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FACULTEIT GENEESKUNDE EN LEVENSWETENSCHAPPEN
master in de revalidatiewetenschappen en de kinesitherapie

Masterproef

What is the influence of an ankle-foot orthosis (AFO) on the spatio-temporal gait parameters and functional balance in stroke patients?

Promotor :
Prof. dr. Peter FEYS

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Proefschrift ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie

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ACKNOWLEDGMENT

With this master thesis, we close our second master year in Rehabilitation Sciences and Physiotherapy. We want to thank some persons for their support and contribution to this thesis.

First of all, we want to thank our promotor Prof. Dr. Peter Feys and co-promotor Msc. Els houben for their outstanding guidance, and for providing us the necessary assistance, advice, and support. Through their experience and knowledge it was possible to gain insight in the gait pattern of stroke patients, and most important to realize this thesis to a successful end.

We want to thank international student Vendula Dolezolova and PhD. Ilse Lamers. They helped us with the statistical analysis, which we needed to obtain and interpret the results. We also want to thank Vendula for the help with the study preparations and data collection.

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A special thank to the patients. Without their time and effort, it was not possible to acquire information on the gait pattern and balance.

And finally, we also thank our parents, family, partners and friends. All of this was never possible without their encouragement and support.

Maaseik en Houthalen, 24 april 2014 L.S. en D.T.

SITUATING

This duo master thesis in the faculty “Medicine and Health Sciences” is situated in the neurological rehabilitation/applied research.

Walking or ambulation is the most important activity that we do during the day. It’s the individual need to move safe and efficient from one place to another (1, 2). Gait seems like an effortless task for healthy individuals (2). But for stroke patients, a safe and adequate gait pattern is a challenge. Stroke is the third leading cause of death and affects many aspects of life (3). Stroke patients often have an altered gait pattern related to a number of factors: muscle weakness, alterations in tone, abnormal synergy patterns, abnormal reflexes, altered coordination, altered motor programming, and disturbances in balance (3-5).

In the Rehabilitation Department of ZOL (Ziekenhuis Oost-Limburg) in Lanaken, very early in the rehabilitation process, an ankle-foot orthosis (AFO) is prescribed if needed to assist in dorsiflexion. During the weekly ankle-foot orthosis consultations, the orthoses of both in- and out- patients are adjusted according the individual needs, to promote an adequate and effective gait pattern. Adaptations are currently made based on visual observation of the gait pattern with and without an assistive device. The aim of the health care professionals in the Rehabilitation Department of ZOL in Lanaken is to evaluate the gait patterns more objectively, with and without individualized orthoses. As such a collaboration between the rehabilitation unit in St.-Barbara Lanaken (physiotherapist Els Houben, rehabilitation physician Dr. P. Hallet) and REVAL (University of Hasselt) was established to perform an observational study. The promoter (Prof. Dr. P. Feys) is responsible for the education program on neurological rehabilitation at the University of Hasselt. Co-promoter (Msc E. Houben) is a physiotherapist and former bobath instructor (until 2010).

The promoter (Prof. Dr. P. Feys) and co-promoter (Msc E. Houben) determined the research questions for this study: *(1) does an individualized AFO (Y-tech) change the gait pattern and gait speed of persons with a stroke, compared with not wearing an AFO? (2) Is this effect different from a standard prefabricated AFO (Maramed)? (3) Has an individualized AFO (Y-tech) a positive effect on the functional balance of persons with a stroke compared with the standard prefabricated AFO (Maramed) and not wearing an AFO? (4) Are there any differences in the gait pattern and in functional balance between two subgroups (need of an assistive device compared with no need of an assistive device)?* Through their knowledge and experience in the work field, they gave us the opportunity to acquire detailed information about the gait pattern, and the effects of an AFO on the gait pattern in stroke patients.

After a literature search according the spatio-temporal parameters and functional balance, the study took place (AY 2013-2014) in the Rehabilitation Department of ZOL in Lanaken. In this observational study, we wanted to investigate the spatio-temporal gait parameters and functional balance in stroke patients when wearing an AFO. To investigate these parameters, we used an instrumented walkway (GAITRite®) and three clinical balance tests.

Together with the promoter and co-promoter, a first version of the protocol was written last year. The documents needed for the approval of committee of the medical ethics were also written in collaboration, and submitted to the EC of Ziekenhuis Oost-Limburg (ZOL) and University of Hasselt (AY 2012-2013). The committee of Medical Ethics of the hospital Ziekenhuis Oost-Limburg and the University of Hasselt approved this study. In AY 2013-2014, we brainstormed together with the promoter, co-promoter and international student V. Dolezolova to make the study protocol complete. Patient recruitment was done by E. Houben and involved patients that are or have been in rehabilitation over the last year. The data of the patients were mainly collected by ourselves. Some of the demographic data (reflex testing, Functional Ambulation Categories, Brunnstrom Fugl-Meyer, Test of Tardieu, and the Modified Ashworth Scale) were collected by a specialised doctor or experienced physical therapist. With guidance of the international student and promoter, we did the statistical analysis. The interpretation of the results was accomplished with the guidance of the promoter and co-promoter.

WHAT IS THE INFLUENCE OF AN ANKLE-FOOT ORTHOSIS (AFO) ON THE SPATIO-TEMPORAL GAIT PARAMETERS AND FUNCTIONAL BALANCE IN STROKE PATIENTS?

Opgesteld volgens de richtlijnen van *Clinical Rehabilitation*

http://www.uk.sagepub.com/msg/cre.htm

ABSTRACT

Objective: To investigate the influence of an ankle-foot orthosis (AFO) on the spatio-temporal gait parameters and functional balance in stroke patients.

Design: Observational study.

Subjects and setting: Fifteen chronic stroke patients attending a rehabilitation outpatient service participated. Based on the score of the Timed Up and Go test (TUG), patients were subdivided into two groups. When patients completed the test in less than 20 seconds, they were placed in “the without assistive device group” (without AD-group), and when they completed the test in more than 20 seconds, they were placed in "the with assistive device group" (AD-group). All the patients in the AD-group used a walking cane during the tests on day two.

Intervention: Patients were tested while wearing standardized sport shoes in three different conditions: wearing no AFO, a standard prefabricated AFO (Maramed) or an individualized AFO (Y-tech).

Outcome measures: Spatio-temporal gait parameters were obtained by walking on an instrumented walkway (GAITRite®) at both usual and fastest speed. The balance was assessed by three functional balance tests: the Timed Up and Go (TUG), the Step Test (ST) and the Four Square Step Test (FSST).

Results: ANOVA’s revealed significant results for some of the spatio-temporal parameters when walking at usual and fastest speed. Interactions were found for some of the spatio-temporal parameters in both speeds. Only significant effects were found in the AD group and in the total group. No effects were found in the without AD-group. The number of significances and difference was greater with the Y-tech than the Maramed, but both didn’t significantly differ from each other. For the balance tests, only the TUG showed significant results in the AD-group and the total group for both the Maramed and Y-tech.

