South African Journal for Research in Sport, Physical Education and Recreation, 2009, 31(2):1-14.
Suid-Afrikaanse Tydskrif vir Navorsing in Sport, Liggaamlike Opvoedkunde en Ontspanning, 2009, 31(2):1-14.
ISSN: 0379-9069

THE CLASSIFICATION OF SPRINTERS WITH INTELLECTUAL IMPAIRMENTS: A PRELIMINARY ANALYSIS

Barry ANDREWS*, Vicky GOOSEY-TOLFREY** & Elizabeth S. BRESSAN*
**Department of Sport Science, Stellenbosch University, Stellenbosch, Republic of South Africa*
***School of Sport and Exercise Science, The Peter Harrison Centre for Disability Sport,*
Loughborough University, Loughborough, England

ABSTRACT

Participation in sporting events sanctioned by the International Paralympic Committee is currently not open to athletes with intellectual impairments. This situation will persist until a valid and reliable sport-specific system is developed that can differentiate athletes with intellectual impairments from athletes without intellectual impairments. Such a system would be used to determine who is eligible for separate competitions, such as the Paralympics, and who should participate without special considerations in mainstream sport. The purpose of this study was to examine the first 30m of the sprint event to determine if there were any differences in the kinematics when athletes with intellectual impairments (n=32) were compared to athletes without intellectual impairments (n=14). Sprint performances were digitally recorded (50 Hz) and analysed using the DartFish ProSuite software programme. The data collected from these analyses were then compared using unpaired t-tests. Between-group differences were significant between 20 m and 30 m for stride frequency and in all three 10m segments for stride length (p<.05) in the acceleration phase.

Key words: Kinematics; Stride length/frequency; Sprinting.

INTRODUCTION

One legacy of the 2000 Paralympic Games was a crisis in terms of the classification of athletes with intellectual impairments. Spain was stripped of its gold medal in basketball when an undercover journalist playing on the team revealed that neither he nor some of the other players on the team had intellectual impairments. The International Paralympic Committee (IPC) investigated and found that the Spanish Paralympic Committee could not provide evidence that the appropriate intelligence IQ tests had been administered to their basketball players (CBC Sports, 2000). This incident led to an IPC announcement suspending the participation of individuals with intellectual impairments at IPC-sanctioned events. The IPC then announced that participation would not be resumed until the challenges were resolved regarding the identification of a valid and reliable method for the determination of a sufficient level of intellectual impairment to establish eligibility for Paralympic participation (*New York Times*, 2001; CBC Sports, 2000). The continued suspension of these athletes from IPC events will persist until a credible system for their classification is developed (INAS-FID, 2003).

A valid and reliable system for classification relies on the identification of differences in the functional characteristics of athletes. Theses differences must be sufficiently critical for success in a particular sport, so that fair competition in that sport is not possible against so-called “normal” athletes or athletes who have different disabilities. Systems for classification exist within many sports. For example, there are weight classes in boxing because it would not be “fair” to expect a 127 kg boxer to compete against a 180 kg boxer. The same premise applies for Paralympic competition, where a 400 m runner with artificial legs does not compete against an athlete who uses a wheelchair. What is “fair” and “unfair” in terms of classification according to functional abilities is also generally regarded on a sport-by-sport basis. In Olympic sport, for example, men compete against women in equestrian events, but not in soccer. Age-group competitions are commonly implemented in many other sports. In Paralympic sport, the determination of classification systems is complicated because there are so many different functional implications for the different disabilities and their impact on performance in different sports must be considered carefully. In fact, if an athlete’s functional characteristics allow him/her to engage in mainstream sport effectively, inclusion is appropriate in order to maximise opportunities for competition and the achievement of his/her full sporting potential.

There is a critical debate in Parlympic sport circles regarding whether or not there is sufficient evidence that an intellectual impairment affect sport performance to the extent that special sporting opportunities should be provided. The contention that there is insufficient evidence is in part due to a lack of scientific clarity about of the exact nature of intellectual impairments. One commonly used definition formulated by the American Association on Mental Retardation (AAMR), described an intellectual impairment as a substantial limitation that is usually manifested before the age of 18, characterised by sub-average intellectual functioning. A minimum of two related limitations in two or more of the following 10 adaptive skill areas will also be present: communication, self-care, home living, social skills, community involvement, self-regulation, health and safety, academics, leisure, and work (AAMR, 1992). The AAMR also stated that the impact of an intellectual impairment on the behaviour of any individual is context-related, meaning that the impairment could have more of an impact in some situations than in others. Transferred to the sporting situation, this description can be used to identify individuals with intellectual impairments, but cannot by itself justify the provision of special competition opportunities. This step must be supported by the demonstration of significant functional limitations brought by an intellectual impairment to sport performance, on a sport-by-sport basis.

