3D KINEMATICS OF GAIT PATTERN IN ACTIVE ELDERLY MEN

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Gait is one of the most important means for the maintenance of an independent life and gait pattern (GP) seems to be associated with falls and, therefore, with the quality of life in the elderly. On the other side, exercise is associated with the maintenance of the physical function and quality of life. Therefore, the purpose of our study was to determine if moderate/vigorous exercise could retain GP with aging. The sample had two groups of subjects: one of five young males (21.8 (0.45) y) and the other of three old males (69.3 (8.4) y). Kinematics data were determined and compared between groups. No significant differences were found between the groups and therefore exercise practise seems to maintain GP trough aging. However, these results should be seen in a conservative way due to the small number of participants of this study.

KEY WORDS: biomechanics, kinematics, elderly, exercise, gait pattern.

INTRODUCTION:

Walking, one of the most common and natural human movement, allows the displacement of the body safely and efficiently across ground level, uphill or downhill (Prince, Corriveau, Hébert, & Winter, 1997). It is a complex motor pattern very important to the autonomy and the quality of life, being a growing concern in the industrial countries with an increased of life expectancy.

The loss of physical function with aging, some injuries or diseases and other factors may induce changes in the gait pattern (GP) and therefore affect the quality of life of the elderly.

Prince et al (1997) states that falls are a major cause of morbidity in the elderly and that in almost all incidents of falls, some aspects of locomotion are involved.

On the other side, it is known that one of the exercise benefits is to increase the physical function and the autonomy of the elderly (ACSM, 2006; Shephard, 1997).

Thus, the purpose of this study was to verify if exercise of moderate/elevated intensity can maintain GP through aging. With this purpose, a description and comparison, between young and old males, of selected kinematics parameters related with gait pattern was performed, employing an inverse kinematics methodology.

METHOD:

Data Collection: Two groups of subjects were studied: one of five young (21.8 (0.45) y) students who were graduating in sports science in the Faculty of Human Movement, and the other of three old subjects (69.3 (8.4) y) who participate in an exercise program in the same institution. All participants were men, participated in structured exercise four times a week and didn't have any gait pathology.

The variables tested in this study are listed bellow:

1. Spatial variables: Stride Length (SL), Metatarsal Height during Vertical Clearance (MHVC), Maximal ROM of the Ankle (AROM), Maximal ROM of the Knee (KROM), Knee Angle at the end of the Swing (KAS), Maximal ROM of the Hip (HROM)
2. Temporal variables: Stride Duration (SD), Stance Duration (STD), Swing Duration (SWD), Double Support Duration (DSD)
3. Spatial-Temporal variables: Stride velocity (SV), Heel Horizontal Velocity at Initial Contact (HHVIC), Maximal Dorsiflexion Velocity of the Ankle (MDVA), Maximal Plantarflexion Velocity of the Ankle (MPVA), Maximal Flexion Velocity of the Knee (MFVK), Maximal Extension Velocity of the Knee (MEVK), Maximal Flexion Velocity of the Hip (MFVH), Maximal Extension Velocity of the Hip (MEVH)

Linear spatial variables were normalized to the length of the lower limb and temporal variables were normalized to the stride duration.
The proceedings included the following steps:

1. Collection of anthropometric data: It consisted in measuring the subjects' weight, height and lower limb length.
2. Anatomical markers: Each subject was marked with 21 reflectors in the following anatomical points: Forefoot right/left, Foot tip right/left, Heel right/left, Maleolus lateralis right/left, Maleolus medialis right/left, Shank right/left, Condylis lateralis right/left, Condylis medialis right/left, Spina ilíaca anterior superior right/left, L4, Trocanther Major right/left. The 4 corners of the force plate were also marked.
3. Collection of video data: A calibration was made before the attempts. This process consisted first in filming the calibration structure and second filming the subject in the anatomical position at the same location with all the markers (force plate). The markers Foot tip right/left, Maleolus medialis right/left, Condylis medialis right/left, Trocanther Major right/left and the 4 markers of the force plate were remove before the attempts.
   Test area had 8.5 meters of length and 1.28 meters width. The cameras' model was Basler 600 III with a sampling frequency of 100Hz and they were positioned so that they would capture a stride starting on the force plate.
   Participants were told to walk so that they would step on the force plate with the right foot at the beginning of the stride. They were also instructed to walk as normal as they could. The images were collected when the participants were comfortable in performing the task. The software used in the collection was SIMI Reality Motion Systems.

