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THE KINEMATICS OF IDIOPATHIC GAIT DISORDER

A Comparison with Healthy Young and Elderly Females

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ABSTRACT. In this study the kinematic gait parameters of healthy young and elderly subjects were compared with those of a group of patients with idiopathic gait disorder of the elderly (IGDE), a condition characterized by dysfunctional walking for which no underlying cause can be determined. The velocity and the temporal/distance gait kinematics were measured for self-selected fast, medium and slow speeds of walking. The elderly walk with a more cautious gait pattern than younger adults. This pattern is characterized by a slow walking speed and a reduced single support phase, with shorter but more frequent strides, and is even more marked in persons with IGDE. The slower the walking speed the more cautious this pattern becomes. The patients with IGDE not only walk far slower than a group of healthy age matched individuals but the range of speeds, from self-selected slow to fast, is much reduced and does not overlap that of the healthy elderly. With objective gait measurements this group might be better identified.

Key words: gait, female, aged, balance, falls.

In a prospective study of ambulatory, institutionalized subjects over the age of 65, it was reported that the incidence of falls was 668 per 1 000 per year, with 45% of the study population having at least one fall during the five year study period (8). The incidence of falling increased with age over 75 and was higher in women for all age groups. This problem of falls in the elderly is one of extreme importance. For example, community surveys have related that a third to a half of the elderly report falls. Such falls can lead to injuries (e.g. skeletal fractures) and according to the National Safety Council in the United States (1), falling is the single largest cause of injury mortality, accounting for half of all deaths due to injury in the elderly. It is not clear whether these problems of balance are due to underlying pathology, the process of aging or are a consequence of some other factor such as the sedentary lifestyle of older people. It has been suggested that, in the sick elderly, factors such as dizziness and syncope, neurological and cardiac disease, poor health status and functional disability (patient-factor falls) are more important causes of falling than are environmental factors such as stairs and floor obstacles (accidental falls) which are more important in younger subjects (16). When clinically analysed it appears that approximately 20–30% of individuals who suffer from patient-factor falls have no obvious medical disease leading to these falls. These "idiopathic fallers" may be comparable with individuals suffering from idiopathic gait disorder of the elderly, IGDE (11). These individuals are troubled by a disabling gait disorder for which no secondary cause can be determined. Falls occur frequently in individuals who suffer from gait disorders of any type while abnormalities of gait occur not uncommonly in frequent fallers. This association is hardly surprising but it is problematic as to cause and effect. Frequent falls may lead to a changed gait pattern, while a change in gait may lead to a greater tendency to fall.

In about the sixth decade of life there begins to develop what Murray and her colleagues have termed a "pre-senile" gait (14). Finely et al. (5) suggest that chronological age per se does not seem to affect gait characteristics. It is, however, well documented that older people walk at speeds slower than their younger counterparts (6, 15). This decreased walking speed may affect their ability to function in an environment designed for younger and faster individuals (13). O'Brien et al. (15) compared the gait patterns of healthy young and elderly females and found that for three self-selected paces of walking; slow, free speed and fast, the elderly group walked slower, but when correction for walking speed was made the gait patterns were indistinguishable. This is an important finding since the changes between the young and the elderly found in other studies (2, 5, 9, 10, 13) may well be due to the observed differences in walking

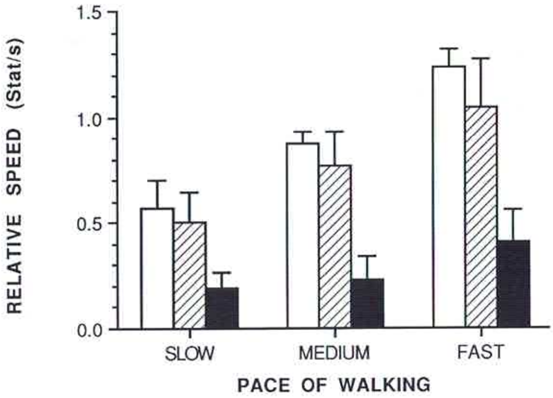

Fig. 1. The relative speeds at which each of the three groups walked when asked to walk at self-selected slow, medium and fast speeds. □, Young; ▨, Elderly, ■, IGDE.