Conclusion: Only the AD-group and the total group showed significant improvements when walking with any AFO compared to walking without an AFO. In both usual and fastest speed significant results were found. The results reveal better and more significant results when walking with the Y-tech compared to the Maramed, but no significant differences were found between them.

INTRODUCTION

Walking, locomotion or ambulation, is the most common activity that we do during the day. The walking pattern needs to be safe and efficient to move from one place to another (1, 2). And it is one of the most important things for the perception of a good quality of life and independence (2, 5).

Gait seems like an effortless task for healthy individuals (2). But for stroke patients, a safe and adequate gait is a challenge. Stroke is the third leading cause of death and affects many aspects of life (3). These patients often have difficulties in mobility, activities of daily living, cognition, communication, etc. But the disturbance in gait is their most frequent complaint (5). Stroke patients often have an altered gait pattern related to a number of factors: “muscle weakness, alterations in tone, abnormal synergy patterns, abnormal reflexes, altered coordination, altered motor programming and disturbances in balance” (3-5). These impairments lead to unsafe walking and to an increased fall risk.

Dependent on the individual, unique and persistent problems of each patient, an ankle-foot orthosis (AFO) can be prescribed, to promote a better and safer walking pattern. An orthosis is an external applied “apparatus to support, align, prevent and correct deformities, or to improve the function of movable parts of the body” (1). Many types of AFO’s exist, all with their own specific functionalities. They are named by the motion(s) they control (e.g. dorsi-assist/dorsi stop AFO (6)) and the joint(s) they surround or support (e.g. ankle-foot orthosis: attached around calf, ankle and under the foot (7, 8)). All AFO’s can be classified into two groups: prefabricated and the custom-fabricated. The prefabricated AFO’s are developed in standard sizes and forms. They are produced in series and no adaptations are made for the individual. There is also the possibility to adapt AFO’s according the individual needs, before and during the rehabilitation process. They can be adapted by optimal shaping to the foot characteristics and by changing the angle and rigidity of the ankle joint. These are called the custom-fabricated or individualized AFO’s.

The gait pattern can be described in terms of kinematic, kinetic and spatial-temporal parameters. For this study, we have focused on the spatial-temporal parameters. The spatial (space) parameters contains: *step length* (distance between the heel contact(s) of the opposite feet: in normal gait, the right step length is equal to the left step length), *stride length* (distance between the heel contact(s) of the same foot: in normal gait this is the double of the step length), *width of base of support* (the lateral distance between the heel centers of the left and right foot), *foot angle* (“degree of toe-out, the angle between the line of progression of the body and the long axis of the foot”(2)), *symmetry of gait* (the right foot step length compared to the left foot step length, is often calculated by dividing the non-affected side step length by the affected side step length (4) (the smaller the value, the better the symmetry (2, 9))). The temporal (time) parameters contains: *step time* (time needed to make a left or a right step), *cycle or stride time* (time needed to make one stride of the left or the right foot), *cadence* (number of steps per unit of time), *double support time* (time when both feet are in contact with the ground, and when the weight transfer takes place), *single support time* (time when only one foot is in contact with the ground).

During the rehabilitation process in the hospital or rehabilitation center, physical therapists in the clinical setting use various ways to determine the gait problems in stroke patients. They investigate these problems, to optimize the rehabilitation process and to determine the degree of recovery. Motion Analysis Systems

(VICON, RIVCAM), electronic walkways (GAITRite®, GAITmat®), force plates, etc. provide a broad range and precise description of gait parameters (8).

Results of previous studies, concerning the spatio-temporal parameters when wearing an AFO have reported significant increases in walking speed (4-6, 8, 10-17), cadence (4, 5, 8, 10, 11), step length (4, 5, 8, 12, 16, 17), step length symmetry (5), stride length (4, 6, 7, 10-12), single support time (5, 8, 18) and a significant decrease in double support time (5). Important to mention is that only the gait velocity, cadence, stride length and step length were often reported as well as consistent in results. Other gait parameters were often divergent and inconsistent in results.
Balance is also important for an optimal gait pattern and is hypothesized to be also influenced by an AFO. Balance can be measured by functional tests (e.g. Berg Balance Scale) and instrumented tests (e.g. Balance Master System). The literature showed an improvement in single support phase during gait when wearing an AFO, but further research is necessary to investigate the effects on functional balance.

When measuring balance with clinical tests, an overall effect was found in favor of the AFO. The Timed Up and Go test (TUG), Berg Balance Scale (BBS), Functional Ambulation Categories (FAC) and modified Emory Functional Ambulation Profile (mEFAP) were often investigated and showed often positive results (4, 10, 11, 13, 14, 19-24). Other clinical tests (e.g. Functional Reach test (FR) and Timed Up Stairs (TUS)) were only investigated once, which makes drawing conclusions difficult.

Only two articles compared different types of AFO's with each other (6, 10), two articles subdivided their population in subgroups (6, 8) and twelve articles investigated functional balance when wearing an AFO (4, 10, 11, 13, 14, 19-25). Three articles studied functional balance in combination with spatio-temporal parameters measured with no clinical tests (4, 10, 11). All the studies measured at comfortable walking speed, but the effect of the orthosis at fastest speed is unknown. Many types of AFO's exist but most of the articles investigated the effect of a custom-molded, plastic AFO on the gait pattern.

All of the above leads to the research questions of interest: (1) does an individualized AFO (Y-tech) change the gait pattern and gait speed of persons with a stroke, compared with not wearing an AFO? (2) Is this effect different from a standard prefabricated AFO (Maramed)? (3) Has an individualized AFO (Y-tech) a positive effect on the functional balance of persons with a stroke compared with the standard prefabricated AFO (Maramed) and compared with not wearing an AFO? (4) Are there any differences in the gait pattern and in functional balance between two subgroups, differentiated on the need of an assistive device during daily life walking?

METHOD

Participants

Patients were recruited from the outpatient services of the Rehabilitation Department of ZOL (Ziekenhuis Oost-Limburg) in Lanaken. Fifteen patients were included for this study. Inclusion criteria were *(a)* diagnoses of hemi-paresis caused by a Cerebro-Vascular Accident, *(b)* chronic phase (> three months post- stroke onset), *(c)* patients can walk safely with and without an AFO, and *(d)* patients can understand simple instructions, *(e)* familiar with wearing an AFO (Y-tech) since at least one month. Patients were excluded when *(a)* bilateral assistive devices were needed for walking, and *(b)* history of orthopedic problems (related to the lower extremities) that would interfere with gait performance.

The Committee Medical Ethics of the hospital Ziekenhuis Oost-Limburg and the University of Hasselt approved this study. All the participants included in the experiment, have read and approved the informed consent.

