BASIC GAIT PARAMETERS MEASURED IN NORMAL SUBJECTS

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ABSTRACT

Normal gait varies with respect to sex and age. In order to achieve an understanding of these differences, and to establish age- and sex related references to be used in future studies of pathological gait, gait analysis has been carried out.

The material consists of 240 healthy males and females between the ages of 5 and 80, divided into 16 groups. Subjects were asked to walk at normal, slow and fast speeds on a 5.5 m long walkway for a total of 13 times.

Basic temporal and distance gait parameters, as well as sagittal angular movements of the hip and knee, obtained by electrogoniometers, have been included in the study.

A total of 43 variables have been analyzed.

KEY WORDS: Gait analysis, normal gait.

INTRODUCTION

Walking, one of the most universal of all human activities, is an act with a high level of complexity.

In the treatment of patients with gait-disorders there is a need of a simple method to objectively register gait and a need to be able to compare collected data with normal gait. The method earlier described at ISPO congress in London 1983 was found to fullfill the necessities and was therefore used in this study (6).

A method of gait analysis system has been developed by Biomechanics laboratory, University of California, Berkeley, USA, together with Orthopedic Dept, University of Uppsala, Sweden. (Öberg & Lamoreux) (14). This system has been further developed by Department of Biomechanics, University College of Health and Care, Jönköping, Sweden.

Objectives:

A study of basic gait parameters in a sex- and age-distributed material was done on normal people with respect to

- *velocity*
- *step length*
- *step frequency*
- *knee angle in the sagittal plane*

There were also other parameters registered during each observation but these are the ones presented in this study.

The material consists of two hundred and fourty healthy subjects, aged 6-80 years, divided into 16 groups according to sex and age. This means that each group is composed of either 15 women or 15 men with an age-difference up to 9 years.

METHOD

The angle diagram method described by Oberg & Lamoreux (1978) was used where the knee angle is plotted against the hip angle on the left and right leg.

The system also includes:

- *- 10 m long walkway*
- *- 2 photocells 5,5 m intervals*
- *- self-aligning electrogoniometers*
- *- computer*
- *- plotter*

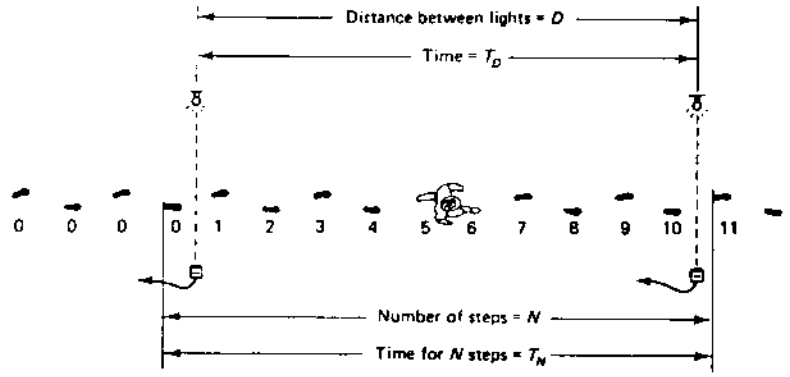

Fig. 1. Schematic top view of the walkway showint the measured variables desired for analysis

