Proceeding

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On footedness and ankle's Dynamic Joint Stiffness relation

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ABSTRACT

Our earlier reports suggest no dynamic joint stiffness (DJS) inter-limb differences related to footedness. A different approach to our data was used in this study: first define ankle DJS, then look for inter-limb differences and finally correlate them with the subject's perceived footedness. Methods: 31 subjects (20 females, 11 males) were assessed for ankle DJS during the stance phase of gait, unilateral triple-jump for distance (TSU) and single-leg hopping (Hop). DJS was obtained by linear models at three stance sub-phases (controlled plantar flexion (CPF); controlled dorsiflexion (CDF); power plantar flexion (PPF)). Footedness assessed by the Lateral Preference Inventory (LPI). Results: Paired samples t-test showed statistical inter-limb differences in ankle DJS at PPF on gait ($p < 0.01$) and Hop ($p < 0.05$) tasks. No footedness-DJS correlation was found with exception of the TSU PPF (Pearson's $p < 0.05$). Descriptive analysis shows that in gait, 55% of the subjects maintained the same stiffer ankle between the CPF and the CDF, 45% keep the same stiffer ankle between CDF and PPF, and only 19% keep the same stiffer ankle along all stance. In TSU and Hop, only 48% and 74%, respectively, keep the same stiffer ankle between CDF and PPF. Conclusion: This approach increased our earlier findings of footedness-DJS correlation, but the results are still low. The variability of DJS along the stance sub-phases between tasks needs more attention. Hop task cold be more adequate for footedness assessment due to a more consistent DJS behaviour along the stance. **Keywords**: Biomechanics; Dynamic Joint Stiffness; Footedness.

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INTRODUCTION

The differences between the motoric preference of one limb to other, is something that fascinate researchers for a long time (Castro-Caldas, 2004). Footedness concept itself defines dominant lower limb as the one used, in a bilateral context, to manipulate and the non-dominant as the one used to support the actions performed by the dominant one (Peters, 1988). In this context, the option of the dominant and non-dominant lower limb should be the same in different tasks and contexts, but this fails to occur (Atun-Einy, 2016; Gabbard & Hart, 1996), leading to the notion that this footedness should be task-specific our even that it do not exist at all (Grouios, Hatzitaki, Kollias, & Koidou, 2009; Previc, 1991). As footedness is usually assessed by preference questionnaires or performance inventories (Gabbard & Hart, 1996), cultural influence or even subject's perceived assumptions can influence the footedness attribution (Fagard & Dahmen, 2004; Zverev & Mipando, 2007). Because of this possible cultural and social influence, and the fact that lateral preference can differ in different domains (motoric, perceptual, cognitive, emotional) in the same subject (Hellige, 2006), we can understand that more objective measures of the human motor behaviour can help researchers to define better the lateral preference for motoric actions like footedness, contributing to a better comprehension of lateral preferences in different research environments.

One of the objective measures that can be selected, is the dynamic joint stiffness (DJS). This measure is usually used to quantify the resistance offered by the active and passive component of a joint to its segments displacement using a linear model, and help in the determination of how effective are the external forces acting in the system absorbed or transmitted by that components (J. M. C. S. Abrantes, 2007; J Abrantes, 2006; JMCS Abrantes, 2009; Aleixo, Vaz-Patto, Moreira, & Abrantes, 2018; Gabriel et al., 2008). This concept rises from the joint stability concept which describes the joint ability to maintain an adequate angular position along a specific path that answers the subject's needs to achieve a determinate motor objective (J. M. C. S. Abrantes, 2007; J Abrantes, 2006; JMCS Abrantes, 2009; Aleixo et al., 2018; Gabriel et al., 2008). DJS can be studied by the analysis of the instantaneous relation between joint moment of force and the coincident joint position angle as $DJS=dM/d\theta$, where M is the ankle moment of force (normalized to body weight) and θ is the ankle sagittal angle, computed by traditional linear models (J. M. C. S. Abrantes, 2007; J Abrantes, 2006; JMCS Abrantes, 2009; Aleixo et al., 2018).

As a measure of the joint's performance in a selected task, it can help discover the differences needed to define dominant and non-dominant limb in a more objective way. In this scenario, if footedness exists then objective measures of the joint stability should present inter-limb differences that can be attributed to that preference. If the latter is true, then DJS should reflect those differences between dominant and non-dominant lower limb joints and can became it objective measure.

