DYNAMICS OF GAIT IN ACTIVE ELDERLY MEN

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The purpose of this study was to identify if, on very active elderly male, the undesirables effects of age in gait dynamic variables where minimized. The gait cycle of 3 healthy and active elderly males (ages: 69.30±1.41 years) and 5 health and active young males (ages: 21.80±0.45 years) was compared in order to verify if the differences (between young and older adults) usually reported in the literature were present. The following kinetics variables were studied: ground reaction force (vertical and anterior-posterior components), joint torques and joint power (ankle, knee and hip joints). The dynamic variables were collected using the inverse dynamics technique. The results show no significant differences between the two groups in ground reaction force, joint torques and joint power. Our results seem to indicate that elderly functional decline is minimized with exercise.

KEY WORDS: gait analysis, inverse dynamics, biomechanics, elderly.

INTRODUCTION:

Daily living activities demand constant mobility, usually walking from a place to another. The aging process brings to the human lower limb a decline in muscular strength and tendon stiffness. Physical activity has been reported as a useful “tool” to minimize the impact and the consequences of this decline. The locomotion function is extremely important in the elderly being related to falls prevention and a useful indicator of this population functionality. In pathological issues, gait assessment is also very useful if we want to monitorize the decline and the rehabilitation of this function. According to the Portuguese National Health Report, about 8.3% of the elderly population is dependent from other and 12% needs help to do their daily activities. The social and physical environment is insufficient for elderly independence and autonomy. Without proper stimulation and appropriate accesses, falls are a major cause of the great number of accidents in this population. The gait pattern, being a sequence of different phases, needs to be identified and described not only in quantitative but also in qualitative ways. Gait analysis gives us important information about kinematics, kinetics, functional variables and, consequently, about lifestyle’s quality.

METHOD:

Data Collection: The gait cycle of 3 healthy elderly males (ages: 69.30 ± 1,41 years old) participating in an exercise program (4x/week) and 5 healthy young males (ages: 21.80 ± 0,45 years old) also physically active (4x/week) was analyzed. The motion capture was performed using four digital cameras (Basler 600 I 1 I) operating at a frame rate of 100Hz. The gait area was a pathway with 8.5m x 1.28m. For the 3D kinematics reconstruction the DLT-11 algorithm was used. For the static calibration 11 markers were used on each limb, defining the individual anatomic reference position of each joint. The ground reaction forces were collected using a force platform (Kistler, type: 9865B). The participants had to walk normally (in their preferred rhythm), in the pre-defined area, and it was necessary that their right foot was placed over the force platform. Each participant had opportunity to train until they reached a comfortably gait level.

Data Analysis: The motion analysis software used was Simi Motion. A 10 Hz second-order Butterworth low-pass filter was used in order to smooth the kinematic data. Joint moment of force and joint power were calculated by inverse dynamics, using the force plate data and the three-dimensional kinematics. All the variables were normalized to the body mass of each participant. The statistical analysis was performed using SPSS 14.0. To verify the existence of significant differences between the groups the Mann Whitney test was used (p-value<0.05). The size effect analysis was used due to the small number of participants.

RESULTS:

The ground reaction forces (GRF) were collected (it were analyzed the anterior-posterior (y axe) and vertical (z axe) components of the gait task.

Table 1 Ground reaction forces peaks (Fy1, Fy2, Fz1, Fz"valley" and Fz2) and the instant at each peak occurs in the step (IFy1, IFy2, IFz1, IFz"valley" and IFz2)

