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OPEN-SOURCE SOFTWARE AS AN ALTERNATIVE MEANS OF BIOMECHANICAL ASSESSMENT

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ABSTRACT. In an attempt to gain more and more resources for dynamic assessment of movement, and especially more accessible ones, we tried to utilize open-source software like kinovea for data extraction and Python for automatization. By using these we can show the ease of creating patterns of investigation, after which further data is simply collected and manipulated on the system created. The best part about having these resources as means for biomechanical assessment is that they are cost free. We broke down the walking cycle into four main stages and extracted the data from those, after which we made it more comprehensible even for the trained naked eye. Video footage was taken from 10 healthy subjects. The hypothesis of this work was thus: If we modify the walking speed we can check out from low intensity to high intensity, we won't see bigger amounts of deviation at ankle level. After analyzing the data collected, we couldn't say that by increasing the walking we also increase the amount of deviation in the ankle

Keywords: *Assessment; Kinovea; open-source; Biomechanics; Python*

REZUMAT. *Software Open-Source ca mijloace alternative de analiză bio–mecanică.* Într-o tentative de a depista și câștiga tot mai multe resurse de analiză biomecanică și mai ales cost eficiente, am încercat să utilizăm mai multe aplicații open-source precum Kinovea pentru colectarea datelor, dar și Python pentru automatizare. Folosindu-ne de acestea putem arăta cât de facil este să creăm șabloane de investigare, după care ne rămâne doar să extragem și manipulăm datele în funcție de obiectivele noastre în cadrul sistemului nou creat. Partea cea mai bună privind aceste mijloace este că sunt absolut gratuite. Am defragmentat ciclul mersului în 4 etape esențiale din care ulterior s-au

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extras datele necesare și au fost gestionate în așa fel încât acestea să devină mai comprehensibile chiar și văzute de un ochi liber neantrenat. Materialul video a fost obținut de la 10 subiecți sănătoși. Ipoteza de lucru presupunea că dacă modificăm de la intensitate mică spre intensitate mare a vitezei de deplasare, pe măsură ce vom crește intensitatea nu vom observa și o creștere a gradului de deviații de la nivelul gleznelor picioarelor. După ce au fost analizate datele colectate, nu putem afirma că prin creșterea vitezei de deplasare în cadrul mersului, favorizăm și introducerea unei cantități de deviere majore la nivelul gleznelor.

Cuvinte-cheie: *evaluare; Kinovea; open-source; biomecanică Python*

INTRODUCTION

Nowadays in the field of human movement regardless of specialty (physical education, sports, physical therapy, medicine etc.), an important aspect that is missing from it is objective yet accessible tools of assessing (Mahadas, Mahadas & Hung 2018). The laboratory is still considered the most valuable means of biomechanical dynamic investigation. The two biggest disadvantages of the lab consist of high cost and rigidity. And by rigidity, I mean the impossible task of investigating movement in the natural environment of where it's occurring (Requena, Requena, García, Villarreal, and Pääsuke 2012).

By being able to capture movement on film in its natural environment, and use open source for data extraction and data analysis, we can reduce the cost of this entire operation and get closer to the results we warrant (Paolino, Zampa 2023). Those results will in themselves mean better decision-making for a broad variety of specialists (Ang, Kong 2013). We can register measurements like length, distance, displacements, time, angles. Using this data, we can further calculate force, velocity, acceleration, mechanical work, power, torque and so on (Liu, Stewart, Wiens, Mcnitt-Gray, Liu 2022).

For data extraction we used Kinovea 0.9.5, an extremely intuitive user-friendly program. It can be calibrated, so that means we don't waste time with tedious camera placing. The data once extracted from the footage is then introduce it into a spreadsheet. We used Excel for the dataset. For operating the data set we used Python, an open source very popular programming language.

Although the experience of a well-seasoned specialist with a lot of training, know-how, intuition is extremely valuable, that alone cannot produce the same level of results for the people the specialist works with. He or she has to use every resource available today in terms of comprehending the individuals and groups that they are working with. If decision-making is based on objective information, then it goes without saying that thing will move towards progress (Van Hooren et all.2019).

1. Walking mechanics

Although when it comes to healthy individuals, walking seems to be to little of a challenge, but for those with walking disfunction (be it from a neurological nature or traumatic), this feat can be tiresome, and quite difficult. Pathological gait can bring the individual to a high-rate energy expenditure so much so that for the same feat, it cost them almost twice the energy or more, as it would a healthy within functional parameters individual (Lovejoy 1981). From a neurological standpoint it can cause difficulties when it comes to motor control, maintaining balance, or in creating the proper patterns for normal walking (Baker 2007).

A healthy walking pattern depends on a series of biomechanical walking traits, led by the central nervous system. But when it suffers and when varied lesions appear here, the result may manifest itself as considerable motor deficits, with detrimental consequences in terms of balance and energy expenditure. Understanding the role of biomechanics within the healthy population with relatively normal walking gait, can give us a better insight and grasp on the deficits in discussion and how to evolve from those (Kuo & Donelan 2009).

