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 dysfuncional 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 walked 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.

Keywords: gait, female, age, 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 injury (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 elderly 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). Finley 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 speed.
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 & Ibas (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 (8). 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 at 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.
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**METHODS**

Ten young and ten elderly females, without a history of falling and with no subjective complaint 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 19-23 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 complaints 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, sarcopenia, 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 analyzed 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 (13). 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 breaking and double support phases (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 in order 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 Grimes & Gear (7), whereby velocity is divided by height, resulting in units of meters per second (m/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 phases of walking are shown in Table 1 together with the standard deviations. The relative speed data were statistically analyzed using one way ANOVA followed by the Duncan test to determine 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 break 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 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 to 1.23 m/s at the slow pace to 1.23 m/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 to 1.05 m/s at a fast speed of 1.05 m/s. There was very little difference between the slow and fast speeds for the IGDE group, 0.19 m/s compared with the fast of 0.41 m/s.
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 1.65s, 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 percentage of stride time (17). It can be seen from Figs. 3-4 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 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 duration 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 = Height/Velocity (m/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 x 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. It is suggested that this is to be used in conjunction with other information, in the identification of patients with this disorder.

REFERENCES

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1. Measure the time taken (t) to cover a set distance (d).
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ABSTRACT. The effects of physical and psychosocial work environment factors on emotions, psychosomatic and endocrine (cortisol and testosterone) patterns, back pain, symptoms of degenerative joint disease, and absenteeism for sickness were studied in 147 men and 60 women in six occupations representing widely different physical and psychological activities. In most subjects, measurements were carried out twice to four times over one year. Statistical analyses were performed of the associations between different factor levels, such as age, gender, height, body mass index, and physical stressors at work. It was found that psychological work demands were associated with physiological indicators of strain (plasma cortisol and self-reported muscle tension) and that self-reported muscle tension was associated with several emotional reactions as well as with symptoms from the back, neck and shoulders. Little possibility for decision-making was associated with a high rate of absenteeism for sickness. In men, a high plasma testosterone level was associated with self-reported muscle tension. The results indicate that work environment factors influence mood, bodily tension and somatic symptoms, but that load on the locomotor system and opportunity to influence decisions play an important and more direct role in absenteeism for sickness.

Keywords: muscle tension, psychosocial job stress, plasma cortisol, plasma testosterone, spine, sickness absenteeism, pain.

The etiology of locomotor symptoms is multifactorial. Environmental load, i.e. physical load and psychosocial conditions, as well as individual disposition are frequently discussed as etiological factors in the literature. Several studies show that ergonomic factors such as lifting in bent and twisted body postures may have an impact on low back pain (10). Repetitive strain or maintained strained postures or work may have an impact on occupational cervico-brachial disorders (12). However, a specific kind of occupational exposure may cause discomfort/pain for some individuals but not for all.

Kihlborn et al. (7) found that the individual's way of performing the work, e.g. the shoulder abduction and neck flexion angles, was correlated with symptoms from the neck and shoulders, indicating more problems at higher loads. The perceived pain and the ability to work despite locomotor discomfort/pain also varies among individuals. Early ergonomic and/or therapeutic interventions may reduce the duration of sickness (5, 11).

Neck and shoulder pain has been found to correlate with psychosomatic symptoms as well as with perceived anxiety and stress at work (9). It has also been shown that serious illness in the spouse during one year increases the risk of developing back pain during the following year in middle-aged construction workers (13). Also, workers in occupations characterized as monotonous or boring or not giving the worker an opportunity to influence decisions showed a higher frequency of back pain than those in other occupations (1).

Thus, there is a need for further clarification of the interplay between mechanical load, psychosocial factors and such bodily reactions, e.g. muscle tensions and endocrine responses, as may induce locomotor symptoms. One problem with analyses of this kind is that independent variables such as work load, years at work, monotony, and opportunity to influence decisions might be interrelated.

The aim of the present study was to analyse how variables such as job conditions and individual factors correlate with psychological and physiological reactions and how all these factors influence perceived locomotor pain and health. Job conditions (physical as well as psychosocial) were hypothesized to influence physiological, emotional and psychiatric states as well as perceived musculoskeletal. These states were then hypothesized to influence the likelihood of back, neck and joint pain. The interrelationships between these classes of factors were analysed.