GRF	Elderly		Young		p-value	Effect Size
	Mean	SD	mean	SD		
Fy 1 (N/kg)	-1.719	± 0.57	-1.799	± 0.30	0.655 NS	-0.20*
IFy 1 (step %)	18.13	± 2.85	18.9	± 0.91	0.655 NS	0.43
Fy 2 (N/kg)	2.197	± 0.29	2.014	± 0.48	0.655 NS	-0.43
IFy 2 (step %)	86.56	± 0.25	86.2	± 1.76	0.655 NS	-0.25*
Fz 1 (N/kg)	10.484	± 0.56	10.679	± 0.48	0.881 NS	0.38*
IFz 1 (step %)	23.50	± 2.45	24.28	± 1.26	0.453 NS	0.45
Fz "valley" (N/kg)	6.862	± 0.57	7.128	± 0.70	0.297 NS	0.40*
IFz "valley" (step %)	49.13	± 1.45	46.76	± 4.67	0.881 NS	-0.61
Fz 2 (N/kg)	10.818	± 0.60	11.113	± 0.56	0.655 NS	0.51
IFz 2 (step %)	76.33	± 2.90	77.10	± 1.85	1.000 NS	0.34*

* significant values (small effect size: ≤ 0.4)

Table 2 Joint torques in the ankle (AT), knee (KT1, KT2, KT3), hip (HT1, HT2) and their instants of occurrence in the step (IAT, IKT1, IKT2, IKT3, IHT1 and IHT2)

Joint torques	Elderly		Young		p-value	Effect size
	Mean	SD	Mean	SD		
AT (N.m/kg)	0.767	± 0.21	1.560	± 0.54	0.101 NS	1.73
IAT(step %)	41.40	± 2.96	44.26	±2.07	0.180 NS	1.19
KT 1 (N.m/kg)	0.262	± 0.01	0.849	± 0.36	0.053 NS	2.00
IKT 1 (step %)	7.80	± 5.99	14.96	± 5.78	0.051 NS	1.22
KT 2 (N.m/kg)	-0.637	± 0.69	-0.214	± 0.55	0.297 NS	0.70
IKT 2 (step %)	42.93	± 17.01	48.44	± 13.50	0.456 NS	0.37*
KT 3 (N.m/kg)	0.326	± 0.13	0.436	± 0.55	0.456 NS	0.24*
IKT 3 (step %)	76.00	± 27.56	78.56	± 25.24	0.655 NS	0.10*
HT 1 (N.m/kg)	1.137	± 0.25	1.447	± 0.67	0.297 NS	0.55
IHT 1 (step%)	12.33	± 5.27	10.18	± 5.44	0.881 NS	-0.40*
HT 2 (N.m/kg)	-0.826	± 0.24	-0.792	± 1.00	0.297 NS	0.04*
IHT 2 (step%)	53.80	± 2.64	53.36	± 5.30	0.881 NS	-0.10*

* significant values (small effect size: ≤ 0.4)

Table 3 Joint power peaks in the ankle (AP2), knee (KP4), hip (HP3) and their instants of occurrence in the stride (IAP2, IKP4, IHP3)

Joint power	Elderly		Young		p-value	Effect size
	Mean	SD	Mean	SD		
AP 2 (W/kg)	0.7846	± 0.27	2.4755	± 1.22	0.053 NS	3.42
IAP2 (step %)	53.30	± 5.00	49.58	± 8.48	0.655 NS	-0.61
KP 4 (W/kg)	-0.9167	± 0.28	-1.2112	± 0.33	0.297 NS	-0.99
IKP4 (step %)	88.20	± 2.81	89.00	± 1.23	0.655 NS	0.36*
HP 3 (W/kg)	0.8628	± 0.40	1.0914	± 1.30	0.456 NS	0.36*
IHP 3 (step %)	59.60	± 14.82	58.36	± 18.54	0.881 NS	-0.08*

* significant values (small effect size: ≤ 0.4)

DISCUSSION:

According to the present analysis, the results were not statistically significant. However, our sample had only 8 participants. Due to that, the ES (Effect size) was calculated showing that some variables had an ES superior to others, "representing results that have great theoretical and empirical value" (Thomas, 1991). For this reason, the results must be stated with some caution and with limited generalization.

