting the spacing of the feet in the track start suggesting that the track start can be performed on shorter starting blocks without diminishing performance.

KEY **WORDS:** swimming, grab start, track start

NTRODUCTION: Two popular starts used by swimmers in individual races are the grab and track starts. The main difference in these techniques is feet placement. In the grab start, the swimmer places both feet at the front of the block while in the track start the feet are staggered. The track start is thought to allow the swimmer to generate a greater horizontal impulse than the grab start (LaRue, 1985). The usefulness of the track start has been questioned because of (1) the inability to achieve a large enough spacing between the feet on smaller blocks, and (2) the lack of a vertical support for the rear foot against which the swimmer can push to maximize the horizontal impulse (LaRue, 1985). Ayalon et al. (1975) reported faster reaction time when using a track start with short and long foot spacing compared to a grab start but time to 5 m was slower when using a track start with short foot spacing than a flat start.
Older starting blocks are approximately 50 cm in length, thus imposing a restriction on the performance of a track start. Ayalon et al. (1975) and LaRue (1985) both considered track starts with greater foot spacing by manipulating the length of the starting block such that it did not conform to competition rules. Recently, newer blocks 80 cm in length have become available and conform to guidelines established by FINA and the NCAA. The longer length of this block reduces the restriction imposed on foot spacing and should provide a better comparison of the track start to the grab start. We assumed that the gliding ability of an experienced swimmer remains unchanged regardless of the start. Thus, a start can be evaluated using the factors that determine the entry characteristics of the swimmer. Given that the swimmer behaves as a projectile after leaving the block, the entry characteristics are determined by the takeoff characteristics and the ability of the swimmer to manipulate body position while airborne.
The purpose of this study was to compare the takeoff and entry characteristics of a grab start to a track start performed with normal and restricted foot spacing. Two hypotheses were tested in this experiment. First, there would be no difference in performance of a grab start and a track start performed with self-selected foot spacing. Second, restricting foot spacing in the track start would not influence performance compared to the unrestricted track start and the grab start.

METHODS: Ten collegiate male swimmers (age = 21.3 years, ht = 180.3 cm, mass = 80.2 kg) experienced in the use of the grab and track starts provided informed consent prior to participation. Foot spacing was defined as the distance from the front edge of the block (where the toes of the forward foot were positioned) to the toes of the rear foot. Self-selected foot spacing for the track start was measured after a swimmer assumed a preferred track start stance on a starting block (80 cm long). The restricted foot spacing was defined as 50% of that value.

Following a warm-up period each subject performed two maximal effort trials of each starting technique in a random order. Two-dimensional sagittal plane kinematic data were collected at 60 Hz using a video camera positioned 10 m from the starting platform, oriented perpendicular to the sagittal plane, and aligned with the front edge of the starting platform. Twenty-one points were digitized to determine whole body center of mass location using a 14 segment inertial model of the body described by Clauser et al. (1969) with adjustments by Hinrichs (1990). Analysis of each trial began 10 video fields prior to initial forward movement of the swimmer and ended at the last video field prior to the swimmer contacting water. Coordinate data were padded and then smoothed using a 4th-order recursive Butterworth digital filter. Cutoff frequencies, individually determined for each coordinate using the Jackson method (Jackson, 1979), ranged from 2 to 9 Hz. For the airborne portion of the start, time series vertical coordinate data were fitted to a parabola and time series horizontal coordinate data were fitted to a line using the method of least squares to further reduce the effects of smoothing and endpoint problems (McLean et al., 2000). Horizontal and vertical velocities were computed by differentiating the respective equations of best fit. These component velocities were used to compute speed (i.e., magnitude of resultant velocity vector) and angle (i.e., angle of resultant velocity vector to the forward horizontal) at takeoff and entry (Figure 1). Distance measurements were defined by the position of the whole body center of mass at discrete instants in time during the start as described in Figure 1. Trunk orientation was defined as the angle the long axis of the trunk made with the forward horizontal.

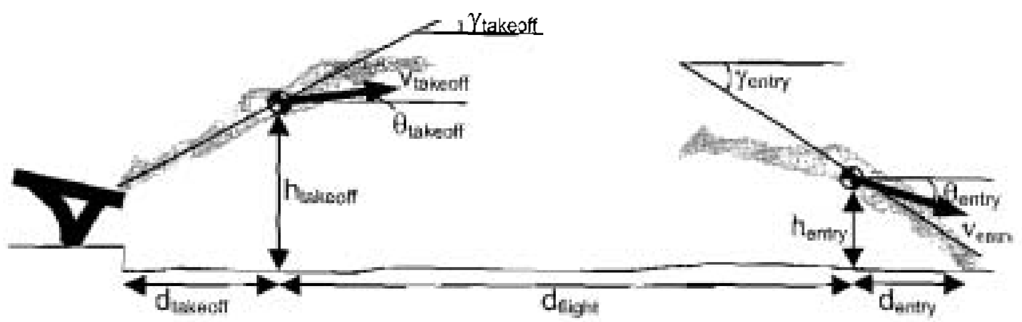
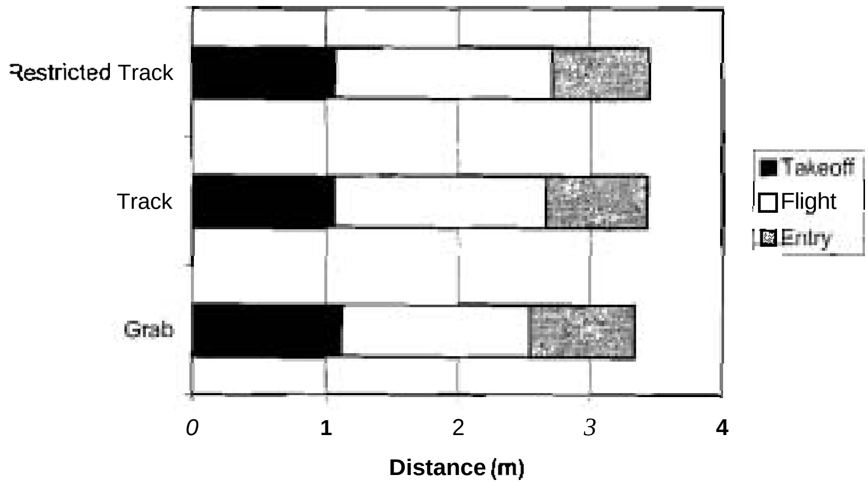