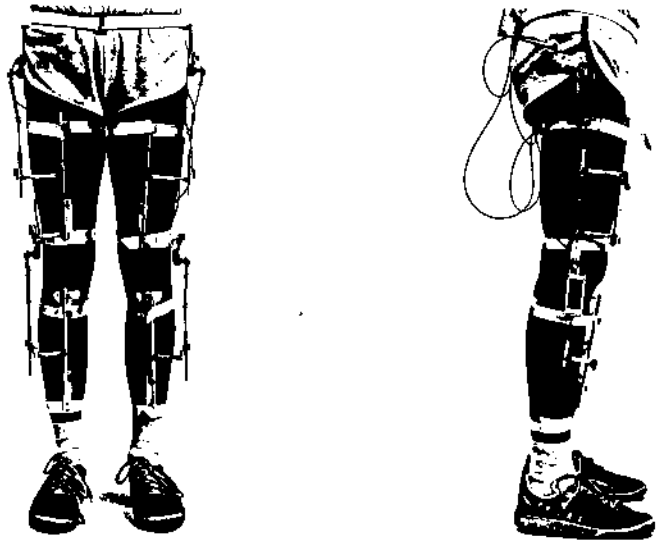

Fig. 2. Self-aligning electrogoniometers mounted to hip and knee

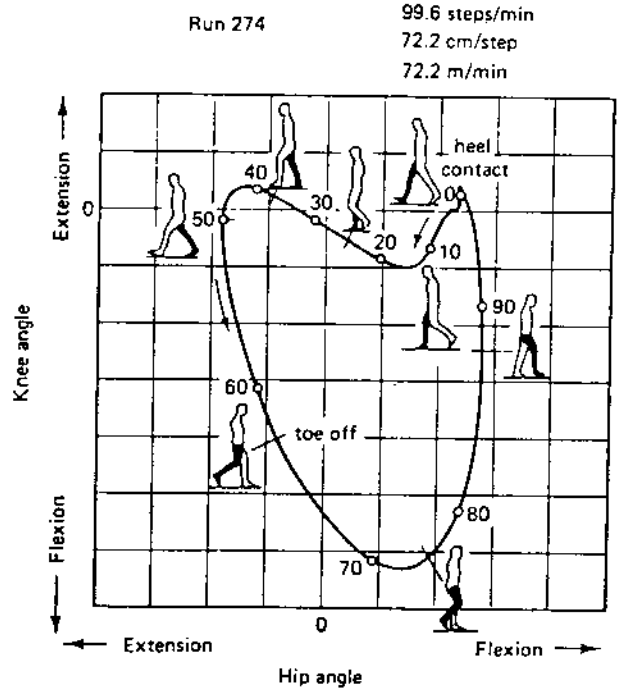

Fig. 3. The schematic graph of knee/hip angle diagram for the right leg of a normal subject walking at moderate speed (Lamoreux 1971).

Walking at normal, slow and fast speeds.

Total of 13 times.

Temporal parameters were gained using a 10 meter long walkway including acceleration - and decceleration - distances.

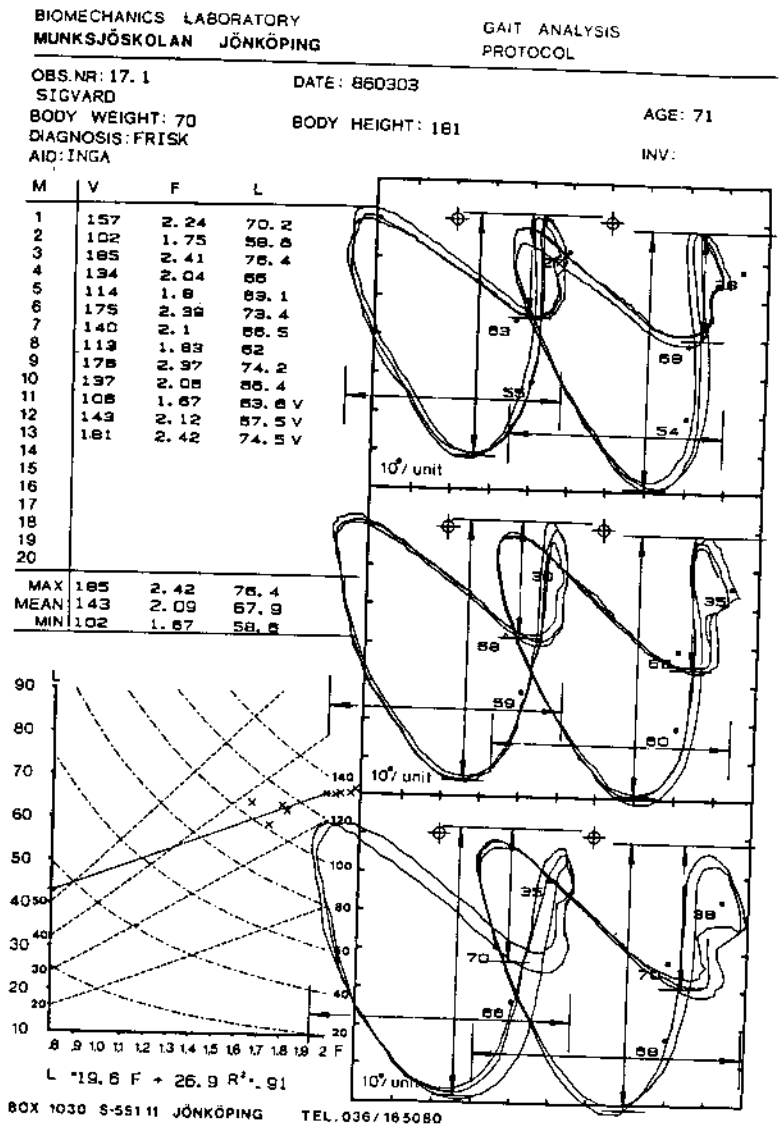

Fig. 4. The protocoll which is filled out.

