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CRPG - REATEC

Title
Analysis of Plantar Pressure and Balance of Transfemoral Amputees Compared with Non Amputee Subjects, Using Their Shoes

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Summary
Plantar pressure and balance of transfemoral amputees' was compared with non amputee subjects. 9 amputees and 18 controls walked over 8m walkway w/a pressure and a force plate. Significant differences registered: COF distance, deltax, deltay, Max/Min APforce, MinMLforce and time, stance and impulse.

Introduction
Lower limb amputation affects daily living, as most of our daily tasks involve standing and moving around the environment. Lower limb amputation as a permanent disabling condition leads to a permanent loss in locomotion and mobility. Posture, a key component of all perception action system, serves to maintain bodily orientation and can
be considered as a primary support for the exploration of the environment serving as a mechanical support for action. (1) Prosthetic fitting and rehabilitation contributes to restore the ability of standing and walking in such conditions. In amputees, weight distribution over the feet on standing and walking is altered, and balance and equilibrium are affected. Prostheses can provide good static support, but asymmetry can be observed, frequently, during dynamic locomotion. (2) The knowledge
on balance and pressure distribution on amputees and comparison with non amputated subjects may be very helpful on prosthetic fitting and rehabilitation.

Methods
9 transfemoral amputees, selected from the population attending CRPG and 18 healthy/active subjects, recruited from FADEUP, the 9 amputees 53 years old (± 16, 23), physically active-

SF36 physical function 62, 78 (± 24, 89) and 18 non amputees 67 years old (± 8, 56), physically active - SF36 physical function 82, 33 (± 18, 01) walked on a 8m
walkway, passing over a pressure plate RSScan ® and a force plate Kistler® wearing their own shoes at a self selected speed. After adaptation, each subject walked six times, at least three randomly selected, for a three times collection of right and left foot. Kinetic data were recorded with Simi Motion System® (1000 Hz). Fx, Fy and Fz peaks and time, duration of stance and resultant impulse were analyzed using MATLAB®. The pressure and balance data were recorded and analyzed using software package Gait Scientific 3D® and Balance®. Statistics with Minitab software package version 14.0. Due to the normality of the data, parametric tests were used.

Results

The subjects where physically active and reported no relevant concern with their health as confirmed by SF36 Scales of Physical Function, General Health and Vitality (Table 1). Amputees had used prosthesis for at least 2 years and reported to be well adapted to the prosthesis currently in use. Total COF traveled way, delta x and delta y were analyzed for the amputee and non amputee group. Results are displayed on Table 2 and graphs Graph 1, 2 and 3 attached. There is significant difference on the total distance traveled by the COF over the base of support longer on the amputee group, as well as the difference of dislocation in x and y direction. Pressure, force, stance time and impulse the results are summarized on Table 3, 4, 5,6,7,8 and 9 attached. For these variables, amputated side and sound side from the amputee group were analyzed. Each subject walked 6 times on the walkway and at least 3 times for the left side and at least 3 times for the right side was recorded. In total, for each variable, a total of 29 measurements for each side were used. Statistical significance with a strong test result was registered for Max AP force, Min AP force, Min ML Force and Min ML Force Time, time and impulse differences.

Conclusion

Prosthesis are usually aligned for a specific shoe and the end result is always a combination of both components. For that reason we have assessed all the variables with the subjects wearing

their shoes. Prosthetic knee and ankle components mimic, to a certain level, the normal human ankle and knee. The mechanical behaviour of the
prosthetic feet and ankle is important during stance phase as it must allow for a correct transition of forces and force application point, when not verified changes in gait can be observed. In this study we have encountered significant differences in COF total travelled way, delta x and delta y between a group of amputees and non amputees. When compared, the amputated side and sound side show significant differences in Max AP Force, Min AP Force, Min ML Force and Time Min ML Force as well as in stance and impulse. Amputees must cope with less flexible ankle and feet and may have to enlarge
their support basis and their sound side support.

References

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	COF total traveled way (mm)	?(delta)x (mm)	?(delta)y (mm)
Amputees (9)	508 (± 255)	147 (± 70,6)	121,3 (± 64,8)
Non amputees (18)	154,1 (± 166)	52 (± 105)	43,2 (± 71,9)
Test result	T-value 4,36 pvalue 0,002 estimated difference 354,082	T-value 2,82 pvalue0,01 estimated difference 95,29	T-value 2,9 pvalue0,009 estimated difference 78, 05

Table 2 – COF total distance traveled, deltax and deltay of amputee and non amputee group.

	Peak Force (%BW)	Peak Force Time (%stance)
Amputated side	101 (±6,8)	46, 24 (±19, 27)
Sound side	103 (±7,3)	57, 44 (±23, 26)
Test result	T-value= - 1,65 pvalue 0,111 estimated difference= -2,27 (±7,43)	T-value = -1,78 pvalue 0,085 estimated difference=- 11,20 (±33,81)

Table 3 – Analysis of Peakforce value and time (amputated side and sound side)

	Max AP Force (%BW)	Max AP Force Time(%stance)
Amputated side	8,82 (±3,19)	76,89 (±7,69)
Sound side	15,03 (±6,82)	79,72 (±15,95)
Test result	T-value= - 3,67 pvalue 0,001 estimated difference=- 6,20 (±9,11)	T-value = -0,77 pvalue 0,449 estimated difference=- 2,82 (±19,8)

Table 4 – Analysis of Max AP force and time (amputated side and sound side)

	Min AP Force (%BW)	Min AP Force Time(%stance)
Amputated side	- 7,41 (±3,27)	20,08 (±5,17)
Sound side	- 11,34 (±3,41)	18,37 (±3,77)
Test result	T-value= 4,54 pvalue 0,000 estimated difference 3,93 (±4,56)	T-value= 1,70 pvalue 0,100 estimated difference 1,65 (±5,23)

Table 5 – Analysis of Min AP force and time (amputated side and sound side)

	Max ML Force (%BW)	Max ML Force Time(%stance
Amputated side	3,66 (±4,18)	63,00 (±36,97)
Sound side	6,24 (± 3,12)	55,89 (±32,13)
Test result	T-value= - 1,96 pvalue 0,060 estimated difference - 2,58 (±7,09)	T-value= 1,07 pvalue 0,295 estimated difference 7,10 (±35,89)

Table 6 – Analysis of Max ML force and time (amputated side and sound side)

	Min ML Force (%BW)	Min ML Force Time(%stance)
Amputated side	- 4,96 (±3,44)	51,41 (±31,14)
Sound side	- 2,37 (± 2,67)	25,13 (± 33,26)
Test result	T-value= - 2,46 pvalue 0,020 estimated difference - 2,58 (±5,66)	T-value= 3,37 pvalue 0,002 estimated difference 26,27 (±41,99)

Table 7 – Analysis of Min ML force and time (amputated side and sound side)

	Stance Time (s)	Impulse (N.s)
Amputated side	94,93 (±16,84)	44 798,7 (±11 518,9)
Sound side	103,65 (± 12,32)	53 204,2 (± 11 629,4)
Test result	T-value= - 2,51 pvalue 0,018 estimated difference - 8,72 (±18,69)	T-value= -3,07 pvalue 0,005 estimated difference - 8 405,52 (±14 740,83)

Table 8 – Analysis of stance time and impulse (amputated side and sound side)