speed. When young and elderly women walked at very slow speeds, however, it was found that the elderly group adopted a more cautious gait pattern characterized by shorter, but more frequent strides and a proportionately longer time spent in the relatively stable periods of double support and less in the more unstable single support phase of the gait cycle (6). Guimaraes & Isaacs (9) studied the gait patterns of elderly fallers and compared them with similarly aged non-fallers, as well as with a group of normal young subjects. The fallers walked at a slower speed with shorter and more variable step lengths, narrower stride widths and a wide range of cadences. The suggestion made is that these changes may reflect a loss of automaticity of gait. In a study of the elderly it was found that the group identified as having an idiopathic gait disorder of the elderly (IGDE) had a far more cautious gait pattern than a group of age-matched controls (11). This gait pattern was identical in nature to that found in normal elderly subjects when asked to walk at very slow speeds (6). In terms of reduced walking speed and reduced step lengths it was also similar to the pattern adopted by the fallers (9).

This paper compares the kinematic gait parameters of healthy young and elderly subjects with those of a group of patients with idiopathic gait disorders of the elderly (11). Of particular interest to this study was the investigation of the range of walking speeds of which these subjects are capable, as well as the relationships between the parameters under study and walking speed. It was hoped that the IGDE group could be more clearly identified from the pattern of walking.

METHODS

Ten young and ten elderly females, without a history of falling and with no subjective complaints of impaired mobility, made up the two control groups. The young group had a mean age of 21 years (±1.70) with a range of 19–25 and a mean height of 1.64 m (±0.052) with a range of 1.59–1.73 m. The elderly female controls had a mean age of 75.7 years (±5.50) with a range of 70–85 and a mean height of 1.59 m (±0.082) and a range of 1.46–1.70. The study group consisted of females who were classified as having IGDE. By definition, these subjects had a functional mobility problem for which no specific diagnosis could be made. These patients typically presented with complains of 'weakness', 'fear of falling', 'unsteadiness', or 'insecurity' while walking. Exclusion criteria included severe degenerative osteoarthritis, marked skeletal deformity, dementia, postural hypotension, chronic alcohol abuse, Parkinson's disease, cervical myelopathy, cerebrovascular disease, normal pressure hydrocephalus, neuropathy, cerebellar ataxia, vestibular dysfunction, severely impaired vision, and/or multiple sensory disorder. The way in which decisions were made regarding the determination of whether or not these deficits were present have been described earlier (11). The IGDE group consisted of ten subjects, ranging in age from 68 to 91 with a mean age of 79 years (±7.06) and a mean height of 1.57 m (±0.046) with a range of 1.50–1.63 m.

The temporal and distance gait kinematics were measured using a walkway described previously (4). The subjects were required to traverse the walkway, which was 10 m in length, the central 7.2 m of which were used to collect data. Data were collected, stored and analysed by a microcomputer, which also controlled the walkway. Each subject was asked to walk at self-selected fast, medium and slow speeds. Data were collected for two traverses of the walkway at each speed. The subjects were videotaped while data were collected (18). The walkway provided measures of step and stride length, stride time as well as the durations of the temporal phases of the gait cycle (19). The durations of braking double support phase (defined as the period immediately following heel strike during which both feet are in contact with the ground), single support, total support and swing phases were calculated as percentages of stride time. The velocity was measured for each traverse of the walkway and this was then normalized to account for differences in height which are known to affect gait (3). Walking speeds are thus reported in terms of relative speed, as suggested by Grieve & Gear (7), whereby velocity is divided by height, resulting in units of statures per second (Stat/s).