Usual methods to explore this assumption are based on the logical path of variables confrontation: look for subject's footedness, assess subjects DJS on selected tasks and compare dominant and non-dominant lower limb regarding those variables. In our idea, footedness can be influence by cultural and social aspects as it was described earlier, and even by the subject's own perception of his dominant limb. Because of the inherent difficulty to separate true footedness from this conditioning, we hypothesized that this logical path for variable confrontation can favour the lack of findings reported in our earlier reports (Atalaia, Abrantes, & Castro-Caldas, 2015a, 2015b, 2015c, 2015d; Atalaia & Abrantes, 2015). One those, we could justify, in some amount, the lack of findings as footedness assessment normally assumes dominant and non-dominant limb by the subject's own perception more than based on a preferable motoric behaviour that overpasses the subject will to perform a task with one or other lower limb. Thus, in this work, it's our objective to use a different path, first to describe left and right differences in terms of DJS and then, to correlate them to the subject's perceived footedness as assessed by the lateral Preference Inventory (LPI) (Atalaia, Abrantes, & Castro-Caldas, 2015e).

MATERIALS AND METHODS

Subjects and Procedures

In the present study, and to be able to compare the results by applying different methods, we used the same sample as used in our previous works (Atalaia et al., 2015a, 2015b, 2015c, 2015d; Atalaia & Abrantes, 2015). This sample was composed by 31 subjects (20 females, mean age 23.0±2.98 years; mean weight = 60.3±9.8 kg; mean height = 163±6.3 cm; and 11 males; mean age 23.64±2.25 years; mean weight = 74.4±11.6 kg; mean height = 176.1±5.1cm), volunteers, with no history of lower limb injuries or other aspects that could influence the data collection or interpretation. They were clinically assessed for joint instability prior to data collection. The footedness distribution as assessed by the Portuguese Version of the Lateral Preference (LPI) was 81.8% right-footed and 18.2% left-footed. Footedness indexes were calculated in accordance with the inventory instructions (Atalaia et al., 2015e). To study the DJS we selected three tasks that are common in both human movement analysis and footedness assessment: gait, final stance of the unilateral triple-jump for distance (TSU) and single-leg hopping task (Hop). Subjects preformed 10 gait cycles for each foot, three TSU for each foot and 10 seconds Hop for each foot. The biomechanical data of each task were collected in the same day and a period of rest between tasks was respected. Data was collected at MovLab (Universidade Lusófona de Humanidades e Tecnologias, Lisbon, Portugal). Kinematic data were recorded at 200Hz using a 3D optometric motion capture system (Vicon®Motion Capture MX System, Oxford, UK), composed of 9 MX cameras (7*1.3Gb; 2*2.0Gb) which were connected to the MXUltranet control hardware and used to track the motion of the 41 spherical reflexive markers (9.5mm diameter) that make up the PlugInGait-Full Body model. Anthropometric data, needed for the PlugInGait-Full Body model, were collected using the SECA 764 scale for weight record and Siber Hegner instruments for the anthropometric measurement. Synchronized kinetic data were recorded at 1000Hz using a force platform (AMTI BP400600-2000, USA) connected to a strain gauge amplifier (AMTI MSA-6 MiniAmp). Each subject recorded data included 10 gait trials for each foot stance, barefooted at self-selected gait speed, 3 stances of the final jump of the TSU for each foot and 10 seconds for each foot during Hop.

Data Processing

In this study we only use ankle DJS scores. To calculate ankle DJS, a plot moment of force /joint angle was computed for the stance phase of each task. This loop was then divided into sub-phases. The best number of sub-phases to be used is still to be defined as different authors sustain different approaches each one with valid fundament. We use the option to divide the stance phase into three sub-phases (Safaeepour, Esteki, Ghomshe, & Abu Osman, 2014): controlled plantar flexion (CPF) that occurs from the initial contact until the maximum plantar flexion angle is reached; controlled dorsiflexion (CDF) that starts at the end of CPF and ends when the maximum value of dorsiflexion is attained; and power plantar flexion (PPF) that comprises the rest of the stance finishing at toe-off. For each of these sub-phases, we apply a least-squares linear regression model to compute DJS. An example can be saw in Figure 1. In the TSU and Hop tasks, the DJS computation was only done for CDF and PPF sub-phases as the CPF sub-phase do not exist. To acquire DJS score, was obtained by the slope of the regression line computed for each sub-phase by linear models.