Figure **1** - Description of kinematic variable definitions.

Measurements were averaged between trials of each technique prior to analysis. Mean comparisons between starting techniques were made using one-way repeated measures ANOVA's and followed with pairwise comparisons using contrast analysis.

RESULTS AND DISCUSSION: Guimares and Hay (1983) argued that the glide was the most important aspect of a competitive swimming start because it accounted for 95% of the variance in performance between swimmers. In the present experiment a within subjects design was used. We assumed that a swimmer's gliding technique was the same regardless of starting technique making entry characteristics the most important aspect of the start over which a swimmer had control. Because entry occurred at the completion of the flight phase of the start, entry characteristics were largely dependent on the takeoff. Therefore, a comparison of takeoff and entry characteristics should have provided a meaningful evaluation of these starting techniques.

Track starts with normal and restricted foot spacing provided several performance improvements over grab starts. Track starts generated an average 10 cm increase ($p = 0.18$) in start distance over grab starts. This difference was characterized by a moderate effect size (ES = 0.6) suggesting that this increase was meaningful (Figure 2). This increase was accounted for by the increases in flight distance ($p = 0.07$) when using a track start. Takeoff speed was 4.2 $m \cdot s^{-1}$ regardless of technique while takeoff angle was nearly flat or 0° (Figures 3 and 4). Takeoff angle was reduced in the track start using restricted foot spacing compared to normal foot spacing ($p = 0.02$) but this difference was small and therefore not meaningful.



Fgure 2 - Start distance described as the sum of takeoff, flight, and entry distances.

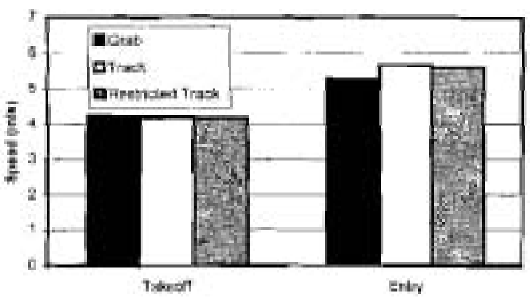


Figure 3 - Takeoff and entry speeds.

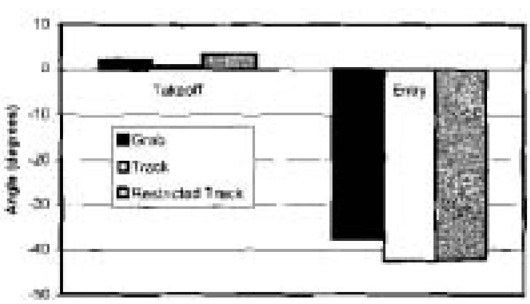


Figure 4 - Takeoff and entry angles.

Use of track starts improved entry characteristics suggesting that an improved glide after entry could be anticipated. Entry speed was 0.3-0.4 $m \cdot s^{-1}$ faster ($p = 0.06$) when using a track start than a grab start (Figure 3). In addition, entry angle was approximately 5° steeper ($p = 0.07$) when using a track start, which would result in less resistance during the entry phase (Figure 4). These changes may have resulted from an increased time of flight because swimmers using a track start fell through a greater height than when using a grab start. Track starts produced higher takeoff heights by approximately 7 cm ($p = 0.01$) and lower entry heights by approximately 7 cm ($p = 0.2$) than grab starts (Figure 5). This increased relative height indicated an increased flight time.

In addition to the entry angle (i.e., the angle of the velocity vector of the whole body center of mass at entry), trunk orientation is associated with the resistance encountered upon entering the water. If trunk orientation is too flat the swimmer will not achieve a sufficient depth during the glide. If trunk orientation is too vertical the swimmer presents a larger area perpendicular to the water surface also increasing resistance. Trunk orientations at takeoff differed by 3° ($p = 0.06$) but this difference was not meaningful since these orientations were relatively flat. There was little difference in trunk orientation at entry regardless of start technique (Figure 6) suggesting that swimmers were able to achieve their preferred entry orientation.

CONCLUSION: Track starts offered performance advantages over the grab start by improving entry characteristics of the start. These data support previous conclusions of LaRue (1985) and Ayalon et al. (1975). However, in contrast to previous work, these data do not suggest that restricting foot spacing negatively impacts performance of a track start. Therefore, use of a track start is supported regardless of starting block dimensions.

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