RESULTS

In the IGDE group one subject took longer than the maximum allowable one minute to complete a traverse of the central section of the walkway when walking slowly and another only attempted the self-selected medium speed of walking. The velocities selected for the three paces of walking are shown in Fig. 1 together with the standard deviations. The relative speed data were statistically analysed using a one way ANOVA followed by the Duncan test to determine

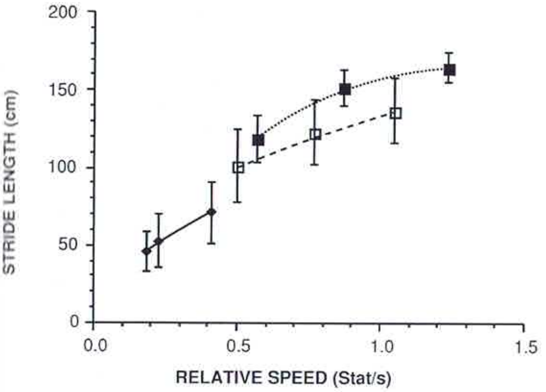

Fig. 2. Stride length plotted against relative speed for each of the three study groups. □, Elderly; ◆, IGDE; ■, Young.

the pairwise mean differences. This analysis revealed that at each of the self-selected paces of walking the IGDE group walked at significantly slower relative speeds than the two groups of healthy subjects ($p < 0.05$). At the fast pace of walking the elderly were significantly slower than their younger counterparts whereas at the other two paces there were no differences in walking speed between these two groups.

In Fig. 2 stride lengths are plotted against relative speed. Stride time is plotted against relative speed in Fig. 3. Figs. 4–6 plot total support time, single support time and braking double support time, respectively, each calculated as a percentage of stride time. Each of these temporal phases of the gait cycle is plotted against relative speed for the three groups.

As can be seen from Fig. 1, the elderly group walked at a slower speed than their younger counterparts at each pace of walking. This confirms the findings of

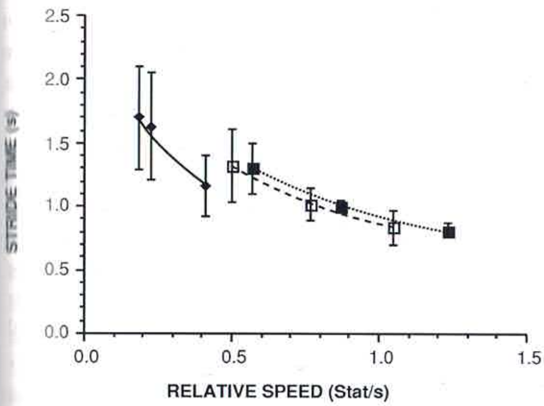

Fig. 3. Stride time plotted against relative speed for each of the three study groups. □, Elderly; ◆, IGDE; ■, Young.

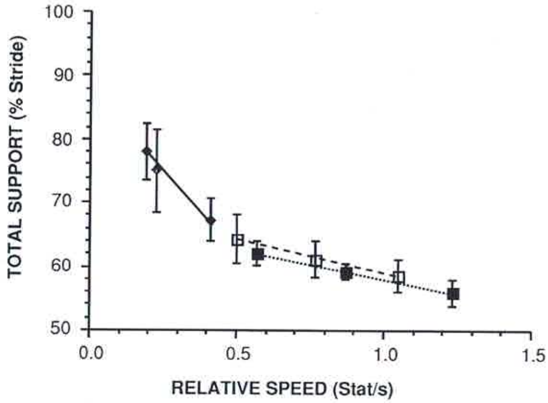

Fig. 4. The duration of the total support phase, expressed as a percentage of stride time, plotted against relative speed for each of the three study groups. □, Elderly; ◆, IGDE; ■, Young.

previous studies (6, 15). The speeds for the IGDE group were much slower at each pace of walking. In fact the fastest walking speed reached by this group was below that of the slow speed for the group of similarly aged, healthy females. The walking speeds for the healthy young female group ranged from 0.57 stat/s at the slow pace to 1.23 stat/s at the fast pace. This range is slightly greater than that shown in the elderly group which went from a slow speed of 0.50 stat/s to a fast speed of 1.05 stat/s. There was very little difference between the slow and fast speeds for the IGDE group, 0.19 stat/s compared with the fast of 0.41 stat/s.

