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Bar Path and the Bench Press

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For any given individual an optimum bar path exists. This path would be the one that maximizes the weight that can be lifted. The nature of the optimum path should be similar for all individuals. For a fixed muscular capacity, geometry dictates the variation in force capacity with position. The rigid definition of the bench press movement and the basic similarity in the anatomies of all lifters implies that the geometry of the lift is comparable across individuals. If one assumes that the ratio of muscular capacities between two subjects is independent of the muscle group of interest, then the bar path is dictated strictly by geometry. A variety of optimum paths is expected, all within a common framework.

The bar paths used by experienced lifters should be closer to their optimum than those of novice lifters. A trial and error process should lead any individual toward his optimum path. The competitive lifter has lifted for a longer period of time and has a greater motivation to identify the optimum path than does the novice lifter. The characteristics of the bar paths used by a large group of high skilled lifters should be indicative of the ideal bar path.

The *typical* bar paths used by experienced and novice lifters are illustrated by Figure 1. The novice subjects generally push the bar more vertically in the upward phase and often have the upward path further down the chest than the lowering path. The two world record holders also depicted in Figure 1 have paths representative of experienced subjects in general.

From a quantative analysis of these bar paths (references 1 and 2), it was shown that the bar path followed by the experienced lifters was significantly different from that used by the novice group. The mean horizontal positions of the bar relative to the shoulder were significantly different between the two groups at every characteristic instant. Mean paths for both groups are displayed in Figures 2 and 3. During the lowering phase the bar paths are nearly parallel with a curvature concave toward the head. The path of the competitive group (see Figure 1) is displaced relative to the novice group path approximately 10 percent of the upper body length from the hip to the shoulder. The competitive group starts the lift 95 percent of the way from the hip toward the shoulder and touches the chest at 70 percent of that same length. The differences during the raising phase (see Figure 3) are even more dramatic. The novice group raises the bar initially moving it nearly vertically and then moving it up and toward the head. The competitive group chooses a path with the opposite convexity. The initial movement of the bar includes a substantial horizontal component toward the head. The horizontal differences in the path increase rapidly at the start of the raising phase. At the sticking point this difference is 20 percent of the upper body length. The paths converge near the end of the lift, the horizontal position differing by 11 percent of the upper body length in the finishing position. The competitive group finishes with a mean normalized position 1 plus or minus 11 percent beyond the shoulder toward the head.

The differences in bar path between the two groups is a contributing factor to the differences in performance. The differences in performance are due to the difference in magnitude of force capability and to the difference in the way in which this capability varies with height above the chest. One explanation of the smoother force pattern displayed by the competitive group is training specificity effects. Training effects can be specific to one position. This could explain the reduction of sticking pint behavior found in the competitive group. The nature of the difference in paths suggests another factor. The displacement of the path toward the shoulder by the competitive lifter reduces the torque he is required to generate at the shoulder. This minimization of torque is an important result of this horizontal shift of the bar path toward the shoulder.

So far, the bar paths discussed have been those of light experts and novices (from reference 1). The same trend was also demonstrated for horizontal bar position for heavy expert bench pressers, (reference 2). Table 1 shows the horizontal locations of the bar during the raising phase for all three groups. Note in this table that the heavy experts maintain a horizontal bar position further away from the shoulder than the light experts. This is probably related to the greater size of the heavy experts and the limitations posed by the fixed grip width (32 inches) on the bar permitted in competition. This may prevent larger, heavier lifts from maintaining geometric similarity with the smaller expert lifters. It may be that the larger high skilled lifters are replicating the technique of the smaller lifters as much as is permitted within the rules of powerlifting. Note that the heavy experts seek to mimic the path of the lighter experts, and even though the heavy expert group are similar in horizontal bar position to the novices early in the lift, they quickly move the bar horizontally throughout the entire raising phase (see Table 1). The major point is that lifters should develop a horizontal bar path that's as close to the shoulders as feasible, and work probably toward the light expert path (as a guide.)

The novice lifter could benefit by modifying his bar path so that it is more similar to the one typical of the light expert group. Clearly this change would reduce the torque required at the shoulder. Are there any hidden costs associated with gaining this benefit? Yes, there is at least one. In moving the bar horizontally toward the shoulder, the perpendicular

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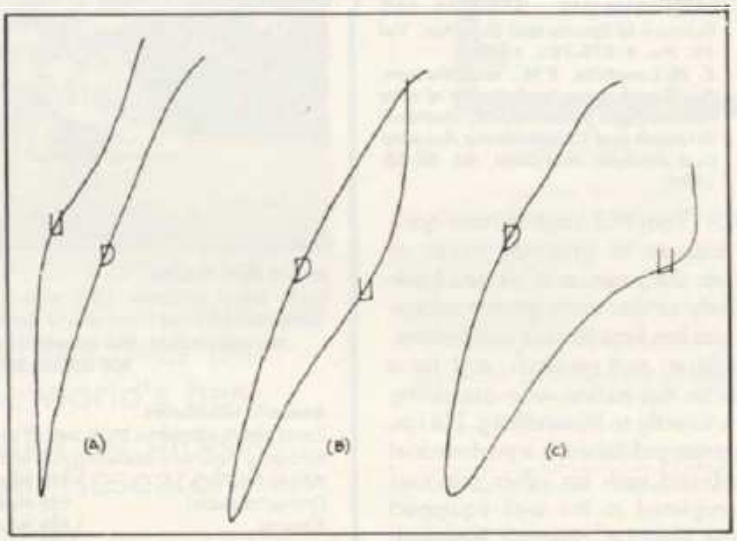