Research to explore the possible eligibility of individuals with intellectual impairments for participation in athletics is critical because of the world-wide popularity of athletics and its centrality to the Paralympic Games. This exploration must be sensitive to the different functional demands placed upon athletes during different atletics events. For example, sprinting is considered to be a closed skill because it is performed in a relatively stable and predictable environment. However, sprinting within the context of a 4x100 relay is a more open skill because it includes challenges to fine coordination and decision-making during baton passing, as well as the need to adjust to teammates’ running pace. Sprinting was selected for this preliminary investigation because it offers a relatively uncomplicated context in which to examine the performance of athletes with intellectual impairments (II). If their intellectual impairment has an impact on sprinting performance, it should be revealed by comparing their sprinting performances to the performances of counterparts without intellectual impairments (non-II). The results of such a comparison could help determine if separate competitions for II sprinters are warranted or whether “fair” competition can be provided by including them without special accommodations in mainstream sprint events.

Eligibility for Paralympic competition is premised on the existence of an enduring characteristic that has a significant impact on the movement performance of an athlete in a particular sport. In other words, a Paralympic athlete brings a different set of abilities to his/her sport than a non-eligible athlete. Because the differences in abilities must be manifested in movement, a kinematic analysis of sport performance is an essential part of classification. Hay (1978) provided the classic framework that identifies the relationship among the critical kinematic components involved in sprinting performance (see figure 1). If there are significant differences in any of these components when the performances of II and non-II sprinters are compared, then those components deserve additional research with the intention of determining whether they are suitable as criteria for the classification of sprinters as II athletes:

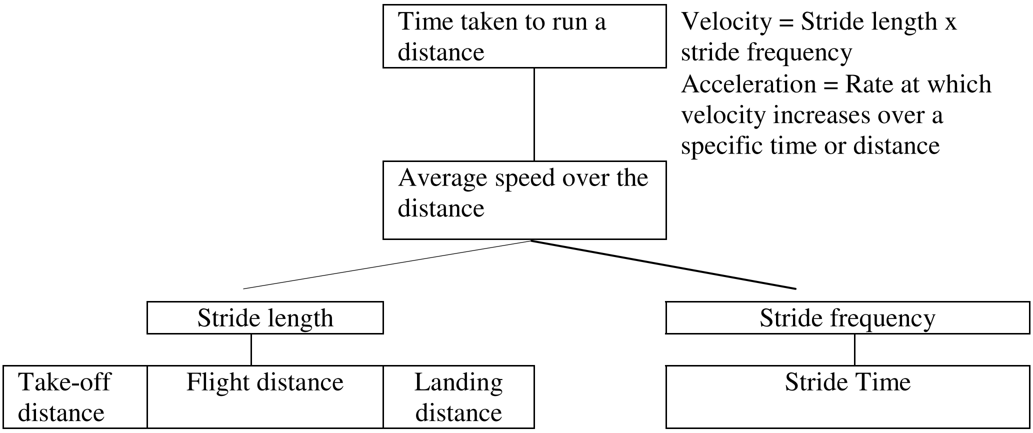
1. Stride frequency.
2. Stride length.
3. Velocity.
4. Acceleration.

PURPOSE

The purpose of this study was to examine the key kinematic performance features of sprinting and to determine if there are any differences between II and non-II athletes during the first 30 m of a sprint.

LIMITATIONS

In order to compare the kinematics of II to non-II sprinters, it was decided to limit the subject pool to top level athletes only. In this way, the athletes in both groups would have had the opportunity for sustained specialised sprint coaching as well as opportunities for regional,



Velocity = Stride length x stride frequency
Acceleration = Rate at which velocity increases over a specific time or distance

FIGURE 1: **AN ADAPTATION OF HAY'S (1978) FRAMEWORK OF THE CRITICAL KINEMATIC COMPONENTS THAT AFFECT SPRINT PERFORMANCE**

national and international competition. Consequently, II participants competing at the 2006 World Championships met this criteria and were recruited as part of a sport classification project. As this project was conducted at an international competition, permission to gather data had been obtained from both the International Sports Federation for Persons with Intellectual Disabilities (INAS-FID) and the participants. As part of the project approval the INAS-FID considered the measurement of the height of the athletes to be non-intrusive, which meant that this data was gathered alongside the video footage and could be related to the stride length data. Unfortunately, permission was not granted to take either leg length or hip range of movement measurements. This presents a limitation to the interpretation of results as it has been shown that common reasons for stride length differences among sprinters are differences in leg length and range of movement in the hip joints (Hay, 1978).