Data for speed, step rate and step length were collected while the subject walked with selected speed (slow, normal and fast) between two photocells placed at 5,5 meter intervals.

The self-aligned electrogoniometers mounted on an exoskelett registers the left + right hip- and knee-movement dynamically. The exoskelett is easily attached to the subject and doesn't disturb the gait. The reliability of the angle diagram measurements and step dimension data is very good according to studies of the system by E. Jansen made in Copenhagen (5).

The angle diagram gives an obvious change of the angle in the hip and the interaction between then in the different phases of the gait cycle (4,6,7,11,12,13).

The system, further developed by the Dept of Biomechanics, is computerized and a plotter is used for the protocolls.

RESULTS

Basic temporal and distance gait parameters, as well as sagittal angular movements of knee will be presented. The changes in walking over the full ragne of practical walking speeds have been investigated.

Dividing the whole material into a female and a male group one can, looking upon the velocity, observe that men choose a higher velocity than women at all three speeds.

Our mean values for velocity while the subject walked with normal speed was 127 cm/sec for men and 118 cm/sec for women.

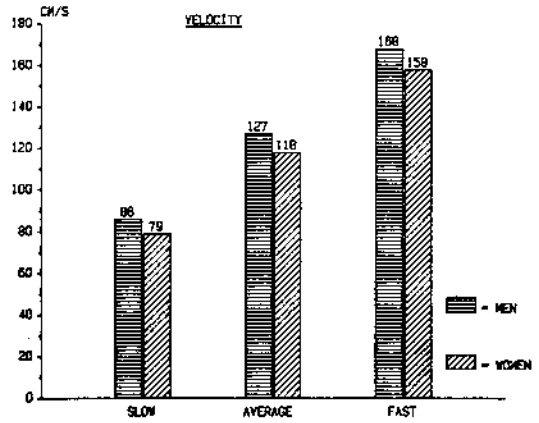

Fig. 5. Velocity for female and a male group at all three speeds

The mean values for velocity reported by Gary L Smidt was 152 cm/sec, M.P.Murray 139 cm/sec and Eberhardt et al 122 cm/sec (2,13,14).

Since velocity is the product of step length and step frequency one has to look upon them separately.

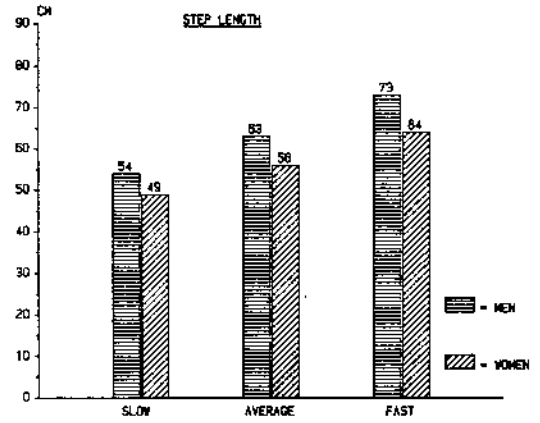

Fig. 6. Step length

The same tendency, as for velocity, can be seen observing the step length where the men has longer step lenths than women at all speeds.

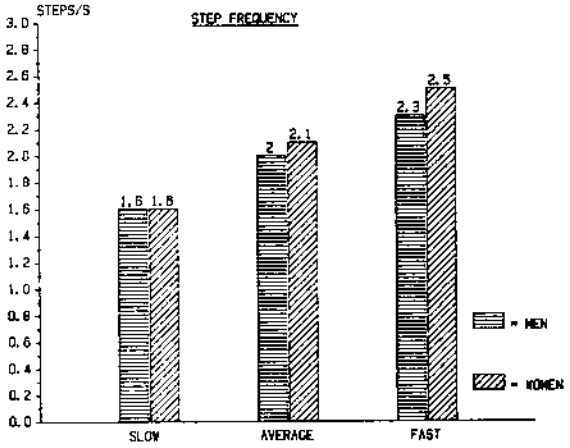

Fig. 7. Step frequency

On the other hand doesn't the step frequency differ between men and women at slow speed, but at average and first speeds do women have a slight higher frequency.

How do these temporal parameters vary between different age-groups?