Apparatus

For this study, two different types of AFO's were used: a Maramed and a Y-tech (see figure 1a and 1b). The Maramed is a prefabricated AFO. This type of orthosis is made of polypropylene and is fabricated in a neutral dorsi-flexed position. The orthosis has a thin and limited width of material behind the ankle, which leads to a limited stability of the ankle. For this experiment three different sizes were available (small, medium, large). The hybrid Y-tech is an individualized AFO from the company V!GO. Each patient included for this study already had his or her own Y-tech. This AFO consists of a polypropylene sheet (4-5mm) with integrated thermoplastic carbon reinforcement, and a strap to fixate the foot in the AFO. It can be adapted according the individual needs of the patient.

Figure 1a: Maramed

Figure 1b: Y-tech

Research design and procedure

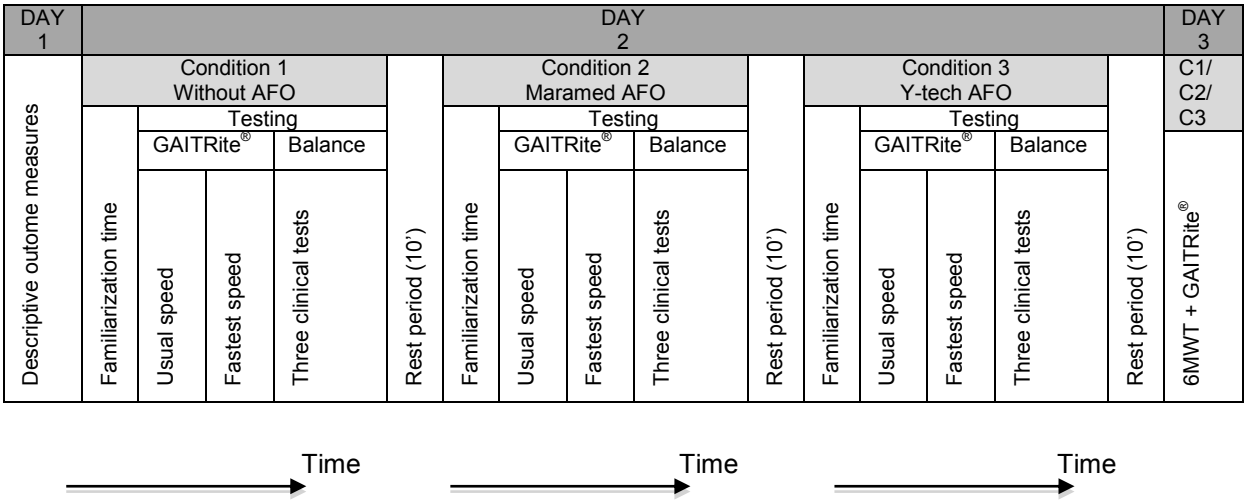
In this observational study, patients were tested on three days within three weeks (see figure 2). In a preparatory session (day 1), patients were familiarized with the Maramed AFO and standardized sport shoes. Descriptive outcome measures were collected and each experimental clinical test was demonstrated and practiced once. The tests of day one were performed in a quiet room to minimize the possibility of being distracted. Results are analyzed in both the total group and subgroups. Based on the Timed Up and Go test (TUG) (descriptive outcome measure), the same patients (total group) were divided into two subgroups. When patients completed the test in less than 20 seconds, they were placed in the "without assistive device group" (without AD-group), and in the "with assistive device group" (AD-group) when they completed the test in more than 20 seconds. All the patients in the AD-group used a walking cane during the tests on day two and three. Except for the Step Test (ST). According to the test instructions of the ST, no assistive device is allowed.

On the second day, patients were tested in three different conditions (*condition 1* without an AFO, *condition 2* with a standardized AFO (Maramed), and *condition 3* with an individualized AFO (Y-tech)) when walking on the GAITRite® and when performing three functional balance tests. The GAITRite® was used to detect spatio-temporal parameters. The patients had the opportunity to familiarize themselves with the devices by walking once on the GAITRite®, before the tests were taken.

All three conditions were randomized for testing using closed envelopes, containing small papers with order of test conditions. Patients first walked at usual followed by fastest speed on the GAITRite®. Each patient performed two trials on the GAITRite® at each walking speed. The GAITRite® was positioned in a room, where there was enough space to allow a dynamic start over the instrumented section of the carpet possible. A dynamic start is necessary to exclude the possibility of measuring the gait acceleration and deceleration. The patients started two meters before the carpet and continued walking two meters after the carpet. These extra walking spaces were marked with a white tape. The patients were positioned with their toes just behind the tape, and were instructed to walk across the mat just behind the marked tape on the other side. They had to turn and walk back to the starting point for the second measurement. The mean was calculated of these two measurements, and was used for analysis. Immediately after the GAITRite® test, functional balance tests (Timed Up and Go (TUG), Step Test (ST) and Four Square Step Test (FSST)) were performed. These balance tests were standardized by using the same room as the GAITRite® and taped marks on the floor. All patients received standard instructions, dependent on the test/item to be taken. Between test conditions, a rest period of ten minutes took place. During this period, the AFO was removed or changed in another condition, with the help of the testing persons.

On the third day of testing, patients were again tested on the GAITRite® and walked the Six- Minute- Walking Test (6MWT) within the three different conditions. These results will be discussed in another article.

Figure 2: Study design



Outcome measures

Following patient characteristics were collected from the patients: gender (male/female), weight (kg), height (cm), BMI (kg/m^2), age (years), stroke onset (months), lateralization of stroke (right/left), stroke location (hemisphere, cerebellum, other), stroke type (ischemic/hemorrhagic), and time with an AFO (months).

The severity of motor and sensory dysfunction was examined by following tests:

The active and passive Range Of Motion (ROM) in the affected ankle was measured with a goniometer in both lying and sitting position. Kim P.J. et al., 2011 reported a low to moderate inter-rater reliability and moderate to high intra-rater reliability in ankle joint dorsi-flexion using a standard goniometer in asymptomatic individuals (26).

The degree of spasticity was measured with the Modified Ashworth Scale (MAS) and Tardieu Scale (TS). The MAS is a 5-point ordinal scale. This test evaluates stiffness in the lower extremity with the use of a passive movement. Neumann D., 2002 reported a good intra-rater reliability [ICC 0.84] and a good inter-rater reliability [ICC 0.83]. Li F. et al., 2014 showed inter- and intra-rater Kappa values of 0.66 and 0.69 for the elbow flexors and 0.48 and 0.48 for the plantar flexors in stroke patients (27). The TS is a 6-point ordinal scale. This test measures muscle spasticity by moving the lower extremity at specified velocities. The tests were taken in supine position. Li F. et al., 2014 reported inter- and intra-rater Kappa values of 0.73 and 0.73 for the elbow flexors and 0.82 and 0.79 for the ankle flexors in stroke patients.

Reflex activity, synergies and coordination of the lower extremities was evaluated by the Brunnstrom Fugl-Meyer test (BFM). This test uses a 3-point ordinal scale. Both the motor and sensory part were used in this experiment. Sanford et al., 1993 reported a reliability of [ICC 0.96] in acute stroke patients (28).

The sensory extinction test (SE), is a 2-point nominal scale. This test was used to identify sensory neglect for light tough on the patient's thighs. This test is taken after the sensory part of the BFM, and can only be done if the sensation is present (tested with the sensory part of the BFM test).