The screening for interlimb differences in the different stance sub-phases for each task was conducted with the paired samples t-test, as we want to maintain left and right limb relation.

To allow the correlation between sides, we hypothesized that the limb normally associated with the manipulation should present a less DJS score (less stiffness) as the one dedicated to support (higher stiffness). Following this hypothesis, to each subject in each sub-phase, we give the attribute 4 (right) or -4 (left) to the less stiff lower limb. This attribute was consistent with the attributes used to express footedness in the LPI so, it allowed the study of correlation between DJS and footedness.

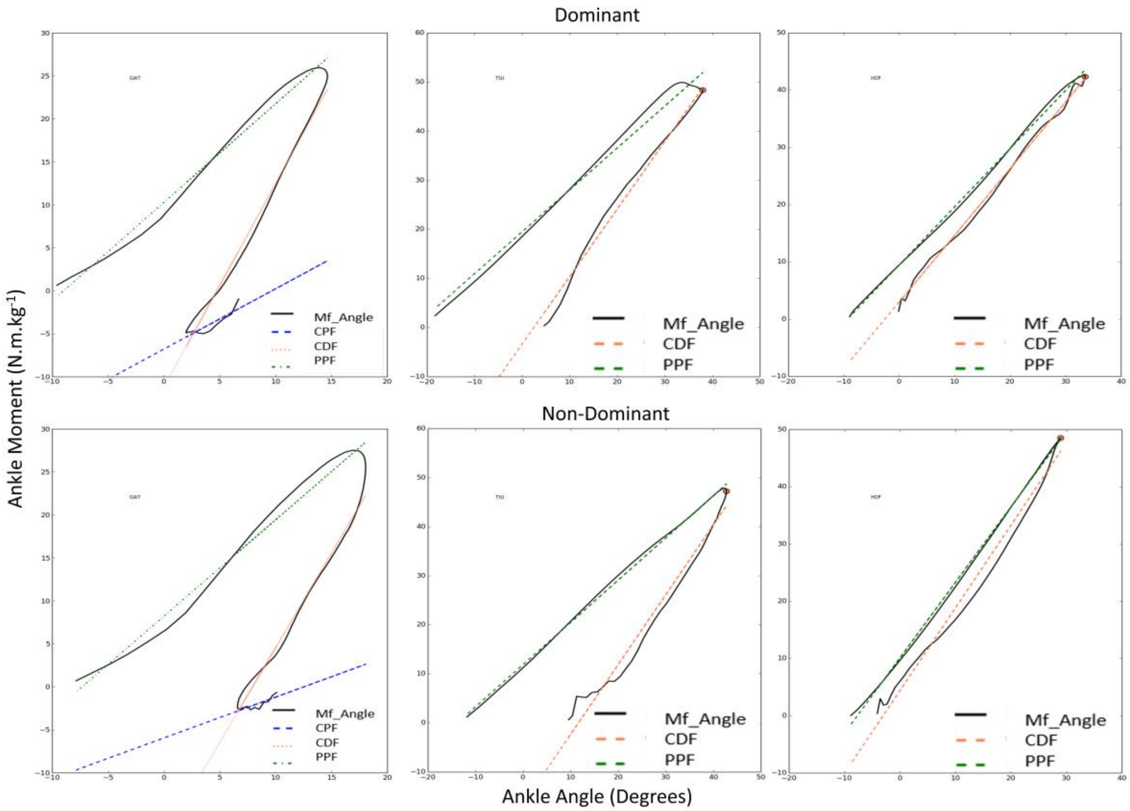

Figure 1. The subphases studied in each task, with the respective regression line.

RESULTS

The study of the differences between left and right lower limbs in each sup-phase of all three tasks can be observed in Table 1. Significant differences can be observed in the Gait PPF ($p<0.01$) and Hop PPF ($p<0.05$).

The results of the correlation between the footedness index obtained from the LPI and the attribute given due to the less stiff limb e each stance sub-phase on all three tasks can be observed in Table 2. No correlation between footedness index and DJS were found with exception of the TSU PPF ($p<0.05$) indicating a stiffer non-dominant ankle.

A descriptive analysis was done to the values of DJS between the dominant and non-dominant limb as attributed from the LPI, as it can be observed in Table 3. The goal was to verify if the stiffness along the stance is stable or it presents differences. As we can observe in Table 4, which is a synthesis of Table 3 information, only 19% of the subjects maintained the same lower limb as the stiffer one along the Gait stance sub-phases. In the TSU task, this number increased to 48% and in the Hop to 74%.