Classification systems for Paralympic sport are not based on gender. The same eligibility criteria are applied to both male and female athletes, although most events are presented separately. For this reason, the participants in this study were both male and female and no discrimination was made in the data analysis. This is an artefact of the purpose of this research, which is to inform the development of a system for classification. The purpose was not to describe differences in the kinematics of male and female sprinters. If an intellectual impairment has an impact on sprint kinematics, that impact will be evident for both males and females.

ASSESSMENT OF SPRINT KINEMATICS

Top level competitors sprint all distances from 100 m up to 400 m and use a crouch start (Novacheck, 1998). Mann and Sprague (1983) divided the 100 m sprint event into three main phases:

1. Acceleration phase (the first 30 m).
2. Maximal running velocity phase.
3. Deceleration phase.

Although sprint kinematics could be assessed during any or all of these phases, the approved sport science video analysis project was restricted to the first 30 m - the acceleration phase. This was based on previous research indicating that II individuals are typically less proficient than non-II individuals in terms of selected fitness variables, including reduced balance control associated with less efficient generation of horizontal ground forces (Di Rocco *et al.,* 1987) and reduced speed of limb movement and explosive strength (Lefevre *et al.,* 2000). Based upon the above aforementioned factors supports the fact that the acceleration phase is the most likely phase in which to discover performance differences between II and non-II sprinters.

Each sprinter performed a 60 m maximal sprint, with the first 30 m filmed. Three digital cameras with a tripod height of 1m were set up on the athletics track in order to separately record each sprinter's performance. The cameras were placed on the track 10 m back from the sprinting lane at the mid-point of each of the three acceleration sub-phases.

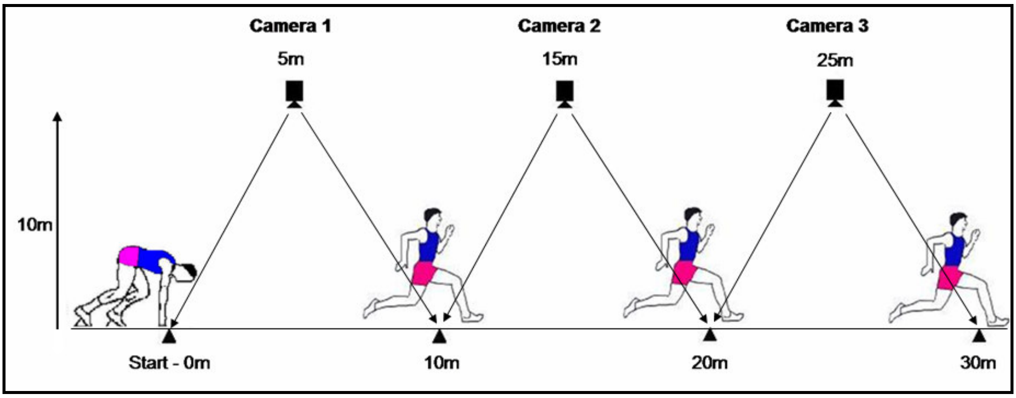


FIGURE 2: **CAMERA LOCATIONS FOR RECORDING THE THREE SUB-PHASES OF ACCELERATION**

The start gun emitted an audible signal and a visual flash, which was used to synchronise the start time of the video recordings. All cameras were fixed, and did not pan at any time during the recording. A team of three sport scientists were trained to do the filming of the II athletes in Sweden. One of these team members was available for filming the non-II athletes in South Africa, but two new team members had to be trained to replicate the filming process.

METHODS

This was a descriptive study that compared the performances of II to non-II sprinters on selected kinematic variables. It was necessary to use samples of convenience for both groups. The II athletes were participants at the 2006 World Games and the non-II athletes were top-level sprinters from a university athletics club.

Participants

There were 32 II athletes (22 male and 10 female) all over 18 years old, who volunteered to participate in this study. The search for non-II athletes with sufficient experience to qualify as a comparison group yielded a group of 14 volunteers (10 males and 4 females) over 18 years old from a university athletics club. All participants competed regularly at athletic events and had regular training schedules. Participants were fully informed of the requirements of the study and subsequently signed a consent form prior to the filming of their sprint performances.

Procedures

Digital video recordings of the sprint performances of the participants were made at two different tartan athletic tracks. Similarities between the two facilities made it possible to replicate the camera set-up. The same procedures were followed during the filming sessions for both the II and the non-II sprinters. After completing his/her warm-up, each athlete performed a 60 m maximal sprint. The sprint was performed individually and each athlete's coach was present to provide encouragement. Each sprinter then completed an appropriate warm-down.