Observing table 1, the anterior-posterior component of GRF (Fy) shows that the push-off (2nd peak) of the elderly presented superior values to the ones in the literature (Winter, 1991), looking similar to the data that the same author refers for the younger population. This fact may suggested that this sample (unlike the regular elderly referred in the mentioned studies) had a vigorous foot push-off. However, this variable has a medium effect size (0.43) showing that if we had a larger sample, the result could be different. About the vertical component of GRF (Fz), it can be seen that the values of the elderly are similar to those referred by Winter (1991), being the 2nd peak the greater. Once again, it supports the hypothesis that elderly active people have a great foot traction on the walking surface. In a general way, these results seem to indicate that elderly participants on this study have a high motor skill, a good locomotion ability and a good foot traction against the ground, which may indicate a reduced fall risk and increased stability.

On table 2 we can see that, the differences between two groups are not statistically significant and also the 3rd knee torque peak (KT3) and the 2nd hip torque peak (HT2) have a small effect size (the sample size has a reduced effect on these results). The literature (Winter, 1991) refers the ankle torque peak (AT) during the plantar flexion, as being one of the most important variables in gait studies. This author obtained values of 1.447 N.m/kg for the elderly males and 1.628 N.m/kg for the young males. In our study, both values were inferior. This variable could be, related with the intensity of the push-off. Considering knee and hip joint torques, literature doesn't indicate any special difference between young and elderly people. For the elderly, the knee 1st and 2nd torque peaks were lower than those referred in literature but the great effect size shows that these results could be different with a larger sample. The knee extensors activity happens until the 15% of the stride, as a way of energy absorption and knee flexion control (KT1). Between the 30% and 50% of the step, the 2nd peak of the knee torque (KT2) occurs associated to the small knee flexion due to the muscular action of the gastrocnemius, which prepared the push-off. Winter's (1991) results were -0.258 N.m/kg for the elderly, while we obtained -0.637 N.m/kg. Between the 40% and 60% of the step, the knee flexes due to the powerful push-off of the ankle, reaching the 3rd peak of the knee torque (KT3). Our results (0.326 N.m/kg) were higher than those referred by Winter (1991) (0.167 N.m/kg). This fact can be related, once more, with the vigor of our elderly group push-off. In what concerned the hip torque, the 1st peak (HT1) was 1.138 N.m/kg, which is a superior value when compared with the one obtained by Winter (1991) (0.685 N.m/kg). The medium effect size indicates that a larger sample could change this result. The 1st peak corresponds to the initial action of the hip extensors, absorbing energy in the initial contact and stabilizing the trunk during the forward movement of the hip. The 2nd hip torque (HT2) corresponds to the instant of concentric contraction of the hip flexors to initiate the lower limb pull-off (this happens visibly at 50% of the step). According with the small effect size value, this variable should be considered.

On table 3 we can observe the most relevant (according to the literature references) peak power results in the three main joints. Once more, the differences found between the groups weren't statistically meaningful. The ankle 2nd power peak (AP2) and knee 4th power peak (KP4) present large effect size values, so we could expect different results if we had a larger sample. The literature refers the AP2 as one of the most importants in gait studies. Prince (1997) refers the AP2 as the greatest predictor of the step length. The result obtained for the elderly was 0.785 W/kg, against 2.478 W/kg collected by Winter (1991) and 1.62 W/kg referred by Prince (1997). The 4th knee power peak happens at the end of the swing phase. The result for the 4th knee power peak was -0.917 W/kg, while Winter (1991) obtained 0.867 W/kg. About the hip joint, the 3rd power peak was 0.863 W/kg, while Prince (1997) collected

0.56 W/kg and Judge et.al, referred by Prince (1997), collected a 0.92 W/kg result. The power variable showed some interesting potential for further investigations because mechanical power seems to decrease with great intensity in the aging process.

CONCLUSION:

The participants in our study are men used to run miles and miles every day. Unfortunately, the consulted literature didn't refer the levels of physical activity nor the type of exercise practiced by the participants. We need to be careful when compare our results with the references because; the step cadence, the physical activity index and the normalization procedures are not quite explicit in some of the studies. In general we can see that, in the most important variables, the studied elderly group had superior results to those referred in the literature.

As the results of the present study (specially those with small effect size values), showed no significant differences between the two groups, it can lead us to the possibility that healthy and physically active lifestyles are important for the maintenance of functional ability, stability, independence and minor risk of falling in the elderly.

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