The Motricity Index (MI) was used to evaluate maximal isometric strength or minimal active amplitude of lower limbs. A 6-point ordinal scale is used. Fayazi et al., 2012 reported a high test-retest reliability [ICC 0.93] with one-week interval in patients with stroke (29).

Following tests were included at activity level, to describe the patient:

The Berg Balance Scale (BBS) is a test to evaluate balance. Each item is scored using a 5-point ordinal scale. Blum et al., 2008, a systematic review reported a inter-rater reliability of [0.95-0.98], an intra-rater reliability of [0.97], a test-retest reliability of [0.98] and floor/ceiling effects (30). Pollock et al., 2011 reported a limited content validity (single leg stance and turning) (31).

The Timed Up and Go test (TUG), evaluates mobility and fall risk. For the descriptive outcome measure, the mean was calculated based on three completed trials. This mean was used to divide the total study population in subgroups, and to determine whether an assistive device was needed for walking or not. When patients completed the tests in less than 20 seconds, they were placed in the “without assistive device group” (without AD-group), and in the “with assistive device group” (with AD-group) when they completed the test in more than 20 seconds.

The Functional Ambulation Categories (FAC) is a 6-point ordinal scale. This test is used to evaluate independence of walking, by using a 6-point ordinal scale. Viosca et al., 2005 reported a good inter-rater reliability [K=0.74] (32).

The Brunel Balance Assessment (BBA) is used to measure both the static and dynamic balance. Patients can complete 12 levels, all hierarchical ordered from easy to difficult. With "pass" or "fail" patients are scored. When the patient failed at a specific level, the test stops. Tyson et al., 2004 reported a high inter-test and test-retest reliability with 100% agreement [Kappa coefficient =1] in stroke patients. They also reported a good concurrent validity with the sitting Motor Assessment Scale [0.83], Berg Balance Scale [0.97], and the Rivermead Mobility Index [0.95] (33).

Important to mention is that all descriptive tests were taken from the patients without an AFO.

For the experimental part of this study, the GAITRite® system (to detect changes in spatio-temporal parameters) and three functional balance tests were used.

The GAITRite® is a computer based instrumented walkway. It contains a flexible roll-up carpet (5.37 meters long) and a computer, which are connected to each other. The sensors embedded in the carpet, are activated by mechanical pressure, when a patients walks across the mat. The computer automatically calculates and visualizes the spatio-temporal parameters and steps taken by the patient. The GAITRite® provides many spatio-temporal parameters. For this study following parameters were used: velocity (cm/sec), cadence (steps/min), bilateral step length (cm), bilateral single support time (%GC), and bilateral double support time (%GC). Bilney et al., 2003 showed a good test-retest reliability, when patients were tested in three consecutive measurements on one day (34). Van Uden et al., 2004 reported a high test-retest reliability of spatio- temporal parameters, over a one-week period in healthy subjects. They also reported an [ICC: 0.92] at preferred walking speed, and an [ICC: 0.89] at fast walking speed (35). McDonough et al., 2001 reported also a good reliability and validity for measuring spatio-temporal parameters. There was a con- current validity with a paper pencil method [ICC: 0.95] and with a video-based analysis [ICC: 0.93] (36).

The Step Test (ST) is a test to measure the balance on one leg while placing the other foot on and off a ten centimetres high box. The number of steps completed in 15 seconds are recorded (ratio scale). Pollock et al., 2011 reported an excellent test-retest reliability [ICC 0.93] for the affected leg, and [ICC 0.94] for the non-

affected leg in older patients. They also reported a limited content validity (single leg stance task), and no ceiling effect (for the stroke population, during inpatient rehabilitation, mean age 72.2 years).

The Four Square Step Test (FSST) is a test to measure the dynamic balance. The patient has to step over two canes placed in a cross, in a forward, backward and sideward direction. The time is measured with a stopwatch from the initial contact of first step until initial contact of final step (ratio scale). Blennerhassett et al., 2008 reported an excellent agreement between two repeated test trials for both tests (Four Square Step Test and Step Test) [ICC 0.94- 0.99] and no practice effect between two repeated successful trial scores (p-value 0.16-0.84) in chronic stroke patients (37). Goh E.Y. et al., 2013 showed a good intra- [ICC 0.82-0.83] and inter-rater reliability [ICC >0.99] in persons with chronic stroke. A cut off score of 11 seconds was found to make a distinction in dynamic balance of healthy persons and chronic post stroke patients (38).

The Timed Up and Go (TUG) is a test to measure mobility and fall risk. The patients must rise from an armchair, walk three meters, turn, and walk back to the starting point (chair) and sit. The time to complete the test is measured with a stopwatch (ratio scale). Ng et al., 2005 reported a good to excellent reliability [ICC range 0.69- 0.99], test-retest [ICC 0.95] for chronic stroke patients (39). The concurrent validity with the Berg Balance Scale [ICC 0.81] and Barthel Index [ICC 0.78] has been reported in O'Sullivan S., 2007. Pollock et al., 2011 (31) reported a content validity (speed of walking and tuning). This test predicts the fall risk in elderly subjects. A score of (< 20 seconds) the patient is independent for basic transfers, (between 20-29 seconds) normal for frail elderly or disabled patients, (> 30 seconds) patients are dependent in mobility skills and activities of daily living (interval scale) (40). Concurrent validity is reported for the Berg Balance Scale (ICC: 0.81) and the Barthel Index (ICC: 0.78). The articles also reported an inter-rater reliability of (ICC: 0.99) and an intra-rater reliability of (ICC: 0.98).

Statistical Analysis

Statistical analysis was carried out with Statistica 7. Parametric two group by three conditions ANOVA's were performed as this allowed us to investigate the interaction effects between groups, regarding to the effect on the different AFO's on their walking and balance tests. Results of parameters in the three conditions were compared for one group using a Repeated Measures Analysis of Variance. When there was a significant difference between conditions, post-hoc tests were performed with a Tukey test to know which condition showed a different result. The analysis was performed for each of the experimental outcome measures.

RESULTS

To summarize data and to interpret the results, four different tables were constructed. Table 1 gives an overview of the patient characteristics of both total group and subgroups. Table 2 gives an overview of the descriptive tests of both total group and subgroups. Table 3 and 4 represents the results of the experimental outcome measures. In table 3 the spatio-temporal parameters, measured with the GAITRite. In table 4 the outcomes of the functional balance tests.

Fifteen patients participated (12 men and 3 women) with mean weight 82.43 kg, mean height 1.74 m, mean age 59.40 years, mean stroke onset 16.67 months, lateralization of stroke (11 right, 4 left), stroke location (11 hemisphere, 1 cerebellum, 3 other (thalamus, a combination of hemisphere and cerebellum, a combination of hemisphere, brainstem and thalamus)), type of stroke (14 ischemic, 1 hemorrhagic), and mean time with AFO (7.27 months)**.** The AD-group and without AD-group showed comparable patient characteristics (see table 1).