Table 1. Results of the paired samples t-test for the analysis of Dynamic Joint Stiffness differences in each sub-phase of the stance of each task

Pair		Paired Differences				t	df	Sig.
		Mean	SD	95% CI				
				Lower	Upper			
1	Gait_CPF_Right_vs_Left	-0.05	0.29	-0.16	0.05	-0.98	30	0.33
2	Gait_CDF_Right_vs_Left	-0.03	0.32	-0.15	0.09	-0.55	30	0.59
3	Gait_PPF_Right_vs_Left	-0.08	0.16	-0.14	0.02	-2.85	30	0.01
4	TSU_CDF_Right_vs_Left	-0.08	0.36	-0.05	0.21	1.18	30	0.25
5	TSU_PPF_Right_vs_Left	-0.04	0.13	-0.09	0.01	-1.69	30	0.10
6	Hop_CDF_Right_vs_Left	-0.05	0.28	-0.15	0.05	-1.01	30	0.32
7	Hop_PPF_Right_vs_Left	-0.07	0.18	-0.13	0.00	-2.11	30	0.04

Table 2. Results of the Pearson's Correlation between the footedness index assessed by the Lateral Preference Inventory and the adapted footedness index attributed in accordance with the less stiffness lower limb criteria

		Footedness Index LPI
Gait_CPF_Less_Stiff_Index	Pearson Correlation	0.21
	Sig.	0.27
	N	31
Gait_CDF_Less_Stiff_Index	Pearson Correlation	-0.15
	Sig.	0.41
	N	31
Gait_PPF_Less_Stiff_Index	Pearson Correlation	-0.22
	Sig.	0.23
	N	31
TSU_CDF_Less_Stiff_Index	Pearson Correlation	0.05
	Sig.	0.78
	N	31
TSU_PPF_Less_Stiff_Index	Pearson Correlation	-0.32
	Sig.	0.08
	N	31
Hop_CDF_Less_Stiff_Index	Pearson Correlation	0.27
	Sig.	0.15
	N	31
Hop_PPF_Less_Stiff_Index	Pearson Correlation	0.11
	Sig.	0.57
	N	31

Table 3. Descriptive of DJS scores along the sub-phases of the stance in the three tasks observed, and subjects LPI scores