Figure 1: *Typical bar paths: (a) Novice subject with 245 lbs, (b) Bridges with 463 lbs at 1980 World Series meet, and (c) Kazmaier with 605 lbs from training session in 1979 at National Strength Research Center, Auburn, AL. (Notes: D and U refer to downward and upward bar paths, respectively. Head position on the right).*

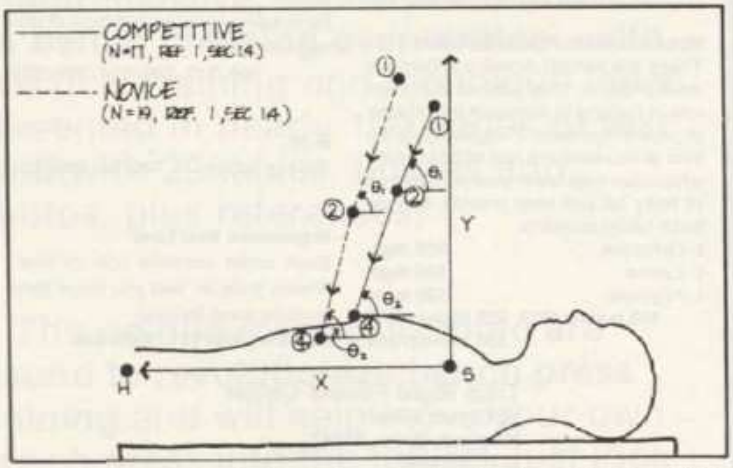

Figure 2: *Comparative Bar Paths - Lowering the Bar. (1) = STRT, (2) = MXVL, (4) = CHST. See text for further description of numbered points and angles.*

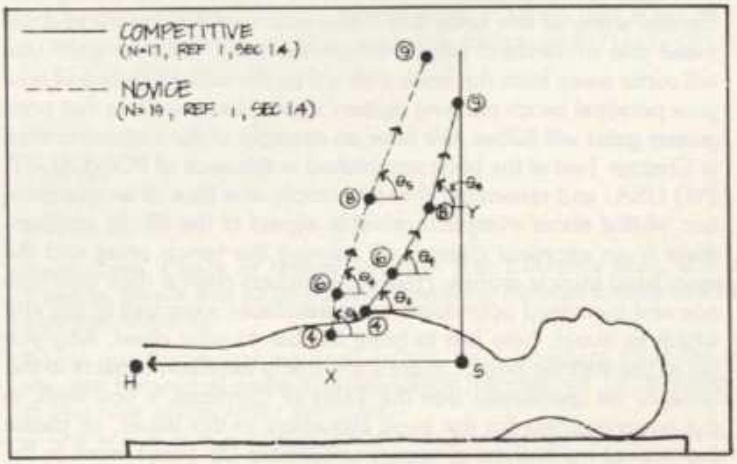

Figure 3: *Comparative Bar Paths - Raising the Bar. (4) = CHST, (6) = MXVR, (8) = MNVR, (9) = end. See text for further description of these characteristic instants and angles.*

Table 1: Comparative Horizontal Bar Locations During Raising the Bar

Horizontal distance from shoulder to bar at various instants (in)	Heavy Experts $\bar{X}$ (in)	Light Experts $\bar{X}$ (in)	Light Novices $\bar{X}$ (in)
At Chest-CHST (4)	7.79	5.27	7.44
At maximum force exertion-MXAR (5)	7.56	5.00	7.44
At maximum bar velocity-MXVR (6)	6.46	3.98	7.16
At minimum force exertion-MNAR (7)	5.27	3.07	6.85
At minimum bar velocity-MNVR (8)	3.89	1.73	5.19

distance between the elbow and the line of action of the bar is increased. The required extensive moment at the elbow is increased as the bar path is displaced toward the shoulder. The force required from the tricep must be correspondingly increased. For a novice lifter to benefit from a change in bar path he must have sufficient tricep force capacity. The data suggests that the novice lifter could benefit by shifting his bar path toward his shoulder. It appears that the novice is requiring too much moment at the shoulder and not enough at the elbow. A bar path displaced horizontally from the present path that approximately balances the shoulder and elbow moment requirements should exist. This path change should improve performance without any increase required in muscle capacity. With experience with the new technique, tricep force capacity should increase and allow the novice to choose a bar path that more closely emulates that used by the competitive lifter.

Other interesting questions remain to be explored here. For example, the significance of the path in determining capacity, and particularly the differences in path during the raising and lowering phases poses some interesting questions about the design and use of exercise machines. Does the use of different paths in lowering and raising the bar 'save' muscle force for the raising phase? These interesting questions require further study.

References:

1. Madsen, N and McLaughlin, T.M., 'Kinematic factors affecting performance and injury risk in the bench press exercise', Medicine and Science in Sports and Exercise, Vol 16, No. 4:376-381, 1984.

2. McLaughlin, T.M., and Madsen, N., 'Bench press techniques of elite heavyweight powerlifters', National Strength and Conditioning Association Journal, Aug-Sept, 44, 62-65, 1984.