For the descriptive tests (see table 2), several significant differences were found when comparing the two groups. The range of motion (ROM) in the ankle showed different results being the smallest in the AD-group. The active ROM in both groups was smaller compared to the passive ROM, and there was less ROM in lying position compared to sitting position. When comparing the Modified Ashworth Scale (MAS) with those of the Tardieu Scale (TS), no differences were found between the groups for the MAS. In the TS there was one borderline significant result ($p=0.067$). This indicates that the AD-group had a higher score than the without AD-group (affected ankle, velocity 1) and that there is no velocity dependent factor involved. So, the patients in both groups are more likely to have muscle stiffness than spasticity in the ankle of the affected side. There was a significant difference for the motor part, and no significant difference for the sensory part of the Brunnstrom Fugl-Meyer test (BFM), when comparing the two groups. In both the motor and sensory part of the BFM, the without AD-group showed higher scores. Also, no differences between the groups were found in the sensory extinction test. The Motricity index (MI) showed significant results in the ankle and total score of the affected leg. The AD-group had a lower strength in the ankle compared to the without AD-group. This result could indicate the use of an AFO in these patients. For the balance tests, there was only a significant difference between the groups for the Berg Balance Scale (BBS). Again the without AD-group had a higher score compared to the AD-group. No differences were found in the Brunel Balance Assessment (BBA). There was also a significant result in the Functional Ambulation Categories (FAC) and the Timed Up and Go (TUG) test. Higher scores were seen in the without AD-group. In general, patients in the without AD-group showed better results in all the descriptive tests compared to the AD-group.

The group-, condition- and the interaction effects were used to interpreter the results (see table 3 and 4). The group effect was significant in all the spatio-temporal parameters and functional balance tests, which means that the subgroups (AD-group and without AD-group) are significantly different from each other based on the gait parameters and functional balance tests. If the condition effect is significant, it demonstrates that there is a difference between the three conditions in the total group (e.g. condition 1 (no AFO) compared to condition

2 (Maramed)). There is an interaction effect, if the two subgroups have different from each other within each condition.

In the total group, significant condition effects were found when a Maramed or Y-tech was provided and when patients walked at usual speed. With a Y-tech, results showed an increase in step length of the unaffected side ($p<0,05$), single support time of the affected side ($p<0,01$), and a decrease in double support time of the affected side ($p<0,05$). There was also an increase for the single support time on the affected side when wearing a Maramed ($p<0,01$). When walking at fastest speed, only significant results were found when wearing a Y-tech. Walking velocity ($p<0.01$), cadence ($p<0.01$), and step length of the unaffected side ($p<0.05$) increased. There was also a borderline significant result for the double support time unaffected side ($p=0.063$).

After analysing the results of the total group, the same patients were subdivided into two groups (AD-group and without AD-group) based on the TUG score. When walking at usual speed, significant interaction effects were found in double support time for both the affected ($p<0,05$) and unaffected side ($p<0,05$), and single support time affected side ($p<0,05$). Post-hoc tests revealed that there was a bilateral decrease in double support time ($p<0,05$), and an increase in single support time of the affected side ($p<0,01$), and this only in the AD-group for both the Maramed and Y-tech compared to no AFO. For the step length unaffected side no significant interaction effect was found, but post-hoc tests revealed that only in the AD-group there was a significant increase in step length unaffected side when comparing the Y-tech with no AFO ($p<0,05$).
In fast speed, there were significant interaction effects in single support time affected side ($p<0,05$), step length unaffected side ($p<0,05$) and a trend towards significance for velocity ($p=0,083$). Again post-hoc tests revealed only significant results in the AD-group and not in the without AD-group. There was an increase in single support time affected side with the Y-tech ($p<0,05$), and in step length unaffected side with both the Maramed ($p<0,05$) and Y-tech ($p<0,01$). There was also an increase in velocity with a Y-tech ($p<0,01$) and a trend toward significance was found with the Maramed ($p=0,072$). For the cadence and double support time unaffected side no significant interaction effects were found, but post-hoc tests revealed that only in the AD-group, significant differences were found with a Y-tech compared to no AFO ($p<0,05$). For the cadence, a trend toward significance was found with the Maramed ($p<0,089$) compared to no AFO.

Table 4 represents the results of balance testing. Only for the TUG, significant effects were found in favour of an AFO. In the total group, there was a significant decrease in time needed to complete the test, when wearing a Maramed and a Y-tech ($p<0,05$) compared to no AFO. No interaction effects were found, but post-hoc tests revealed that only the AD-group showed a significant decrease in time to complete the test with a Maramed and a Y-tech ($p<0,05$) compared with no AFO. No significant results were found in the without AD-group regardless of the condition. For the Step Test and Four Square Step Test no significant results were found.

DISCUSSION

This study investigated the effects of different ankle-foot orthoses (AFO's) on the gait pattern and functional balance of persons with stroke. Significant effects of spatio-temporal parameters were found at both usual and fastest speed, for both types of AFO's, and only for the more severely affected group of patients using assistive devices for walking. The effect was also present for a combined balance-walking clinical test (Timed Up and Go test) but not for other dynamic balance tests.

It has already been well- established that there are beneficial effects of wearing an AFO on the gait pattern. When stroke patients wear an AFO and walk at self-selected speed, previous studies have reported significant increases in walking speed (4-6, 8, 10-17), cadence (4, 5, 8, 10, 11), step length (4, 5, 8, 12, 16, 17), step length symmetry (5), stride length (4, 6, 7, 10-12), single support time (5, 8, 18) and a decrease in double support time (5). The current study confirmed these results only for step length unaffected side, single support time affected side, and double support time affected side when wearing a Y-tech. With the Maramed, effects were smaller as there was only a significant result for single support time affected side. No other studies were found, in which non-clinical tests were used to investigate spatio- temporal parameters when wearing an AFO at fastest speed. When wearing a Y-tech, present study also showed significant results concerning some of the spatio-temporal parameters when walking at fastest speed. In the total group there was a significant increase in velocity, cadence and step length unaffected side. There was also a borderline significance ($p=0.063$) result for double support time unaffected side.
Based on the results, following interpretations can be made: without an AFO, stroke patients stand less on their affected side compared to the unaffected side while walking at usual speed. When wearing a Y-tech or a Maramed, the single support time significant increased on the affected side, but the single support time on the unaffected side remained the greatest. This could indicate, that there is an improved stability in the affected ankle, which makes these results possible.
If patients stand longer on their affected side, the step length of the unaffected side should increase. The results showed a significant increase in unaffected side step length, when wearing a Y-tech. There is still a bigger step length on the affected side, but the unaffected side made the biggest improvement. Based on this, we concluded that the step length symmetry improved. This conclusion is comparable with the article of Esquenazi et al., 2009(5). They reported a significant decrease in step length asymmetry. They also reported an "ideally condition", when the affected limb is unloaded and weight is transferred to the unaffected limb, double support time would be shorter as compared with transferring the weight to the affected limb. Recent study showed that the double support time towards the affected leg decreased when wearing a Y-tech. If the double support time decreases, the single support time should increase. This interpretation is again, confirmed by our results.