Data collection and analysis

Three video cameras were set up on the athletics track during officially scheduled data collection sessions in the positions described previously. Sprinters reported to the starting blocks when their names were called by the starter. When the sprinter indicated readiness, the starter delivered the command sequence: 'take your marks' and 'set' shortly followed by the firing of the start gun. Cameras one, two and three began to record simultaneously with the starting gun. The digital record that was captured for each sprinter was downloaded from each camera to a computer file using the DartFish ProSuite software programme (version 4.0.9.0). This software is capable of elite performance analysis and allowed the investigator to later digitise kinematic aspects of performance, such as marking the front of the foot at first contact with the track. Digitising was completed in a frame-by- frame manner in order to produce the most accurate calculations based on take-off, flight distance, landing and stride time for the designated strides in each sub-phase.

The performance of the non-II athletes was taken as the normal expectation for sprint kinematics. Analysis was based on the group mean scores for complete strides recorded per 10 m sub-phase. The non-II athletes covered the initial 10 m with their first seven strides (an eighth stride took them beyond the 10 m mark), the second 10 m with their next four strides (a fifth stride took them beyond the 20 m mark), and the third 10 m with their next three strides (a fourth stride took them beyond the 30 m mark). This became the benchmark for the kinematic analysis for both the non-II and II sprinters: the first seven strides of the initial 10m sub-phase, the first four complete strides in the second 10 m sub-phase, and the first three complete strides in the third 10 m sub-phase. Unpaired independent t-tests were then used to determine differences between II and non-II athletes in each sub-phase for each of the following variables: Stride frequency, stride length, velocity and acceleration.

RESULTS

A comparison of the mean stride frequencies between the two groups is presented in figure 3. The non-II athletes had a higher stride frequency in every sub-phase, achieving a significant difference in sub-phase three ($p<.05$). The standard deviation in stride frequencies was also greater for the II group in every sub-phase, reflecting a greater variability in sprinting kinematics among II sprinters.

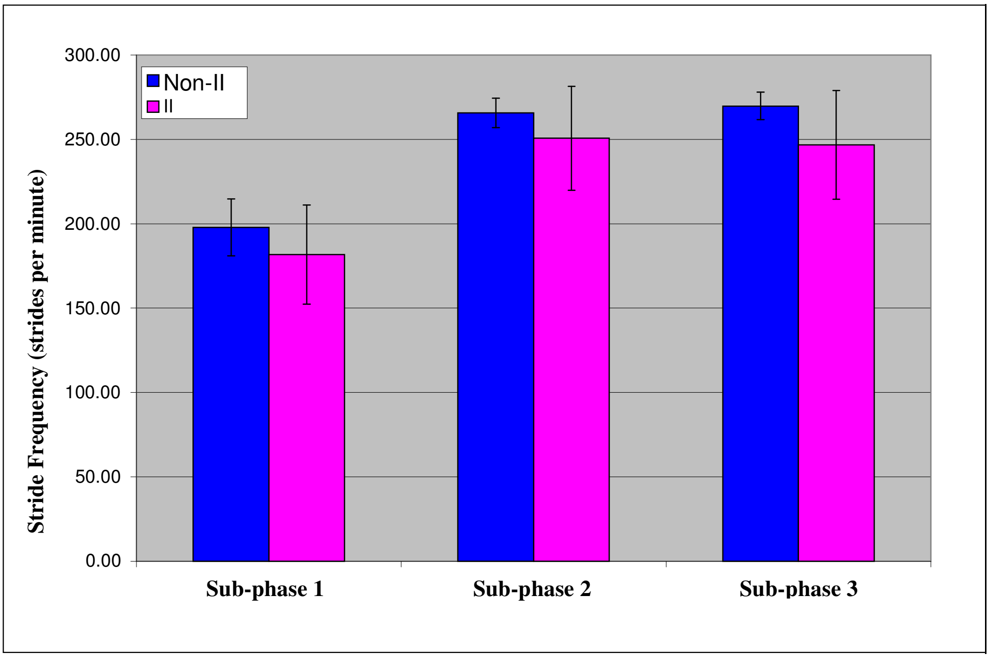


FIGURE 3: **A COMPARISON BETWEEEN THE STRIDE FREQUENCIES OF NON-II AND II ATHELTES DURING THE THREE SUB-PHASES OF ACCELERATION IN A 60 M MAXIMAL SPRINT**

A significant difference was found in each sub-phase when stride lengths were compared between the non-II and II athletes (p<.05) (see figure 4). Not only were the stride lengths of the II athletes significantly shorter, but the trend toward a shorter stride length for II sprinters became greater as the end of each sub-phase was approached. It was also evident from a visual examination of figure 4 that not only did the stride length of the non-II sprinters became progressively longer, but the strides in each sub-phase also became longer than the strides in the previous sub-phase. This was not the pattern among the II sprinters, however, where there was a progressive increase in stride length through stride 5 in the first sub-phase, then a shortening of strides 6 and 7. The first complete stride in the second sub-phase was a much longer stride than the stride at the end of first sub-phase. Stride length was maintained for strides 2 and 3, and then became shorter again for stride 4. The first complete stride in the third sub-phase was again longer than the last stride in the previous sub-phase. Stride 3 in this sub-phase was also shorter than was the first or second stride. This uneven stride length pattern was distinctly different from the pattern of the non-II sprinters.