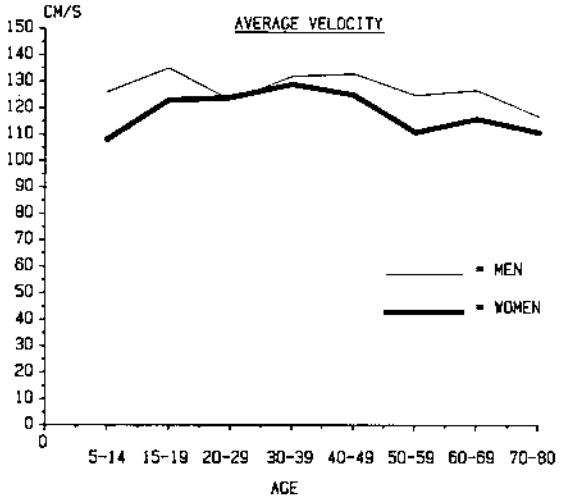

Fig. 8. Average velocity

Figure 8 shows a graph of the average velocity, with the age-groups on the x-axis and the velocity in centimeters per second (cm/s) on the y-axis. The thin line represents men and the thick line women.

The tendency found in these results is that children and older people walk slower. The highest velocity is found among youngsters 15-19 years old and among persons in the middle age. A tendency to slow down their gait can be seen in the age-group 50-59. Results presented by F.R. Finley (3) indicated that the elderly women had shorter step length and slower velocity.

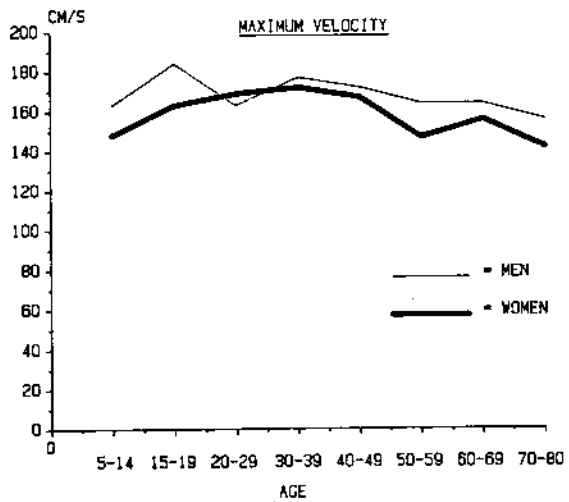

Fig. 9. Maximum velocity

Men choose, almost for all ages, a higher velocity than women, except for a short period around 20-30 when the sexes walk at same speeds.

The characteristics of these curves can also be observed looking upon maximum (Fig. 9) and minimum (Fig. 10) velocity.

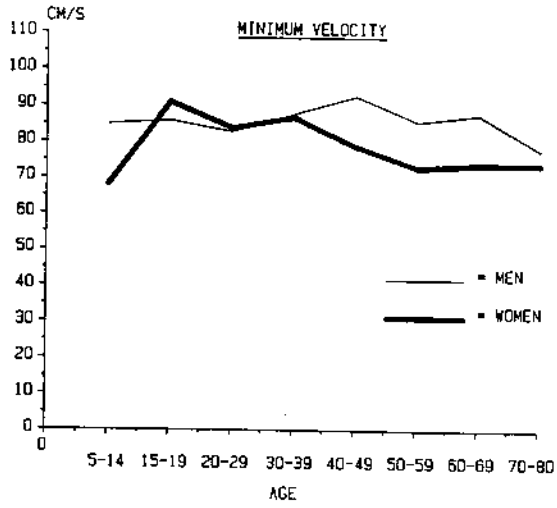

Fig. 10. Minimum velocity

The speed of pedestrians is an important parameter at the time setting of traffic signals. The speed of 140 cm/sec velociy is the recommended norm in Sweden for pedestrains at signalized intersections (1,8).

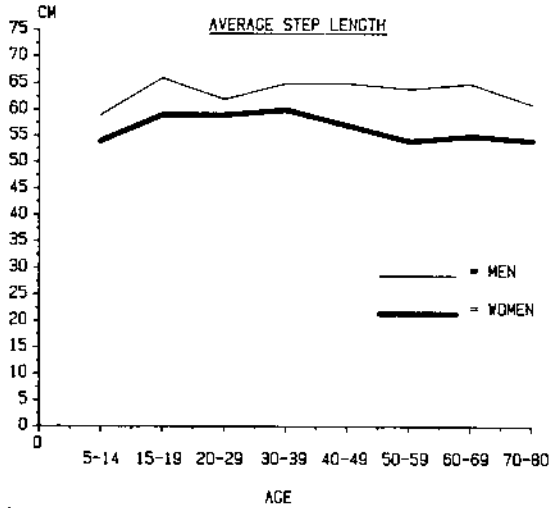

Fig. 11. Average step length

According to studies of 70 year old people by B. Lundgren made in Sweden the recommended norm reached 32% of the women and 79% of the men at their maximum walking speed. In our study both men and women pressed through 140 cm/sec velocity.

The velocity at slow speed walking has the same tendency as for the velocity at fast speed walking for all ages.