	Gait												TSU								Hop								LPI	
	CPF				CDF				PPF				CDF				PPF				CDF				PPF					
	Right	Left	Dif	Stiffer	Right	Left	Difference	Stiffer	Right	Left	Dif	Stiffer	Right	Left	Dif	Stiffer	Right	Left	Dif	Stiffer	Right	Left	Dif	Stiffer	Right	Left	Dif	Stiffer	Score	Dominance
S01	0,88	0,55	0,33	D	1,93	1,94	-0,01	ND	1,06	1,29	-0,23	ND	2,51	2,02	0,49	D	1,25	1,31	-0,06	ND	1,12	1,29	-0,18	ND	1,01	0,98	0,03	D	2	R
S02	0,41	0,74	-0,34	ND	1,93	2,29	-0,35	ND	1,12	1,20	-0,08	ND	1,32	1,31	0,01	D	1,24	1,23	0,00	D	1,58	1,64	-0,06	ND	1,45	1,34	0,12	D	2	R
S03	0,18	0,15	0,03	D	1,20	1,01	0,19	D	0,70	0,83	-0,13	ND	1,36	1,80	-0,45	ND	0,96	1,18	-0,22	ND	1,59	1,41	0,18	D	1,33	1,25	0,08	D	4	R
S04	0,42	0,25	0,18	D	1,78	1,73	0,04	D	1,11	1,58	-0,47	ND	1,42	1,39	0,04	D	0,73	0,78	-0,05	ND	0,79	1,15	-0,36	ND	0,67	0,96	-0,29	ND	2	R
S05	0,24	0,38	-0,13	D	1,22	1,13	0,09	ND	0,73	0,71	0,02	ND	0,74	0,83	-0,09	D	0,61	0,54	0,07	ND	0,59	0,63	-0,04	D	0,56	0,54	0,03	ND	-2	L
S06	0,38	0,43	-0,04	ND	1,01	1,00	0,01	D	0,70	0,85	-0,15	ND	1,12	1,21	-0,08	ND	1,00	1,10	-0,10	ND	1,01	1,29	-0,28	ND	0,78	1,19	-0,41	ND	2	R
S07	0,41	0,69	-0,28	ND	0,93	1,64	-0,71	ND	0,73	1,28	-0,56	ND	1,01	1,37	-0,36	ND	0,77	0,92	-0,15	ND	1,07	1,23	-0,16	ND	0,93	0,98	-0,05	ND	2	R
S08	0,50	0,31	0,19	ND	1,33	1,96	-0,63	D	0,99	1,03	-0,04	D	1,69	1,36	0,33	ND	1,22	1,02	0,19	ND	1,63	1,44	0,19	ND	1,65	1,52	0,13	ND	-2	L
S09	0,62	0,41	0,21	D	1,60	1,99	-0,38	ND	1,01	1,33	-0,32	ND	1,21	0,93	0,28	D	0,71	0,75	-0,03	ND	1,42	1,06	0,36	D	0,77	0,82	-0,05	ND	2	R
S10	1,16	1,78	-0,63	ND	2,57	2,33	0,23	D	1,26	1,23	0,03	D	1,57	2,24	-0,66	ND	0,70	0,85	-0,15	ND	1,10	1,19	-0,10	ND	0,81	1,13	-0,32	ND	4	R
S12	0,44	0,31	0,13	D	1,32	0,94	0,38	D	1,00	1,05	-0,05	ND	0,66	0,72	-0,06	ND	0,67	0,62	0,05	D	1,71	1,08	0,63	D	1,02	1,06	-0,04	ND	4	R
S13	0,31	0,22	0,09	D	2,11	1,53	0,58	D	1,19	1,34	-0,15	ND	1,49	0,95	0,54	D	0,82	0,87	-0,05	ND	0,80	0,63	0,17	D	0,72	0,67	0,05	D	2	R
S14	0,15	0,32	-0,17	ND	1,23	1,19	0,03	D	1,21	1,03	0,18	D	1,38	1,61	-0,24	ND	0,78	0,99	-0,21	ND	1,32	1,32	0,00	ND	1,07	1,12	-0,05	ND	4	R
S15	0,25	0,00	0,25	D	1,17	1,04	0,14	D	0,77	0,86	-0,09	ND	0,88	0,63	0,25	D	0,45	0,38	0,08	D	0,87	0,62	0,25	D	0,74	0,59	0,15	D	4	R
S16	0,15	0,13	0,02	D	0,85	1,48	-0,64	ND	0,97	0,88	0,09	D	2,05	2,29	-0,24	ND	0,80	0,94	-0,14	ND	0,58	1,09	-0,51	ND	0,55	0,83	-0,28	ND	2	R
S17	0,17	0,71	-0,54	ND	1,23	1,48	-0,25	ND	1,43	1,45	-0,02	ND	1,66	1,16	0,50	D	0,69	0,70	-0,01	ND	1,04	1,12	-0,08	ND	0,79	0,77	0,02	D	4	R
S18	0,35	0,62	-0,26	ND	0,93	0,97	-0,04	ND	0,56	0,58	-0,02	ND	0,79	0,60	0,19	D	0,52	0,55	-0,03	ND	0,71	0,81	-0,10	ND	0,65	0,67	-0,02	ND	2	R
S19	1,06	0,80	0,26	D	2,36	1,92	0,44	D	1,11	1,18	-0,07	ND	1,46	1,40	0,07	D	0,70	0,91	-0,21	ND	1,74	1,73	0,02	D	0,95	1,27	-0,33	ND	2	R
S20	0,75	0,57	0,18	D	1,45	1,65	-0,20	ND	1,18	1,14	0,04	D	1,72	1,61	0,10	D	0,86	0,70	0,16	D	0,91	0,54	0,37	D	0,77	0,56	0,21	D	4	R
S21	0,60	0,54	0,06	D	1,11	0,93	0,18	D	0,86	1,00	-0,15	ND	0,74	0,55	0,19	D	0,63	0,74	-0,10	ND	1,15	1,26	-0,11	ND	1,04	1,16	-0,12	ND	4	R
S22	0,41	0,65	-0,24	ND	1,28	1,14	0,15	D	1,06	1,27	-0,21	ND	1,96	2,18	-0,22	ND	0,61	0,56	0,04	D	0,55	1,06	-0,51	ND	0,64	0,77	-0,13	ND	4	R
S23	0,43	0,56	-0,13	ND	1,01	1,05	-0,04	ND	0,80	0,84	-0,04	ND	1,49	1,01	0,48	D	0,86	0,96	-0,10	ND	1,19	1,13	0,06	D	0,90	0,93	-0,02	ND	4	R
S24	0,51	0,28	0,23	D	1,50	1,41	0,09	D	1,34	1,48	-0,14	ND	1,70	1,12	0,59	D	1,35	1,20	0,15	D	1,29	1,31	-0,02	ND	1,06	1,17	-0,11	ND	0	R
S25	0,65	0,53	0,12	D	1,56	1,52	0,04	D	1,10	1,11	-0,01	ND	1,32	1,09	0,23	D	0,75	0,86	-0,10	ND	1,06	0,92	0,13	D	1,11	0,82	0,29	D	4	R
S26	0,09	0,25	-0,16	ND	1,61	1,47	0,14	D	1,07	1,15	-0,08	ND	1,67	1,25	0,42	D	0,77	0,94	-0,17	ND	1,09	1,15	-0,06	ND	1,03	1,05	-0,02	ND	4	R
S27	0,27	0,75	-0,47	ND	1,10	1,44	-0,34	ND	0,55	0,66	-0,11	ND	0,67	0,93	-0,26	ND	0,66	0,83	-0,18	ND	0,65	0,99	-0,34	ND	0,57	0,86	-0,29	ND	4	R
S28	0,22	0,58	-0,35	ND	0,83	0,82	0,02	D	0,73	0,73	0,00	D	1,10	1,32	-0,22	ND	1,12	1,01	0,11	D	1,39	1,12	0,28	D	1,32	1,13	0,19	D	4	R
S29	0,59	0,42	0,17	ND	1,46	1,61	-0,15	D	1,24	1,22	0,03	ND	1,53	1,58	-0,06	D	1,22	1,07	0,15	D	1,00	1,31	-0,31	D	1,05	1,22	-0,16	D	-4	L
S30	0,34	0,97	-0,63	D	1,07	1,58	-0,51	D	0,85	0,79	0,06	ND	0,83	1,39	-0,56	D	0,84	1,16	-0,32	D	0,78	1,30	-0,52	D	0,81	1,13	-0,32	D	-4	L
S31	0,15	0,21	-0,06	ND	2,14	1,88	0,26	D	1,76	1,55	0,21	D	1,97	1,41	0,56	D	0,92	0,92	-0,01	ND	0,91	1,31	-0,40	ND	1,06	1,33	-0,27	ND	2	R
S32	0,58	0,13	0,45	ND	1,34	1,07	0,27	ND	0,90	0,97	-0,07	D	1,33	0,73	0,60	ND	0,80	0,67	0,13	ND	0,93	1,00	-0,06	D	0,81	0,95	-0,14	D	-4	L

