COMPARISON OF CEREBRAL PALSIED AND HEALTHY SPRINTERS

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Opportunities for cerebral palsied children and young adults to participate in sports training and competition are increasing. The Education for All Handicapped Children Act (Public Law 94-142, 1975), Section 504 of the Rehabilitation Act (Public Law 93-112, 1973), the Amateur Sports Act (Public Law 95-606, 1978), the formation of the National Association of Sports for Cerebral Palsy (NASCP), and greater media visibility have all contributed to the increased awareness and acceptance of cerebral palsied individuals' participation in sports.

The United States Olympic Committee (USOC) has recently designated a Committee on Sports for the Disabled (COSD) which is comprised of seven national organizations for specific disabled sports. Research and development in training, coaching, and performance analysis of specific disabilities has been encouraged by the COSD (DePauw, 1984). Additionally, through the COSD, member organizations have received financial support from the USOC to conduct competition. This recognition by the USOC reaffirms the timeliness of the need for sports research with disabled athletes.

This increased awareness and acceptance of cerebral palsied individuals' participation in competitive sports has emphasized the need for sound training techniques based on field-tested research. To adequately prepare coaches, a body of quantitative, scientifically-based research is needed to generate sound coaching techniques. Roper (1984) was encouraged by the rapid growth of cerebral palsied sports participants but noted that it accentuated the lack of sports research on the unique abilities of the disabled. An initial step in developing techniques for individuals with specific disabilities is to first identify commonalities with able-bodied athletes in order to build a foundation for further research addressing the unique characteristics of disabled individuals.

The literature on cerebral palsied persons is robust with qualitative and quantitative studies of walking patterns (Mann, 1983; Samilson & Dillin, 1978; Skrotzky, 1983) but is devoid of descriptions of the running patterns. Similarly, a large body of literature exists on able-bodied runners, but no studies have been identified examining running patterns of cerebral palsied individuals. The purpose of the study, therefore, was to contrast the biomechanical characteristics of the cerebral palsied (CP) athletes performing a sprint run with those reported for able-bodied (AB) runners.

METHODS

In an attempt to provide equitable competition levels for CP athletes with varying disabilities, the Cerebral Palsy-International Sports Association (CP-ISRA) utilizes a sports classification system based on functional assessments determined by trained classifiers. Classes VI through VIII, who are ambulatory and use no assistive devices, were the classification levels of interest in this study. Class VI athletes are typically moderate to severe quadriplegics, with athetosis often present. Class VII athletes are typically moderate to minimal hemiplegics, triplegics, or quadriplegics. Class VIII athletes are minimally affected hemiplegics, monoplegics, or very minimally involved quadriplegics (CP-ISRA, 1983).

Subjects in the study were 17 male and female Class VI, VII, and VIII CP athletes (ages 18 to 38 years) who competed at the 1984 International Games for the Disabled in New York. Subjects represented eight countries and were finalists or semifinalists in sprint events. Subjects were selected according to the purposive sampling design described by Kerlinger (1973). Among the subjects analyzed, each CP-ISRA classification level studied was represented by 3 male and 3 female athletes, with the exception of Class VIII females ($\underline{n}$ = 2).

All subjects were sprinters, competing in either the sprint distance for their classification level or in the 100-meter leg of a 400-meter relay. Final 60-meter dash times ranged from 9.14 s to 9.86 s (Class VI males) and from 12.40 s to 13.44 s (Class VI females). Final 100-m dash finish times for Class VII athletes ranged from 13.89 s to 14.08 s (males) and from 16.73 s to 17.29 s (females). Final 100-m dash finish times for Class VIII athletes ranged from 14.54 s to 15.30 s (males) and from 17.91 s to 18.37 s (females).

Because of the lack of symmetry displayed in locomotor patterns of CP individuals, it is difficult to anticipate what movement will be occurring when a body segment is obscured from camera view. In order to accurately represent the movement that occurred, a two-camera set-up was used to film the running pattern from both right and left sagittal views. High speed films were taken in a staged setting on the approach path to the pole vault using two Bell and Howell movie cameras operating at 50 and 54 frames per second. Cameras were bilaterally positioned 13.72 m from the subjects. Subjects were requested to run a distance of 35 m, with the midpoint of the filming being at a point 20 m into the run.

Data reduction of both film views was performed using a 1224 Numonics digitizer, Apple II Plus microcomputer, graphics printer, and the BIOMEK computer program (Richards & Wilkerson, 1984). Consecutive frames were digitized beginning three frames before foot touchdown and ending three frames after the same foot again touched the ground. Raw data were smoothed using a cubic spline function. One stride cycle for each subject was analyzed for selected temporal and kinematic variables. Kinematic variables analyzed were (a) stride length, (b) step frequency, (c) vertical displacement of the total body center of gravity, (d) mean horizontal velocity of the total body center of gravity, (e) step time, (f) times of support, nonsupport, and recovery, (g) angular displacement at the hip joint, (h) trunk angle to the horizontal, and (i) angles of takeoff and touchdown of the total body.

RESULTS

Means and standard deviations were calculated for linear, temporal, and angular variables. Comparisons to findings in the literature on AB runners are reported for CP males and females.

Linear Variables

Mean stride length was 3.11 m (SD = .15) for CP males and 2.74 m (SD = .28) for CP females. Reported stride length values in the literature range from 3.72 to 4.51 m for AB male sprinters (Deshon & Nelson, 1964; Dillman, 1970; Hoffman, 1971; Mason, 1980) and from 3.30 to 3.94 m for AB female runners (Bates, 1973; Bates & Haven, 1974; Haven, 1977; Hoffman, 1972; Teeple, 1968).

