SIMULATION OF PARECTIC GAIT IN NORMAL SUBJECTS BY LOADING THE ANKLES

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ABSTRACT. Normal subjects were loaded with increasing weights (2-6 kg) applied around the ankles. During these conditions stride length increased in relation to velocity. The percentage duration of single support in relation to stride duration increased. Provided the same load was applied around both ankles increase was symmetrical. Consequently there was also an increase of swing as well as a decrease of stance and of double support. The results contrast in all aspects to what was found in previous experiments when the load was carried in the hand. During these conditions stride length decreased as well as the duration of single support. The two experimental conditions differed in that with ankle loading the swing phase was loaded while in the other case stance was loaded. The two types of experiment may help to explain why some patients with parietal gait walk with short strides, while others walk with strides that are normal or slightly prolonged.

Key words: Gait, stride length, load, paresis

The relations between stride frequency and stride length are seldom fully specified in the descriptions of different gait disorders (4). A change in this relation is, however, often an early sign of a gait disorder. Most often this change is to be towards a short stride length in relation to stride frequency (1), but sometimes such decrease of stride length does not appear or there is a tendency to a somewhat longer stride in relation to stride frequency (2, and unpublished observations).

Stride length results from the cooperation between the extensors and the flexors of the legs. The flexors lift and swing, the contratensers push the swinging leg forward. The swing phase is dominated by the flexors and the stance by the extensors.

A relative increase of body weight, due either to paresis or to loading will primarily affect the extensors during stance. The result is a decrease of single support and an increase of double support, such as has also been shown to be the case (3). In symmetrical gait the duration of swing will consequently decrease, and, provided velocity is kept constant, stride length will be shorter. If, on the other hand, muscles acting during the swing phase are relatively weakened; then the duration of swing may be expected to increase, partly due to low acceleration and possibly also to low deceleration of the leg.

With constant velocity we may therefore expect that stride length will be longer. According to Inman et al. (4) there is in fact a tendency to take longer steps when 2 kg are applied to each foot. No measurement values were presented, however.

The aim of the present paper was to test the last suggestion by investigating the effect of loading the ankles and thus changing the relation between the weight of the legs and the muscles acting during swing. If confirmed, the result may help to explain why in certain patients stride length remains comparably unchanged in spite of increasing weakness of the legs.

MATERIAL AND METHODS

Subjects

Fifteen subjects consisting of hospital workers and students of different disciplines who were attending a course in biomechanics were used for the experiments. Five of them were women while ten were men. Their age range was 18 to 62 years while the ranges for the height and weight were 1·59 to 1·92 m, and 52 to 97 kg respectively. All were healthy without known neurological or orthopedic disorders.

Method

A foot switch method was used for the recordings. The method has been described previously in detail (6) and it has also been used in another paper to which the present work is pertinent (3). Essentially the subjects walked on a 10 m walkingway consisting of a metallic net. They used thin stocks with a sole deeply in plastic. Metallic tapes were fastened to the balls and the heels of the feet, and these were then connected to wires which were in turn connected to the recording apparatus by means of a long cable following the subject through a pulley attachment in
The subscripts r and l mean the direction of weight transfer (r = right to left, l = left to right).

SS = duration of single support, SW = duration of swing.

In symmetrical gait SS = SW.

RESULTS

In the test conditions there was an obvious decrease of maximum as well as of ordinary velocity in comparison with the control values.

In the upper part of Fig. 2 is shown the percentage increase in stride length for all 10 subjects at ordinary velocity when both legs were loaded at the ankles with 2, 4 and 6 kg respectively. The ordinary velocity used for calculation was the average between all four tests for each subject. It is seen that stride length increased with load. The increase for all points was statistically significant in relation to zero load (p<0.001, paired t-test). Stride frequency decreased as a consequence of the increase of stride length at constant velocity (eq. 1).

For comparison the lower part of Fig. 2 illustrates the percentage decrease of the stride length with increasing load carried in the hand. The values are obtained from 9 subjects already described (3) and are calculated as above.

In the same way the upper part of Fig. 3 shows an increase of single support with bilateral ankle loading. The increase was statistically significant both for 4 kg (p<0.01) and 6 kg (p<0.05) but not for 2 kg. The stride duration used for calculation was the average for ordinary speed for all subjects. Since in symmetrical gait swing has the same duration as single support, the inevitable consequence will be a decrease of stance and double support (eq. 2). These results were in fact obtained.

The lower part of the figure shows how single support decreased when the load was carried in the hand by the same subjects as described above.

In addition, slopes of the regression lines in the relations stride frequency to stride length were compared for the unloaded with the different ankle loaded conditions. There was a very slight tendency to a decrease in most subjects, but this was not statistically significant (paired t-test). The increase in the stride length with an increase of the load around the ankle must therefore be valid for all velocities tested.

DISCUSSION

In a previous paper (3) we asked normal subjects to carry a weight of 16 to 24 kg in the hand. We then found a decrease of stride length and of single support, primarily in high velocities. Consequently stride frequency increased (stride duration decreased). The changes were symmetrical. Since single support decreased, swing decreased also while stance and double support increased. In the present study, where the weight was applied around the ankles, the results contrast in all these respects. The difference is explained by the difference of application of the load in the two test conditions. In the first condition the stance phase was mainly loaded. The subjects therefore tended to rely on both legs as much as possible, with a shortening of single support and an increase of double support. In the condition of ankle loading, the increased mass of the leg will mean an increased difficulty to accelerate (and decelerate) the leg during swing. The
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The weight of a limb during swing is often considered the weight of the limb without the leg, which is approximately equal to the weight of the leg without the foot. However, in some cases, the weight of the leg during swing is even greater than the weight of the limb without the leg. This occurs when the leg is raised high above the ground during swing, causing the center of gravity of the body to shift forward. The increased weight of the leg during swing may affect the balance and stability of the body during locomotion. Therefore, the weight of a limb during swing should be carefully considered when assessing the weight of the body during locomotion.

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