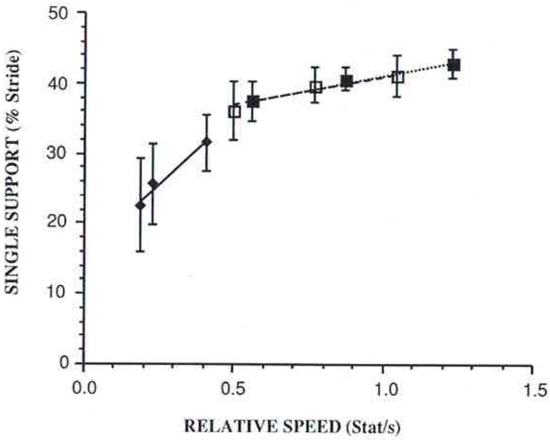

Fig. 5. The duration of the single support phase, expressed as a percentage of stride time, plotted against relative speed for each of the three study groups. □, Elderly; ◆, IGDE; ■, Young.

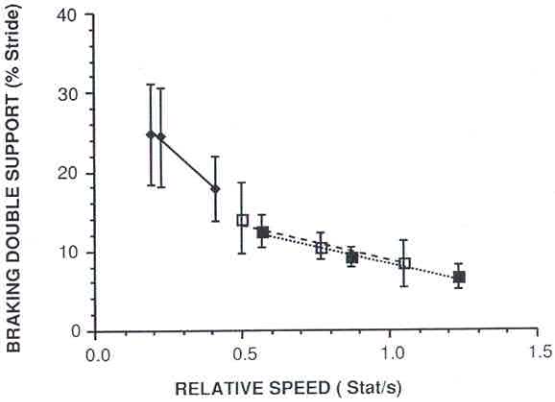

Fig. 6. The duration of the braking double support phase, expressed as a percentage of stride time, ploted against relative speed for each of the three study groups. □, Elderly; ◆, IGDE; ■, Young.

From Fig. 2 it can be seen that the young group walked with a greater stride length than did the elderly group, with the difference becoming more apparent as walking speed increases. This shortening of stride length for a given walking speed is even more marked in the IGDE group. If two groups walk at the same relative speed but with different stride lengths this means that the group with the shorter stride length must also have a shorter stride time. It can be seen from Fig. 3 that this occurs since it is the young group that has the longest stride time for a given walking speed, although this difference appears less marked than the stride length data shown in Fig. 2. At their medium speed of walking the IGDE group walked with a stride time of 1.63s, this is shorter than the 1.84s found earlier (6) for a group of healthy elderly females walking at approximately the same relative speed.

The support phases of the gait cycle, double, single and total support, have been shown to vary linearly over the normal range of walking speeds when the durations of those phases are expressed as percentages of stride time (17). It can be seen from Figs. 3–6 that this holds true for the two healthy groups in this study. This linear relationship between the duration of a support phase and walking speed is also apparent for the IGDE group. Although the groups of healthy individuals were not walked at very slow speeds it is interesting to extrapolate the relationships found for the elderly group back into the range of walking speeds exhibited by the IGDE group in order to demonstrate a number of trends. The total support time for the IGDE group is greater than would be anticipated for a healthy individual of the same age walking at these slow speeds. Also greater than anticipated from normal data would be the duration of the double support phase. The single support phase would be shorter than predicted. The slower the walking speed the greater the difference between the predicted durations of these support phases and those found for the IGDE group.

DISCUSSION

The differences in the durations of the support phases point to a cautious gait pattern in which longer time is spent in the more stable double support phase and less in the more demanding single support phase. Such a method of locomotion would seem logical in a group that presents with such symptoms as "difficulty" or "unsteadiness" while walking.

It is interesting to note that the differences found between the elderly group and the IGDE group also are apparent when the young and the elderly are compared. The older females tend to walk with greater percentage of the stride in total and double support and less in single support, although these differences were not statistically significant.