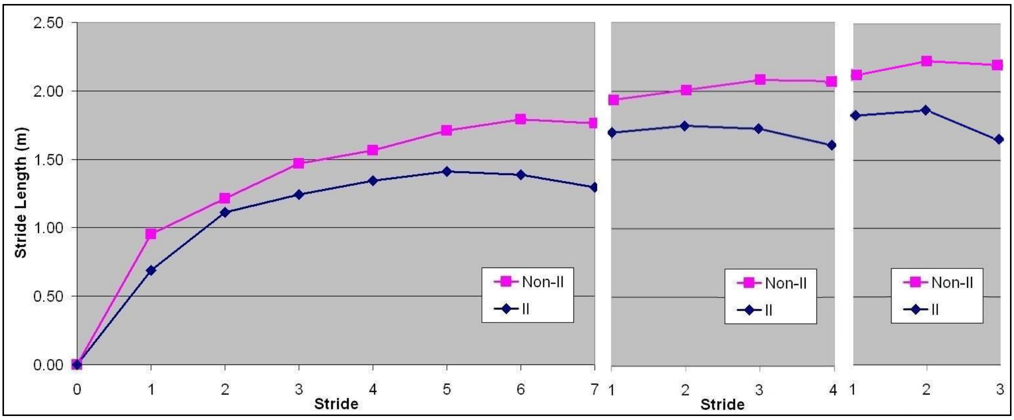


FIGURE 4: **A COMPARISON BETWEEN STRIDE LENGTHS OF NON-II AND II ATHELTES DURING THE THREE SUB-PHASES OF ACCLERATION**

Figure 5 illustrates the differences in velocity and figure 6 the differences in acceleration found when the non-II and II sprinters were compared. In both cases, significant differences were found between the non-II and II sprinters in every sub-phase.

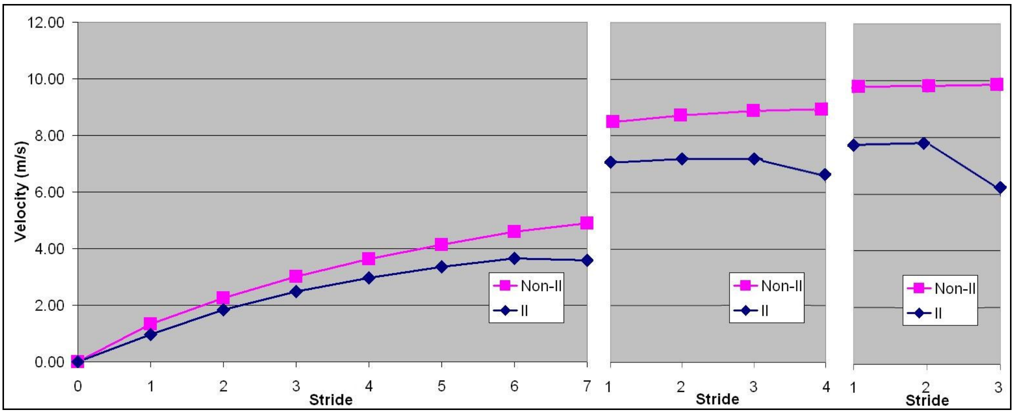


FIGURE 5: **A COMPARISON BETWEEN THE VELOCITY PER STRIDE ON NON-II AND II ATHELTES DURING THE THREE SUB-PHASES OF ACCELERATION**

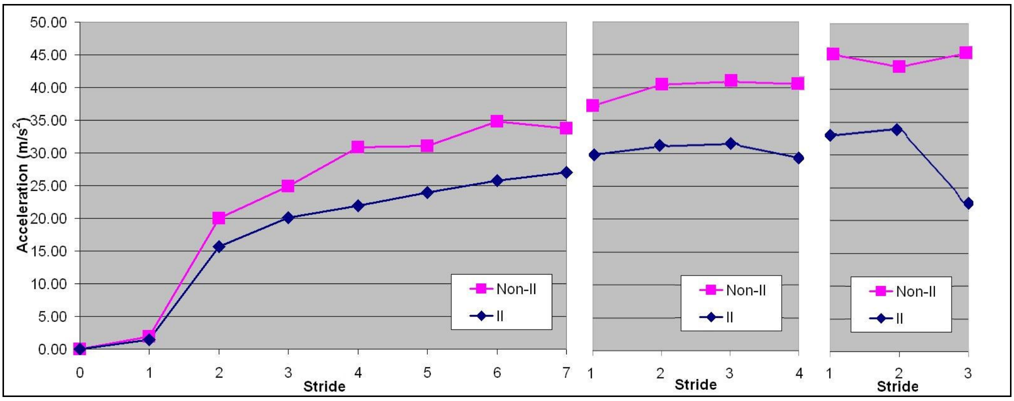


FIGURE 6: **A COMPARISON BETWEEN THE ACCELERATION ACHIEVED PER STRIDE OF NON-II AND II ATHELTES DURING THE THREE SUB-PHASES OF ACCELERATION**