Horizontal velocity was determined by dividing the horizontal displacement of the total body center of gravity by stride time. Mean horizontal velocity was 7.14 m/s (SD = .33) for CP males and 5.79 m/s (SD = .54) for CP females. Reported horizontal velocity values in the literature range from 7.80 to 11.40 m/s for AB male sprinters (Atwater, 1980; Deshon & Nelson, 1964; Dillman, 1970; Hoffman, 1971; Mason, 1980) and from 6.81 to 7.36 m/s for AB female runners (Bates, 1973; Bates & Haven, 1974; Haven, 1977; Hoffman, 1972; Teeple, 1968).

Mean step frequency was 4.63 steps/s (SD = .44) for CP males and 4.26 steps/s (SD = .50) for CP females. Reported step frequency values in the literature range from 3.42 to 3.94 steps/s at velocities of 6.67 to 11.4 m/s for AB male runners (Deshon & Nelson, 1964; Dillman, 1970; Hoffman, 1971; Hoshikawa, Matsui, & Miyashita, 1973) and from 3.60 to 4.48 steps/s at velocities of 6.81 to 7.36 m/s for AB female runners (Bates, 1973; Bates & Haven, 1974; Haven, 1977; Hoffman, 1972; Teeple, 1968).

Mean vertical displacement of the total body center of gravity was 7.50 cm (SD = 2.00) for CP males and 7.41 cm (SD = 1.34) for CP females. Reported vertical displacement values in the literature range from 4.00 to 8.00 cm for AB runners (Bates, 1973; Fenn, 1930).

Temporal Variables

Mean step time was .218 s (SD = .021) for CP males and .237 s (SD = .027) for CP females. Reported step times in the literature range from .218 to .222 s for male AB runners (Atwater, 1980; Dillman, 1975) and from .267 to .278 s for female AB runners (Bates & Haven, 1974; Haven, 1977).

The ratio of percentage of total stride time spent in support to nonsupport was 53:47 for CP males and 58:42 for CP females. Reported support to nonsupport ratios in the literature are 43:57 for AB male runners (Atwater, 1980); values of 44:56 and 47:53 are reported for AB female runners (Bates & Haven, 1974; Haven, 1977). Mean recovery time was 74.0% of total stride time for CP males and 71.0% for CP females. Reported recovery times in the literature range from 76.8% to 78.3% for AB runners (Bates & Haven, 1974; Haven, 1977).

Angular Variables

Trunk angle was measured counterclockwise from the right horizontal and represented an average throughout the stride. Trunk angle was 75° for CP males and 77° for CP females. Reported values in the literature range from 80° to 85° for AB runners (Bates, 1973; Haven, 1977; Teeple, 1968).

Hip joint range of motion was measured from maximum thigh back to maximum thigh forward positions. Hip joint ROM was 89° for CP males and 84° for CP females. Reported values in the literature are 94° for AB males and 100° for AB females (Dillman, 1970; Haven, 1977).

Angle of takeoff was measured as the angle formed by the total body center of gravity to the toe of the support foot and the right horizontal. Angle of takeoff was 62° for CP males and females. Reported values in the literature are 61° for AB runners (Bates, 1973; Haven, 1977).

The angle of touchdown gives an indication of the position of the total body center of gravity in relation to the support foot at the time of footstrike. This angle was measured from the total body center of gravity to the malleolus of the support foot to the left horizontal. Angle of touchdown was 86° for CP males and 83° for CP females. Reported values in the literature are 76° for AB males (Deshon & Nelson, 1964) and range from 67° to 77° for AB females (Bates, 1973; Haven, 1977).

DISCUSSION

In able-bodied running, researchers generally agree that at the higher velocities (sprint pace), increases in speed are accomplished by increasing step frequency, while at the lower velocities, increases in velocity are a result of an increased stride or step length. The cerebral palsied subjects in the present study were running at step frequencies equivalent to those reported at sprint pace in able-bodied running, although the velocities of the cerebral palsied subjects were lower than those of able-bodied sprinters. Stride lengths were shorter for the cerebral palsied athletes in the present study, indicating that the increases in velocity were accomplished by the higher step frequencies. As reported by Mann (1983), Samilson and Dillin (1978), and Skrotzky (1983), limitations in step length could be the result of hip flexion contractures and corresponding decreases in pelvic rotation, increased lumbar lordosis, and lack of flexion at the hip.

In order to increase stride length and consequently increase stride velocity, coaches and athletes should examine the contributing components of stride length. Physiological limitations may influence the ability of some cerebral palsied athletes to alter some of the components of stride length and may necessitate emphasizing other components that are physiologically obtainable for that athlete.

Observable differences contributing to a longer stride length were seen between cerebral palsied runners and able-bodied runners in the literature. These differences included (a) a more forward trunk lean which could limit the ability to bring the thigh forward, (b) a limited range of motion at the hip joint, which also could limit the ability to bring the thigh forward as well as to generate a large velocity during the forward swing period, and (c) a higher percentage of time spent in support.

CONCLUSION

Based on information from the study, it was concluded that elite Class VI, VII, and VIII cerebral palsied athletes descriptively differ from findings in the literature on able-bodied runners on variables of stride length, velocity, step time (females only), ratio of support to nonsupport time, trunk angle, hip angle, and angle of touchdown. Since the present sample included too few subjects to appropriately use inferential statistics, additional research involving a larger sample size would be recommended. It is suggested that further study be conducted filming more than one stride cycle in order to compare intrasubject variability. Such research should provide additional information that could prove beneficial in developing research-based coaching techniques.

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