Figure 11 shows a graph averae step length with the age-groups on the x-axis and the step-length in centimeters on the y-axis.

Men choose longer steps than women do at all ages. Both sexes have longest step-lengths between the age of 15 and 40 and smaller step-lengths when children dand after retirement.

Studying the same kind of graphs for step frequency, with steps per second on the x-axis it shows a little difference between the age groups. Women choose a higher step frequency than men except for the youngest age group.

The measuring of the knee angel has been calculated for the stance phase and the swing phase separately.

Figure 13 shows a plot over knee movement during stance phase. On the x-axis you have the velocity in cm/s and on the y-axis you have the knee angel in degrees.

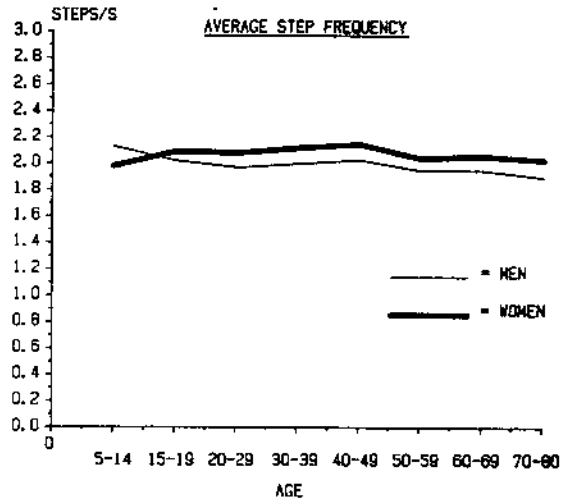

Fig. 12. Average step frequency

The squares represents men and the stars women. The three calculation are for slow, normal and fast speeds.

The knee movement during stance phase increases very much with higher velocity of walking. Women have clearly less degree of knee flexion during stance phase while walking over the full range of practical walking speeds. Women have less degree of knee flexion than men do even though they walk at the same velocity.

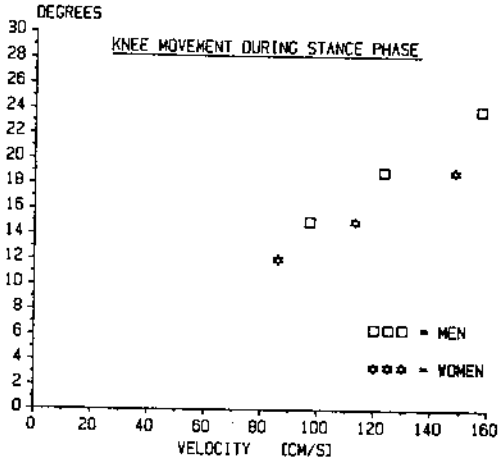

Fig. 13. Knee movement during stance phase

As shown in figure 14 the knee angel increases in some degree as speed increases for both men and women.

Knee motion in the sagittal plane has been most studied (3,6, 7,9,11,12,14).

During swing phase the knee angel doesn't change significantly with speed. Women seem to have less movement.

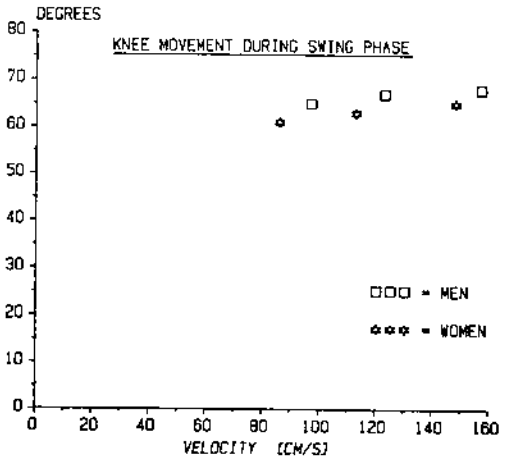

Fig. 14. Knee movement during swing phase

Our mean electrogoniometric values for total knee movement (felxion - extension) in swing phase (normal both for left and righ) agree with the 70 degrees reported by Eberhart and associates (2) and 65 degrees reported by Murray (9,10) and 67.4 degrees reported by Kettelkamp et al (7).

CONCLUSIONS

- *Women choose a lower velocity than men at all speeds.*
- *Women had shorter step length than men at all speeds.*
- *Women had higher step freqyency at average and fast speed.*
- *Velocity and step length varies between ages. Children, adolescents and elderly chose slower speeds and shorter step lengths.*
- *Age does not affect step frequency significantly.*
- *Knee angle during stance phase increases with speed for both men and women.*
- *Women were found to have a tendency towards smaller knee angles during stance phase.*

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