Table 4. The change of ankle's Dynamic Joint Stiffness of the stiffer ankle, along the three sub-phases of the stance phase of the different task studied

Stiffer Ankle Joint							
	Gait			TSU		Hop	
Subject	CPF	CDF	PPF	CDF	PPF	CDF	PPF
S01	D	ND	ND	D	ND	ND	D
S02	ND	ND	ND	D	D	ND	D
S03	D	D	ND	ND	ND	D	D
S04	D	D	ND	D	ND	ND	ND
S05	D	ND	ND	D	ND	D	ND
S06	ND	D	ND	ND	ND	ND	ND
S07	ND	ND	ND	ND	ND	ND	ND
S08	ND	D	D	ND	ND	ND	ND
S09	D	ND	ND	D	ND	D	ND
S10	ND	D	D	ND	ND	ND	ND
S12	D	D	ND	ND	D	D	ND
S13	D	D	ND	D	ND	D	D
S14	ND	D	D	ND	ND	ND	ND
S15	D	D	ND	D	D	D	D
S16	D	ND	D	ND	ND	ND	ND
S17	ND	ND	ND	D	ND	ND	D
S18	ND	ND	ND	D	ND	ND	ND
S19	D	D	ND	D	ND	D	ND
S20	D	ND	D	D	D	D	D
S21	D	D	ND	D	ND	ND	ND
S22	ND	D	ND	ND	D	ND	ND
S23	ND	ND	ND	D	ND	D	ND
S24	D	D	ND	D	D	ND	ND
S25	D	D	ND	D	ND	D	D
S26	ND	D	ND	D	ND	ND	ND
S27	ND	ND	ND	ND	ND	ND	ND
S28	ND	D	D	ND	D	D	D
S29	ND	D	ND	D	D	D	D
S30	D	D	ND	D	D	D	D
S31	ND	D	D	D	ND	ND	ND
S32	ND	ND	D	ND	ND	D	D
Dom	15 (48%)	19 (61%)	8 (26%)	19 (61%)	9 (29%)	14 (45%)	12 (39%)
Ndom	16 (52%)	12 (39%)	23 (74%)	12 (39%)	22 (71%)	17 (55%)	19 (61%)
Switch D-ND	N/A	5 (16%)	14 (45%)	N/A	13 (42%)	N/A	5 (16%)
Switch ND-D	N/A	9 (29%)	3 (10%)	N/A	3 (10%)	N/A	3 (10%)
No change	N/A	17 (55%)	14 (45%)	N/A	15 (48%)	N/A	23 (74%)
No change along all subphases	6 (19%)			15 (48%)		23 (74%)	