In the current study, subgroups were differentiated based on the use of an assistive device as it was hypothesized that effects would be different depending on ambulatory impairment level. Indeed, for both usual and fast speeds only significant results were found in the AD-group. The step length of the unaffected side, the single support time on the affected side both increased and the double support time decreased bilateral when walking with usual speed. To link and understand the results, the same interpretation as

described in above paragraph is used. When walking at fastest speed; velocity, cadence, single support time affected, step length unaffected increased and double support time unaffected side decreased when wearing a Y-tech. Only for the step length, there was also a significant result when wearing a Maramed, and some borderline significant results for velocity (p=0.072) and cadence (p=0.089). Because patients stand longer on their affected side, the step length off the unaffected side should increase. The result of current study showed an increase in step length of the unaffected side, regardless of the type of AFO. The biggest improvement is seen with the Y-tech. There is a significant decrease in double support time of the unaffected side while wearing a Y-tech. When double support time decreases, single support time should increase. Current study showed a significant increase in single support time affected side when using the Y-tech.

Only two other articles had previously subdivided their population in subgroups (6, 8). In current study, patients were placed into two groups based on the Timed Up and Go (TUG) score. Mulroy et al., 2010 (6) divided the population based on the amount of passive dorsi-flexion (DF) in the ankle (neutral group: DF 0° with knee extension, and moderate group: PF 10-15° with knee extension). Overall, the neutral group showed better results in velocity, cadence and stride length, regardless of the condition, and they did not show that for example a Rigid AFO (R-AFO) was superior to a Dorsi-Assist AFO (DA-AFO). In current study, we found a higher Range Of Motion (ROM) in the ankle in the without-AD group and better results were found in the same spatio-temporal parameters in the AD-group but not in the without AD-group.
The neutral group in the article of Mulroy et al., 2010 (6) showed no effect of the R-AFO on velocity, cadence or stride length. In the neutral and moderate group significant increases were found in all AFO conditions (DA-AFO, Plantar flexion stop AFO (PS-AFO) and R-AFO) for stride length and for walking speed there was only a significant increase when wearing a D-AFO.
Important to mention is that when wearing an AFO more stiffness will occur in the ankle joint. With a Y-tech there is less movement possible in the ankle and therefore special attention in therapy is needed to maintain the ROM.
Rao et al., 2009 (8) divided their population in an acute and a chronic group. The chronic group showed significant increases in velocity, cadence, bilateral step length and single support time unaffected side when wearing an AFO. Current study, only showed a significant result in step length unaffected side with usual speed in the total group.
There are only two other studies that compared effects of multiple AFO's with each other, similar to current study. Mulroy et al., 2010 (6) compared three different AFO's (a DA-AFO, a PS-AFO and a R-AFO). These AFO's are not comparable to the AFO's used in current study, because they were adjusted to the patients but contain no carbon. The carbon in an AFO is an important aspect for the dynamics. Park et al., 2009 (10) compared an anterior with a posterior ankle-foot orthosis. The posterior ankle-foot orthosis is comparable with a Maramed. They showed significant differences in velocity, cadence, and stride length. Recent study found no significant difference with a Maramed. This article reported inconsistent results compared to current study.

Besides gait, it was hypothesized that also balance would be positively affected by wearing an AFO. Prior studies have reported that wearing an AFO provide medio-lateral stability during stance (10, 11, 13, 14, 22)

and correct the ankle joint alignment (4, 10). In current study stroke patients were tested by using three functional balance tests (Timed Up and Go test (TUG), Step test (ST) and the Four Square Step Test (FSST). Six studies have investigated the TUG with and without an AFO. Five of them showed significant results in time needed to complete the test in favour of the AFO (13, 20-22, 25). Similar results were found in current study for the total group and the AD-group. For the other balance tests in recent study no significant results were detected. Important to mention is that no previous article concerning the balance, used the FSST or the ST to detect balance when wearing an AFO. It might be possible that these tests are not sensitive and reliable enough. In previous studies balance was measured with other tests. The Berg Balance Scale (BBS) and the Functional Ambulation Categories (FAC) were often used and showed in most cases significant results in favour of the AFO.

Normally, there is an improvement in single support time on the affected side obtained by a better stability in the ankle. This better stability results in an increase in step length of the unaffected leg, when wearing an AFO. This is confirmed by the results of the GAITRite®, but not by the results of the balance tests. No other articles used the GAITRite® in combination with the functional balance tests. They investigated spatio-temporal parameters by using other methods or techniques (e.g. paper walkways, footswitches, etc.).

For the included patients the FSST was a too difficult. In the total group, seven patients (all from the AD-group) were not able to complete the test. In the without AD-group all patients were able to do the test. Five out of seven patients were unable to complete the test in all the three conditions, which means that there is no effect of an AFO. The ST just showed no significant differences. Although all these tests have good reliability and validity in stroke patients.

There are several possible limitations in this study. Due to our small sample size, there can be a great variability between our selected participants and the entire population. The GAITRIte® is used to detect spatio-temporal parameters. A limitation of this instrumented walkway is that we cannot detect if the quality of movement changes when wearing an AFO. To observe these changes kinematic analyses are needed. This was not investigated in current study.

An additional limitation is that all the participants already had been prescribed an individualized AFO (Y-tech) prior to the experiment. Ideally, the familiarization time should be equal with a Y-tech as with a Maramed. The results showed that the Y-tech had better results compared to the Maramed. These results may be the result of the longer familiarization time with the Y-tech compared to the Maramed. In four articles the patients used an AFO for at least one month before the study started (8, 11, 21, 22). All performed tests showed significant results in favour of the AFO (except for Timed Balance Test (borderline significant) in Simons et al., 2009).

Additional research is necessary to investigate the long-term effects of an AFO. All the patients included in this study wore already an AFO (7.27±3.52 months) before tested on the GAITRite®. This can be seen as a long term- effect. Another interpretation of the long-term effect was to measure the patients when they first walking with an AFO, and again after x time we can check the progression of the gait pattern or functional balance. In the rehabilitation unit, patients have (re)learned to walk with their own adjusted Y-tech. It could be that they somehow have adjusted their walking pattern according the functions of the Y-tech.

In conclusion, groups were comparable based on the patient characteristics although the without AD-group showed better results in all the descriptive tests compared to the AD-group. When measuring spatio-temporal parameters and functional balance (only TUG), significant results were found in the total group and in the AD-group. In both usual and fastest speed, significant results were found when patients walked with a Maramed or a Y-tech. Overall, the Y-tech showed more and better results than the Maramed. In addition, no significant differences were found between the Maramed and Y-tech.