Data Analysis: Data processing was made with the previously noted software. Kinematics' data was smoothed using a 10 Hz second-order, Butterworth low-pass filter. Statistical Analysis was done with the SPSS 14. Descriptive Statistics was used to determine the central tendency and standard deviation of the variables and the Mann-Whitney test was used to determine the differences between groups. Significance level was fixed at p-value=0.05. Due to the small sample, an effect size study was performed.

RESULTS AND DISCUSSION:

Statistical analysis presented the results that are shown in the tables below. There were no significant differences between groups for all the variables analysed.
The results of spatial variables are shown in table 1.

Table 1: Spatial variables: descriptive statistics and comparison betwen groups

Spatial Variables	Young (n=5)		Old (n=3)			
	Mean	SD	Mean	SD	p-value	Effect Size
SL (m)	1.37	±0.13	1.54	±0.14	--	-1.274
NSL (m)	1.61	±0.16	1.9	±0.24	0.101 (NS)	-1.523
MHVC (m)	0.071	±0.01	0.067	±0.01	--	0.400
NMHVC (m)	0.084	±0.01	0.083	±.01	0.655 (NS)	0.100
AROM (º)	31.14	±8.24	28.07	±1.10	0.456 (NS)	0.454
KROM (º)	61.54	±2.85	59.03	±4.64	0.297 (NS)	0.707
KAS (º)	-1.48	±3.98	2.25	±9.40	0.439 (NS)	-0.590
HROM (º)	41.46	±5.44	49.07	±5.76	0.101 (NS)	-1.371

NS – Not significant

The results obtained for SL (and NSL) diverge from the results obtained in previous studies that report a reduction for SL through aging (Perry, 1992; Prince, Corriveau, Hébert, & Winter, 1997; Winter, 1991). However, we could not verify differences between these two groups for the described variables.
In fact, comparing the results with the references we can verify that the elderly group obtained a larger SL. Nevertheless, it is important to refer that, in the references, the normalization process is not clear, so, some of the differences, might derive from this fact.

Agreeing with Winter (1991) (who compared the heel and foot tip height during vertical clearance between young and old males), there were no significant differences between groups for the MHVC (and NMHVC). Therefore it appears that the elderly group tested had a safe foot trajectory, not lifting the foot more than the young during the most dangerous instant for tripping (the vertical clearance).

The maximal ROM of the ankle (AROM) occurs during the push-off. Therefore a lower AROM was expected in the elderly group, agreeing with the less vigorous push-off that these individuals are expected to have. This difference was not verified and the results were in conformance with the results obtained by Winter (1991) with young males.

Analysing the maximal ROM of the knee, there were no significant differences between groups, even at the KAS, which was referred by Winter (1991) as the instant in which this angle would be different. According with this author's study, the elderly would finish the swing with the knee with a slight flexion while the young would finish it with the knee almost extended. However, the results obtained for KROM were inferior to those revealed as normal (to the young) by Perry (1992) (70º).

To conclude spatial variables, in the maximal HROM, for which the elderly group was expected to have a superior range of motion, there were also no differences between groups and the values obtained were superior to the values referred as normal by Perry (1992) (40º).

Table 2 shows the results of temporal variables.

Table 2: Temporal variables: descriptive statistics and comparison betwen groups

Temporal Variables	Young (n=5)		Old (n=3)			
	Mean	SD	Mean	SD	p-value	Effect Size
SD (s)	1.06	±0.08	1.15	±0.04	0.101 (NS)	-1.299
STD (%Stride)	61	±2.24	59	±3.61	0.451 (NS)	0.721
DSD (%Stride)	21.8	±5.07	17.67	±6.11	0.368 (NS)	0.759
SWD (%Stride)	39	±2.24	41	±3.61	0.451 (NS)	-0.721

NS – Not significant

For temporal variables, the most important fact is the difference between the stance and the swing duration. Winter (1991) states that with aging the STD and namely the DSD, has tendency to increase with the need of finding greater stability and prevent the loss of balance during the stride. However between these two groups no differences were found and the values obtained agree with the ones referred as normal (to the young) by the same author (STD – 58%-61%, DSD 16%-22%, SWD 39%-42%).