DISCUSSION

Our first assumption was that a different method of variable confrontation could emphasize differences in terms of DJS that could reflect the expected footedness influences on human movement behaviour, something that we fail to observe in our earlier work. Even with the fact that we gain more relation with the use of this method than the traditional one, we still fail to observe those expected differences. Other impressions one can take, is that human movement is both variable at the kinematic and kinetic demonstrations. This gives some emphasis to the idea defended by some authors that footedness can be task dependent (Gabbard & Hart, 1996) as subject's motoric goals influence the level of stiffness a joint need, to allow the fulfilment of that intended motoric goal. As variability of human behaviour is predictable and expected (Atun-Einy, 2016), the notion that the joint stiffness, as measured by DJS, changes along the stance sub-phases, can be a clue to the definition of which tasks can be more suitable for footedness assessment. In our data, we found that DJS was changing along the stance in all three tasks but, some of the subjects could maintain the same lower limb as the stiffer one along all the stance. The higher number of subjects that keep the same lower limb as the stiffer one along all the stance sub-phases was observed in the Hop task. In this task, the same amount of importance needs to be given to the manipulation and support needs, as the subject focus both on supporting the body and to mobilize the foot to achieve the expected jump and the task continuum. The result observed can be in part explained with the complexity of the task itself. Some authors define that laterality is influenced by the task characteristics, and those characteristics can define the preference lower limb may depend on the context or even because of the concurrent task objectives that comprises both stabilization and mobilization needs (Hart & Gabbard, 1998; Peters, 1988).

Considering the concurrent tasks, we can hypothesize that the limb selection is in part due to the subject's thoughts regarding the success in the task performance (Freides, 1978). By other words, it means that the limb selection is related somehow with the subject's feelings regarding what is for him the best limb to achieve what is intended in that task. If so, then a stability strategy should be related in any way, with the stiff limb, as one preferable behaviour should indicate a less or higher stiffness needs. None of those assumptions were supported by our findings as it was observed in tasks with the same needs (TSU and Hop), the fluctuation of the stiffness levels indicate that this behaviour is not stable enough to become a valid assumption. What we can retrieve from this is that Hop demonstrate a more stable relation of limb-stiffness level, information that should be considered in future studies were footedness needs to be assessed.

Even changing the way, the relation between footedness and DJS is assessed, which increase the data relating DJS with footedness, the expected differences in objective measures of human behaviour like DJS fail to be observed. As in our earlier work (Atalaia et al., 2015a, 2015b, 2015c, 2015d; Atalaia & Abrantes, 2015) and in other authors opinion (Grouios et al., 2009; Previc, 1991), footedness can be task dependent (an then we need to consider that the variability is not only observed as kinematic but also as kinetic) or really do not exists at all. Due to its importance in different knowledge fields, defining if footedness exists or not and if it's related to task specificity, will orientate future studies with more samples not from a wider subject's sample but from the same subject as human variability is, in our opinion, subject-specific.

CONCLUSIONS

This method provided more relation then the traditional one but still fail to find significant footedness-related differences on DJS. The variability noticed on DJS along the stance needs more attention, as it can be somewhat related with the footedness concept that is task specific or help to indicate that the footedness does not exists at all. Hop task could be a more suitable task for footedness assessment due to it consistency in the DJS scores along the stance.

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