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Table 1. Descriptive outcome measures, Patient characteristics

	Total group (n=15)	With AD (n=9)	Without AD (n=6)	p-value
Age (years), mean ±SD	59,40 ± 9,32	58,22 ±11,01	61,17 ±6,55	ns
Gender (male/female), n	(12 / 3)	(6 / 3)	(6 / 0)	ns
Weight (kg), mean ±SD	82,43 ±15,45	83,06 ±14,54	81,50 ±18,11	ns
Height (m), mean ±SD	1,74 ±0,08	1,74 ±0,08	1,74 ±0,07	ns
BMI (kg/m2), mean ±SD	27,13 ±4,37	27,37 ±4,85	26,77 ±3,93	ns
Stroke onset (months), mean ±SD	16,67 ±23,84	9,67 ±3,64	27,17 ±36,74	ns
Stroke location, n				ns
Left/right hemisphere	11	7	4	
Cerebellum	1	1	0	
Other	3	1	2	
Stroke type, (ischemic/hemorrhagic) n	(14 / 1)	(8 / 1)	(6 / 0)	ns
Stroke lateralization (left/right), n	(4 / 11)	(2 / 7)	(2 / 4)	ns
AFO time (months), mean ±SD	7,27 ±3,52	7,22 ±3,77	7,33 ±3,45	ns

Table 2. Descriptive outcome measures, Tests (Motor and Sensory)

	Total group (n=15)	With AD (n=9)	Without AD (n=6)	p-value
Ankle dorsi flexion, affected, mean ±SD				
Sitting /a/	71,67 ±17,81	72,33 ±14,09	93,67 ±9,59	**p<0,01**
Sitting /p/	94,60 ±10,45	91,56 ±11,63	99,17 ±6,88	ns
Supine /a/	80,87 ±16,23	60,78 ±14,12	88,00 ±5,97	**p<0,01**
Supine /p/	83,33 ±10,40	78,44 ±10,63	90,67 ±3,78	**p<0,05**
Tardieu scale, affected, mean ±SD				
Ankle: V1	0,87 ±0,64	1,11 ±0,60	0,5 ±0,55	**p=0,067 #**
Ankle: V2	1,6 ±1,5	2 ±1,41	1 ±1,55	ns
Ankle: V3	1,93 ±1,28	2,22 ±1,20	1,50 ±1,38	ns
Modified Ashworth Scale, mean ±SD				
Affected side				
Ankle	1,80 ±1,52	2,22 ±1,48	1,17 ±1,47	ns
Knee flexion	0,53 ±0,83	0,78 ±0,97	0,17 ±0,41	ns
Knee extension	0,73 ±1,10	0,78 ±1,09	0,67 ±1,21	ns
Unaffected side				
Ankle	0 ±0	0 ± 0	0 ± 0	ns
Knee flexion	0 ±0	0 ± 0	0 ± 0	ns
Knee extension	0 ±0	0 ± 0	0 ± 0	ns
Fugl-Meyer, motor score (LE), mean ±SD	21,93 ±4,25	19,89 ±3,41	25,00 ±3,63	**p<0,05**
Fugl-Meyer, sensory score (LE), mean ±SD	10,27 ±2,43	11,00 ±1,32	9,17 ±3,37	ns
Sensory Extinction Test, affected, n				ns
Score 0	3	2	1	
Score 1	12	7	5	
Motricity index, affected, mean ±SD				
Ankle	15,00 ±0,96	10,89 ±6,17	21,17 ±9,37	**p<0,05**
Knee	22,47 ±5,03	22,11 ±6,15	23 ±3,10	ns
Hip	20,87 ±4,90	19,44 ±5,50	23 ±3,10	ns
Total	58,33 ±15,29	52,44 ±13,78	67,17 ±13,96	**p=0,065 #**
Berg Balance Scale, mean ±SD	44,47 ±7,41	41,56 ±7,50	48,83 ±5,04	**p<0,05**
Brunnel Balance Assessment, mean ±SD	11,33 ± 1,40	10,89 ± 1,69	12 ± 0	ns
Functional Ambulation Categories, mean ± SD	3,27 ±0,96	2,78 ±0,83	4 ± 0,63	**p<0,05**
Timed Up and Go test (sec.), mean ±SD	23,13 ±12,73	30,82 ±11,68	12,87 ±3,05	**p<0,01**

Values are mean ± SD; #, borderline significance (p<0,07)