For example, the velocity of the II athletes was 4 m or more per second less than the velocity of non-II sprinters by the time stride 3 was taken in sub-phase three. Because velocity is the product of stride frequency x stride length, this result underscores the impact of the lower stride rate and the shorter stride length (between 20 cm to 50 cm) of the II athletes on their sprint times.

Acceleration is the rate at which velocity increases. The significantly slower acceleration of the II athletes was a reflection of their velocity results. The sharp drop in acceleration of the II sprinters between strides 2 and 3 in sub-phase three was evidence of a loss of efficiency on their part and was in contrast to the maintenance of acceleration evident among the non-II sprinters.

DISCUSSION AND CONCLUSION

The sprinting performances of II athletes were found to be different from the performances of non-II athletes in every sub-phase of the acceleration phase of the sprint, based on the following differences:

1. The mean stride frequencies of the II athletes revealed a trend to be slower in each sub-phase, and significantly slower between 20 m and 30 m. Mean stride lengths were significantly shorter ($p<.05$) for every stride in every sub-phase for the II athletes (ranging between 20 cm and 50 cm). These results imply that II athletes have to take more strides to cover the same distance as non-II athletes.

2. Both velocity and acceleration were significantly less ($p<.05$) for the II athletes during every sub-phase. These results were anticipated when the differences in both stride frequency and length were found, because velocity and acceleration are products of these two variables.

Functional limitations as the source of differences

Because this was a descriptive study, these results cannot explain why these differences occurred, only that they occurred. However, some discussion of the findings is possible. It was previously mentioned that stride length can be affected by height. MacKenzie (2007) reported in one study that optimal stride length could determined by height(m) x 1.35 , and in another study determined it by height(m) x 1.14. The average height of the II athletes in this study was 1.67 m and it was 1.71 m for the non-II athletes. This average difference of approximately four centimetres in height would support an anticipated difference in stride length of approximately 5 cm, regardless of which MacKenzie formula was used. In this study, the mean stride length differences between groups ranged from 20 cm up to 50 cm per stride. This was well beyond the range that could be attributed to differences in height alone. This means that stride length can be regarded as a difference between II and non-II sprinters during the acceleration phase.

Previous studies have identified some physical variables that may help explain differences in stride frequency and stride length (see table 1). Although the differences between II and non-II individuals in previous research in terms of fitness cannot be disregarded, there is insufficient evidence to conclude that these differences should be regarded as enduring functional limitations. There is other research that suggests that the physical fitness is fairly similar when active II and non-II populations are compared (Van de Vliet *et al.,* 2006). The finding that many II individuals manifest reduced balance control could help explain stride length differences (Rider & Abdulahad, 1991). Balance control, both static and dynamic, is a critical underlying ability upon which many other abilities and skills rely (Burton & Davis, 1992).

TABLE 1: **DIFFERENCES IN FITNESS VARIABLES THAT MAY AFFECT SPRING KINEMATICS IN II SPRINTERS**

Research results comparing II to non-II individuals	**Possible implications for sprinting and stride length**
Weaker in the strength of elbow and knee extension and flexion (Horvat *et al.,* 1997; Pitetti & Yarmer, 2002).	1. Diminished toe-off push due to the weaker knee strength. 2. Reduced leg drive because of the diminished toe-off. 3. Shorter stride length because of the reduced leg drive and diminished toe-off.
Differences in speed of limb movement, explosive strength and flexibility (Lefevre *et al.,* 2000).	1. Slower sprinting speed of the athlete because of slower limb movement speed. 2. Shorter stride length due to less explosive strength and/or flexibility.
Children show diminished fundamental and complex motor skill development (Shapiro & Dummer, 1998).	1. Poor running form developed during childhood could limit the ability of the athlete to achieve a mature and efficient running pattern as an adult. 2. Shorter stride length because of the poor running form could become automated, thus affecting adult stride length.
Diminished development of normal balance (Rider & Abdulahad, 1991).	1. Reduced balance control could lead to compensatory movements, e.g. shorter arm

Reduced long jump performance attributed to less effective balance control (Di Rocco *et al*., 1987). Reduced balance control associated with less efficient generation of horizontal and/or vertical ground forces (Di Rocco *et al.,* 1987).	swing, that could limit the ability of the athlete to achieve a mature and efficient running pattern as an adult. 2. Most common adjustment would probably be shorter stride length to compensate for reduced balance control.