The slower the IGDE subjects walked the more cautious the pattern became. Gillis et al. (6) found that this cautious pattern of walking also showed up in healthy elderly females when they were asked to walk at very slow speeds. A comparison of the durations of the various support phases from these two studies, at almost identical walking speeds, is also of interest. At the medium speed of walking the IGDE group had a total support time of 75.03% compared with 71.4% found in the earlier study. Single support in the present study (25.3%) is less than the 28.4% found earlier and the double braking support for the IGDE group was found to be longer (25.3%) than for the healthy group (20.9%). The nature of the cautious gait pattern shown by the IGDE group is, therefore, more marked than that found in a healthy elderly group when asked to walk at the same very slow walking speed. This is exactly the trend predicted from the extrapolation of the relationships found for the elderly group back into the range of walking speeds exhibited by the IGDE group discussed earlier.

CONCLUSIONS

This study has confirmed the findings of others that the elderly walk with a more cautious gait pattern than younger adults. This pattern is even more marked in those subjects classified as having an idiopathic gait disorder of the elderly. This pattern is characterized by a slow walking speed and a reduced percentage of the stride spent in single support which is the least stable of the support phases. The slower the walking speed the more cautious this pattern becomes. This may suggest that by simply encouraging these subjects to walk faster, a more normal, though less stable gait pattern, would result with respect to the durations of the support phases.

The gait pattern is also one of "minced" steps in which the subject takes shorter but more frequent strides. This study also reveals that these patients not only walk far slower than a group of healthy age matched subjects but that the range of speeds is much reduced and does not overlap that of the healthy elderly. The graphs also suggest that even if the subjects walked faster this pattern of minced steps would persist.

There are a number of implications from the results of this study for clinicians involved in the care of patients with Idiopathic Gait Disorder of the Elderly. The first of these relates to the gait assessment. Clearly, not all clinical facilities will have even the relatively simple and inexpensive gait measurement system used in this study. However, there are a number of measurements which can be made which appear from our results to more clearly identify this group of patients. The following protocol is suggested:

1. Measure the time taken (t) to cover a set distance (d).
2. Velocity $= d/t$(m/s)
3. Measure the subject's height (h).
4. Relative speed = Velocity/h (Stat/s).
5. Time a set number of strides, where a stride is defined as the time taken for one complete gait cycle, usually measured from heel strike to the next heel strike by the same foot (19). Dividing this time by the number of strides taken will result in stride time.
6. Stride length (m) = stride time $\times$ velocity.
7. Determine these measures for a range of self-selected walking speeds from slow to fast.

These measurements can then be compared with the results given in this paper in order to help classify the patient. It should be pointed out that these measures alone are not sufficient to necessarily distinguish this gait disorder from others, such as that associated with Parkinson's Disease, but should be helpful, when used in conjunction with other information, in the identification of patients with this disorder.

From a treatment viewpoint, the person with IGDE presents rehabilitation personnel with a formidable challenge. Balance re-education would seem to be a logical strategy although the role of such a strategy has never been established. Given that the patient appears incapable or unwilling to spend time in the single support phase, practicing balance on one leg would seem a sensible exercise in the hope that this would result in an improvement in weightbearing ability in single limb support as well as an increase in the duration of this phase of the gait cycle. The adoption of a walking frame would probably improve the overall stability of the patient but, unfortunately, at the expense of mobility and the further lessening of the demand on the balance mechanisms of the patient. It is likely that this situation would further compromise the balance of the patient and interfere with the production of a normal, functional gait pattern to an even greater extent.

The results of this study also suggest that, in addition to balance training, apprehension needs to be given attention. Subjective observation of these patients clearly demonstrates nervousness while walking and during transitional movements interspersed with brief periods of panic. During these panic episodes, postural adjustments are often inappropriate and sometimes made despite the fact that they are probably unnecessary. These somewhat wild movements themselves are sometimes enough to cause the patient to lose balance (12). Oddly, the presence of a therapist in close proximity or simply the carrying of a walking cane by the patient seems to improve this postural "over-reaction". Many of these patients are able to walk normally when lightly holding another person's finger even in open spaces which, without this reassurance, appears to be a daunting proposition. From the data obtained in this study as well as these observations, reducing levels of apprehension perhaps through relaxation techniques, may be indicated. There is a need for further study concerning the role of rehabilitation techniques in the treatment of such patients.

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