Table 3. Results of Gaitrite: Spatio-temporal parameters in usual and fast speed

Spatio-temporal parameters	Walking speed	Assistive device	Comparing two groups mean ± SD			p-values					
			Without AFO	Maramed	Y-tech	Group	Conditions	Interaction	*C1-C2*	*C1-C3*	*C2-C3*
Velocity (m/sec)	Usual	With AD	0,39±0,17 (0,13-0,65)	0,40±0,16 (0,16-0,65)	0,42±0,19 (0,19-0,72)	**p<0,01 ¥**	ns	ns	*ns*	*ns*	*ns*
		Without AD	0,95±0,18 (0,63-1,11)	0,92±0,21 (0,54-1,16)	0,93±0,21 (0,62-1,17)				*ns*	*ns*	*ns*
	Fast	With AD	0,50±0,27 (0,16-0,98)	0,56±0,26 (0,18-1,04)	0,59±0,28 (0,20-1,07)	**p<0,01 ¥**	**p<0,01 ***	**p=0,083 Φ**	**p=0,072 Φ**	***p<0,01***	*ns*
		Without AD	1,22±0,19 (0,96-1,45)	1,22±0,17 (0,94-1,43)	1,24±0,16 (1,04-1,41)				*ns*	*ns*	*ns*
Cadence (steps/min)	Usual	With AD	59,24±16,85 (28,10-85,30)	61,89±13,56 (32,20-78,00)	61,88±14,59 (35,30-80,50)	**p<0,01 ¥**	ns	ns	*ns*	*ns*	*ns*
		Without AD	97,63±11,77 (78,20-108,00)	94,88±13,11 (69,90-104,80)	96,17±13,91 (73,70-108,10)				*ns*	*ns*	*ns*
	Fast	With AD	71,73±21,13 (32,70-103,70)	76,32±20,85 (34,90-102,00)	78,58±21,02 (36,60-105,60)	**p<0,01 ¥**	**p<0,01 ***	ns	**p=0,089 Φ**	***p<0,01***	*ns*
		Without AD	111,30±10,89 (95,50-123,30)	112,13±10,57 (95,40-121,70)	113,12±9,85 (99,40-122,40)				*ns*	*ns*	*ns*
Double support time affected side (%GC)	Usual	With AD	50,73±9,41 (36,00-66,50)	46,58±7,52 (37,10-60,60)	45,97±7,51 (33,80-55,40)	**p<0,01 ¥**	**p<0,05 ***	**p<0,05**	***p<0,05***	***p<0,01***	*ns*
		Without AD	32,77±3,20 (28,50-37,80)	32,90±3,71 (28,80-38,90)	33,50±3,94 (28,20-38,30)				*ns*	*ns*	*ns*
	Fast	With AD	46,08±9,75 (30,30-64,30)	43,58±8,59 (31,50-58,10)	43,12±8,94 (31,10-59,00)	**p<0,01 ¥**	ns	ns	*ns*	*ns*	*ns*
		Without AD	29,33±2,61 (25,20-32,10)	29,70±2,94 (24,70-33,00)	28,83±2,83 (26,20-33,80)				*ns*	*ns*	*ns*
Double support time unaffected side (%GC)	Usual	With AD	50,08±9,28 (35,80-66,10)	46,61±7,51 (36,80-61,10)	46,00±7,52 (34,30-56,30)	**p<0,01 ¥**	**p<0,05 £**	**p<0,05**	***p<0,05***	***p<0,05***	*ns*
		Without AD	33,12±3,39 (28,80-38,50)	33,18±4,12 (28,40-39,80)	33,65±4,04 (28,40-38,40)				*ns*	*ns*	*ns*
	Fast	With AD	46,86±9,75 (30,60-65,60)	43,57±8,96 (31,10-60,50)	43,09±9,20 (31,90-61,10)	**p<0,01 ¥**	**p=0,063 #**	ns	*ns*	***p<0,05***	*ns*
		Without AD	28,77±2,69 (25,20-31,30)	29,07±3,15 (24,10-32,60)	28,82±2,38 (25,80-32,70)				*ns*	*ns*	*ns*
Single support time affected side (%GC)	Usual	With AD	20,14±4,90 (10,80-26,40)	22,41±5,16 (11,50-29,00)	22,42±4,72 (13,90-28,40)	**p<0,01 ¥**	**p<0,01 *$**	**p<0,05**	***p<0,01***	***p<0,01***	*ns*
		Without AD	30,23±2,89 (25,80-33,10)	30,60±2,43 (26,60-33,10)	30,32±3,05 (26,00-33,00)				*ns*	*ns*	*ns*
	Fast	With AD	21,66±4,83 (11,80-29,20)	23,19±5,21 (12,80-29,70)	25,30±6,15 (13,50-34,80)	**p<0,01 ¥**	ns	**p<0,05**	*ns*	***p<0,05***	*ns*
		Without AD	33,30±1,58 (31,60-34,90)	32,62±2,28 (28,60-35,50)	32,32±1,89 (29,80-34,80)				*ns*	*ns*	*ns*
Single support time unaffected side (%GC)	Usual	With AD	30,27±4,98 (23,40-37,90)	31,26±2,93 (27,20-35,10)	31,87±3,71 (26,90-38,20)	**p<0,01 ¥**	ns	ns	*ns*	*ns*	*ns*
		Without AD	37,07±1,57 (34,80-39,60)	36,55±1,47 (34,40-38,70)	36,65±1,65 (35,10-39,10)				*ns*	*ns*	*ns*
	Fast	With AD	32,56±5,66 (22,60-41,20)	34,33±4,48 (26,80-39,50)	31,94±6,64 (17,90-39,70)	**p<0,05 ¥**	ns	ns	*ns*	*ns*	*ns*
		Without AD	38,37±1,36 (36,60-40,30)	38,33±2,06 (35,60-40,70)	39,25±2,20 (35,80-42,10)				*ns*	*ns*	*ns*
Step length affected side (cm)	Usual	With AD	42,84±6,35 (31,93-53,63)	41,44±7,08 (31,70-50,13)	41,56±8,73 (32,75-57,40)	**p<0,01 ¥**	ns	ns	*ns*	*ns*	*ns*
		Without AD	57,28±7,00 (47,68-64,92)	57,48±9,28 (45,65-66,08)	56,41±8,33 (43,73-66,69)				*ns*	*ns*	*ns*
	Fast	With AD	43,55±9,79 (29,05-57,33)	45,04±10,42 (32,69-63,25)	46,02±10,59 (33,60-62,72)	**p<0,01 ¥**	ns	ns	*ns*	*ns*	*ns*
		Without AD	65,27±7,51 (54,90-74,29)	65,14±7,01 (55,43-71,41)	64,36±4,71 (57,76-69,64)				*ns*	*ns*	*ns*
Step length unaffected side (cm)	Usual	With AD	32,90±10,97 (15,91-48,15)	34,96±9,97 (18,67-50,39)	37,27±11,04 (23,66-54,43)	**p<0,01 ¥**	**p<0,05 ***	ns	*ns*	***p<0,05***	*ns*
		Without AD	58,38±4,80 (49,61-64,25)	57,40±6,85 (46,80-67,31)	59,40±5,72 (52,25-68,92)				*ns*	*ns*	*ns*
	Fast	With AD	35,09±14,86 (8,78-55,54)	40,17±11,92 (21,46-59,56)	41,17±13,02 (26,17-61,50)	**p<0,01 ¥**	**p<0,05 ***	**p<0,05**	***p<0,05***	***p<0,01***	*ns*
		Without AD	66,66±5,14 (61,23-76,36)	66,03±5,94 (60,57-76,53)	67,43±5,36 (62,39-76,75)				*ns*	*ns*	*ns*

*Values are mean ± SD (Range:min-max); *, without AFO compared to Y-tech; $, without AFO compared to Maramed; #, borderline signficant in favour of the Y-tech (p<0,07); Φ, trend toward significance (p<0,09); ¥, significant difference between the two groups; £, sigificant results with ANOVA but after post-hoc tests no significant results between the conditions was found*

Table 4. Results of balance testing

Balance test	Assistive device	Comparing two groups mean ± SD			p-values					
		C1: Without AFO	C2: Maramed	C3: Y-tech	Group	Conditions	Interaction	*C1-C2*	*C1-C3*	*C2-C3*
TUG	With AD	27,26±11,65	24,29±10,35	24,10±8,96	**p<0,01 ¥**	**p<0,05 *$**	ns	**p<0,05**	**p<0,05**	*ns*
	Without AD	11,09±2,45	10,81±1,15	10,74±1,37				*ns*	*ns*	*ns*
Step test affected side	With AD	3,00±2,29	2,67±2,00	3,11±1,69	**p<0,01 ¥**	ns	ns	*ns*	*ns*	*ns*
	Without AD	7,00±1,10	6,83±0,98	6,83±0,98				*ns*	*ns*	*ns*
Step test unaffected side	With AD	3,78±2,29	4,44±2,30	4,00±3,04	**p<0,01 ¥**	ns	ns	*ns*	*ns*	*ns*
	Without AD	9,00±2,28	8,50±1,87	9,00±1,41				*ns*	*ns*	*ns*
Four Square Step Test	With AD	31,36±13,35	23,50±6,56	25,52±11,72	**p<0,01 ¥**	ns	ns	*ns*	*ns*	*ns*
	Without AD	13,06±1,73	12,68±1,71	13,07±2,06				*ns*	*ns*	*ns*

*Values are mean ± SD; *, without AFO compared to Y-tech; $ without AFO compared to Maramed; ¥, significant difference between the two groups*
£, sigificant results with ANOVA after post-hoc tests no significant results between the conditions was found

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Richting: **master in de revalidatiewetenschappen en de kinesitherapie-revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen**
Jaar: **2014**

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