Table 3 present the results obtained for the spatial-temporal variables.

Table 3: Spatial-Temporal variables: descriptive statistics and comparison betwen groups

Spatial-Temporal Variables	Young (n=5)		Old (n=3)			
	Mean	SD	Mean	SD	p-value	Effect Size
SV (m/s)	1.54	±0.26	1.64	±0.15	0.456 (NS)	-0.436
HHVIC (m/s)	0.3	±0.16	0.43	±0.55	0.724 (NS)	-0.379
MPVA (rad/s)	-6.13	±1.84	-5.6	±0.52	0.881 (NS)	-0.346
MDVA (rad/s)	3.57	±0.83	2.8	±0.82	0.297 (NS)	0.931
MEVK (rad/s)	-7.12	±0.98	-6.35	±0.99	0.456 (NS)	-0.783
MFVK (rad/s)	5.72	±0.90	7.03	±0.76	0.101 (NS)	-1.531
MEVH (rad/s)	-2.26	±0.18	-2.5	±0.63	1.000 (NS)	0.612
MFVH (rad/s)	3.29	±0.44	4.08	±0.37	0.101 (NS)	-1.890

NS – Not significant

The values obtained for SV were, in general, superiors to those found in the references (Prince et al, 1997; and Perry, 1992), though more close to the results revealed by Perry (1992). Besides that, there were no differences between groups when it was expected a decreasing of the value of this variable with aging (which was mentioned by Prince et al (1997) as a valid and practical measure for mobility and a parameter which might reflect the daily living activity function).

Although SV seems to decrease with aging, the horizontal velocity of the heel during the initial contact (HHVIC) appears to increase. Winter (1991) states that this velocity rapidly reduces to zero after the start of weight bearing and that this reduction results from friction between the heel and the floor. Therefore, if the friction of the ground is low (because of ice, water or other condition), the potential for a slip-induced fall increases drastically.
However, no differences were found for this variable between the two groups compared in this study. It is also important to refer that the values obtained were very different comparing with the data referred by Winter (1991) (young adults: 0.872 m/s and elderly: 1.15 m/s).
Very few data was found in the literature for the angular velocities of lower limb joints. In our study, we find no differences between the groups, which seem to be in accordance with Winter (1991).
Effect size represents an estimate of meaningfulness between two levels of comparison (Thomas, Salazar, & Landers, 1991). Our results showed (table 1, 2 and 3) that the GP variables related to functionality which present moderate or large effect sizes are supporting the conclusion that the studied elderly subjects have, in general, higher functionality than the young. The exceptions were the maximal ROM of the ankle, the knee and the hip. If the sample was bigger, differences between groups for these variables could be seen in such way that the elderly subjects would have a smaller ankle and knee ROM and a bigger hip ROM than the young. This fact is in accordance with Shumway-Cook & Woollacott (1995).
Nevertheless, it is important to point out the fact that we have tested a small number of subjects, which make us look at the results in a conservative way.

CONCLUSION:

The present study should be considered as an exploratory one. The small sample will not allow us to present strong conclusions even if we were careful on the statistic significance and presented the effect size vales for all the studied variables. Nevertheless we found that all the kinematics variables tested did not present significant differences between young and old active males and that, in general, the two groups obtained values that are considered normal (to the young) in the references. This means that exercise practise is apparently related with the maintenance of these parameters with aging so that the elderly won't lose function, autonomy or increase the fall risk. It is important to point out some important issues concerning these comparisons, such as the normalization of linear spatial variables in relation with the lower limb or the level of physical activity of the participants, which are not clear in the references. Besides that, it is also important to reinforce the limitations of this study which might constitute sources of error. They are: the small number of participants, the possibility of the subjects altering the markers positions with movement and the fact that the experience was made in a laboratory (restricted area) and that the participants would have to begin the stride with the right foot in the force plate (conditions that can alter the natural behaviour of the subjects). To conclude we can point out the importance of performing further studies of this type that should emphasize, in special, the angular spatial-temporal variables, such as angular velocities.

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