Reduced balance control could account for shorter stride length, although speculation about the relationship between reduced balance control and an intellectual impairment is beyond the scope of this investigation.

According to Mero *et al.* (1987), stride frequency has a more important role in maximal sprinting performance than stride length. Differences in speed of limb movement between II and non-II individuals have been found (Lefevre *et al.,* 2000) and differences in stride frequency could be attributed partly to that. However, once again, there is insufficient evidence to conclude that speed of limb movement is an enduring functional limitation brought by II individuals to their sprinting performance.

Training as the source of differences

In order to develop a valid classification system, it is necessary to identify those measurable variables that can define legitimate sources for the differences in performance between II athletes and non-II athletes. Hoover and Wade (1985) noted that there has been so much certainty in the scientific and educational communities that II individuals have a “deficit” somewhere in their information processing capabilities that insufficient effort has gone into developing teaching and training strategies to optimalise their development. In fact, they suggested that a limiting variable on the achievement of II individuals is the assumption by their teachers and coaches that they will not be able to attain the same levels of performance as non-intellectually impaired individuals.

How might this assumption relate to differences found in this study in stride frequency, stride length, velocity and acceleration? It is common practice for coaches to work with sprinters specifically to improve stride frequency and stride length, for example (Fortner, 2007):

1. Strengthen the legs: by improving the strength in the leg muscles, an athlete will be able to produce a stronger push-off from the track that will drive the athlete further and help them maintain their momentum better. Ways for coaches to promote improvements in an athlete’s leg strength would include plyometric (jumping) activities, hill work, speed work, and leg-concentrated gym work.
2. Increase flexibility: increased flexibility is associated with a longer stride length. The longer an athlete’s foot remains in contact with the ground before toe-off, the longer the athlete’s stride length. The maximum angle that an athlete’s ankle and hip can achieve in a stride limits how long the athlete’s foot can remain on the ground. These maximum angles are largely determined by the flexibility of the leg muscles, ankles and hip flexors. Stretching will increase the flexibility of all of these, enabling an extended foot contact and resulting in a later push-off more from an athlete’s toes than from the ball of the foot, thus, a longer stride length.

3. Improve the athlete's running form: the key here is for the coach to get the athlete to keep the centre of gravity forward, especially at the hips. Coaches stress that an athlete try to be erect when running with no forward bend at the waist, and eyes looking straight ahead. It important not to over-stride while trying to achieve a longer stride length because it leads to a braking action which actually slows the athlete down.

According to Hoover and Wade (1985), if coaches believe their athletes can only achieve a certain level, then their athletes will only achieve that level and no better. If this is the case with the II athletes in this study, then their less frequent and shorter strides in the acceleration phase may not be evidence of a functional limitation but rather of their training experiences. No data was gathered from the II athletes in this study regarding their sprint training, so it is not known how much emphasis was put on stride frequency and length training. This means that future research must look beyond kinematic differences and information processing models to include investigations into current training and coaching strategies as possible sources for the differences between II and non-II sprinters.

Recommendations for future research

Future research on the balance control, speed of limb movement, strength, explosive strength and flexibility of II athletes is needed to determine if limitations to the development of one or more of these variables might be a functional characteristic of the II individual, for example:

1. If in future research it is found that significant differences exist in stride length between II and non-II athletes in other sports, then the measureable determinants of stride length, such as balance control, may be identified as appropriate criteria for a classification system.
2. High speed digital video records of the sprint performances of II athletes can be made during competition. If stride length has been identified as a characteristic for classification and a protest is filed regarding the participation of an II sprinter, his/her sprint performance could be analysed to determine whether his/her stride length exceeded the range acceptable for II sprinters.
3. If research finds the performance gap between II and the non-II sprinters can be closed with sprint-specific training, it would imply that there does not need to be a class for II sprinting at the Paralympics. The II sprinters would not be eligible for Paralympic competition because they could be accommodated fully within mainstream athletics. However, if Hoover and Wade (1985) are correct, coaches cannot simply train their II-athletes in the same way they do their non-II athletes and enter them in mainstream sprint events. They must find new approaches to training based on new insights about how individuals with intellectual impairments learn.

It is clear from this preliminary research that there are substantial challenges ahead regarding the development of a valid classification system for II athletes. Even when limited to the first 30 m of a sprint race, differences in the performances of II and non-II athletes can be documented, they still cannot be explained. Without an explanation, it is difficult to identify recurring observable and measurable factors that operate as enduring functional limitations on the performances of II athletes compared to non-II athletes. This study was a first step to confirm that there are differences in sprinting performances. Future research is needed to determine additional differences and the reasons for those differences.

ACKNOWLEDGEMENT

Special thanks are extended to Neil Fowler (Manchester Metropolitan University) for his suggestions regarding kinematic analysis and data processing, and Yves Vanlandewijck (Catholic University Leuven) for his guidance and support during the data collection process.

REFERENCES

AAMR (American Association on Mental Retardation) (1992). Mental retardation: Definition, classification, and systems of supports. Washington, DC: American Association on Mental Retardation.

BURTON, A.W. & DAVIS, W.E. (1992). Assessing balance in adapted physical education: Fundamental concepts and applications. *Adapted Physical Activity Quarterly*, 9(1): 14-46.

CBC SPORTS (2000). "Spanish Paralympic exec resigns amid scandal." [Hyperlink www.cbc.ca/sports/story/2000/11/30/para001130.html]. Retrieved 14 November 2007.

DI ROCCO, P.; CLARK, J. & PHILLIPS, S. (1987). Jumping coordination patterns of mildly mentally retarded children. *Adapted Physical Adapted Quarterly*, 4: 178-191.

FORTNER, J. (2007). "Increasing Stride Length." [Hyperlink http://www.thefinalsprint.com/2007/05/increasing-stride-length/]. Retrieved 21 November 2007.

HAY, J.G. (1978). *The biomechanics of sports techniques* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

HOOVER, J.H. & WADE, M.G. (1985). Motor learning theory and mentally retarded individuals: a historical review. *Adapted Physical Adapted Quarterly*, 2(3): 228-252.

HORVAT, M.; PITETTI, K.H. & CROCE, R. (1997). Isokinetic torque, average power, and flexion/extension ratios in non-disabled adults and adults with mental retardation. *Journal of Orthopedic Sports Physical Therapy*, 25: 395–399.

INAS-FID (International Sports Federation for Persons with Intellectual Disablities) (2003). "Eligibility system unsatisfactory: Athletes with intellectual disability cannot participate." [Hyperlink http://www.paralympic.org/release/Main_Sections_Menu/News/Press_Release/2003_02_02_a.html]. Retrieved 9 November 2007.

LEVEVRE, J.; PHILIPPAERTS, R.M.; DELVAUX, K.; THOMIS, M.; VANREUSEL, B.; VANDEN EYNDE, B.; CLAESSENS, A.L.; LYSENS, R.; RENSON, R. & BEUNEN, G.P. (2000). Daily physical activity and physical fitness from adolescence to adulthood: a longitudinal study. *Journal of Human Biology*, 12: 487-497.

MACKENZIE, B. (2007). "Running Economy." [Hyperlink http://www.brianmac.co.uk/economy.htm]. 24 November 2007.

MANN, R. & SPRAGUE, P. (1983). Kinetics of sprinting. *Track and Field Quarterly*, 83: 4-9.

MERO, A.; KOMI, P.V.; RUSKO, H. & HIRVONEN, J. (1987). Neuromuscular and anaerobic performance of sprinters at maximal and supramaximal speed. *International Journal of Sports Medicine*, 8: SS-60, Supplement.

NEW YORK TIMES (2001). 30 January. "Plus: Paralympics; Palalympic group orders suspensions".

NOVACHECK, T.F. (1998). The biomechanics of running. *Gait and Posture*, 7: 77-95.

PITETTI, K.H. & YARMER, D.A. (2002). Lower body strength of children and adolescents with and without mild retardation: a comparison. *Adapted Physical Adapted Quarterly*, 19(1):68-81.

RIDER, R.Z. & ABDULAHAD, D.T. (1991). Effects of massed versus distributed practice on gross and fine motor proficiency of educable mentally handicapped adolescents. *Perceptual and Motor Skills*, 73: 219-224.

SHAPIRO, E.R. & DUMMER, G.M. (1998). Perceived and actual basketball competence of adolescent males with mild mental retardation. *Adapted Physical Adapted Quarterly*, 15(2): 179-190.

VAN DE VLIET, P.; RINTALA, P.; FROJD, K.; VERELLEN, J.; VANOUUTTE, S.; DALY, D.J. & VANLANDEWIJCK, Y. (2006). Physical fitness profile of elite athletes with intellectual disability. *Scandinavian Journal of Medicine & Science in Sports*, 16: 417–425.

Prof. Elizabeth S. Bressan: Department of Sport Science, Stellenbosch University, Private Bag XI, Matieland 7602, Republic of South Africa. Tel.: +27 (0)21 808 4915, Fax: +27 (0)21 808 4817, E-mail: esb@sun.ac.za

(Subject editor: Dr. G.K. Longhurst)