2. Goal

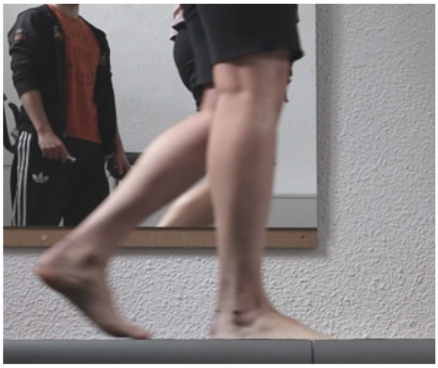
To observe if walking speed influences the amount of deviation in the segments monitored. So, if we were to increase walking speed, we would expect more deviation.

METHODS

1. Subjects

A number of ten healthy adult were monitored in this study. They were filmed in a physical therapy clinic on a basic treadmill. All were healthy within functional parameters, without accusing and prior traumatic incidents for more than a year timespan. For determining the level of plantar and dorsal flexion, the video footage was recorded from a frontal plane, and for determining the level of lateral incline, into either talovalgum or talovarum, the footage was recorded from a sagittal plane posterior wise.

a. Green



b. Red

c. Yellow

d. Blue

Figure 1. a, b, c, d

a

b

Figure 2. a, b

Four key stages (figure 1) were spotlighted and from the four, in two of them, the distances between the two joints were noted also (figure 2).

2. Data Extraction

The program used for extracting the data was Kinovea 0.9.5, in its updated version, the whole process ran smoothly making the actual app very user friendly. Even without prior training, the operator can shortly get the hang of it. It works pretty good even with video footage as low quality as 25FPS (frames per second), but the less errors you'd like to have, the higher frame rate the camera capacities should be. We chose to film with two 50 FPS cameras which were stabilized on tripodes so movement would not compromise or creep errors with the data extraction process (Balsalobre-Fernández, Tejero-González, del Campo-Vecino & Bavaresco 2014).

This program has proven its utility and effectiveness when compared to other either open-source freeware or ones that are purchased. It was used in numerous and varied studies that had their aim in biomechanical analysis (Nor Adnan et all 2018).

The horizontal axis was calibrated in order to extract the data needed for the stages color coded green and yellow, for each of all of the 6 speeds tested. The calibration was made after the total length of the treadmill, that being 142.5 cm (figure 3).

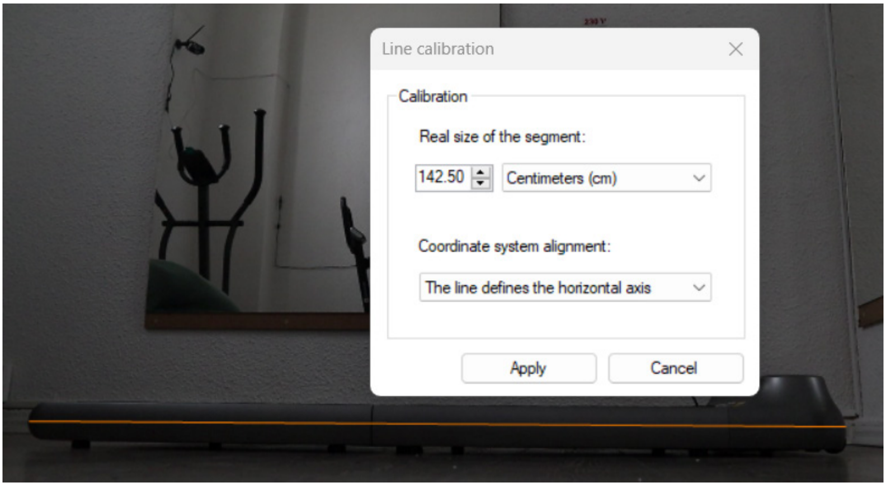
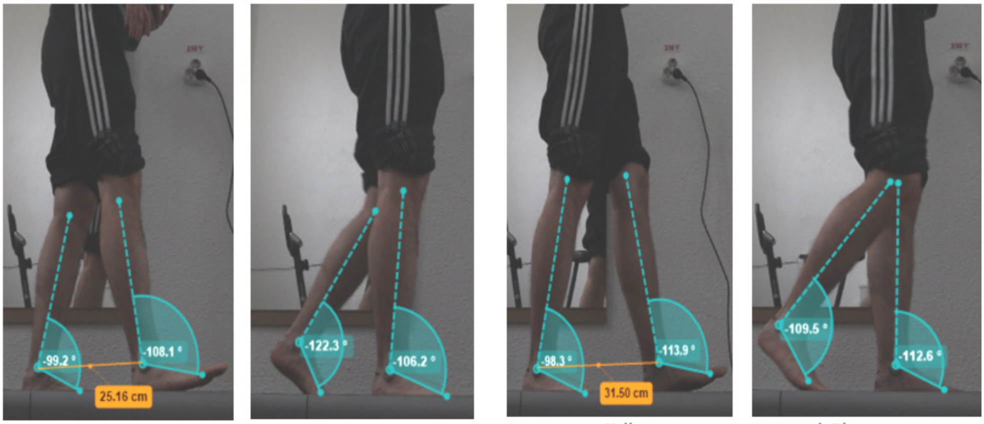


Figure 3. Calibration

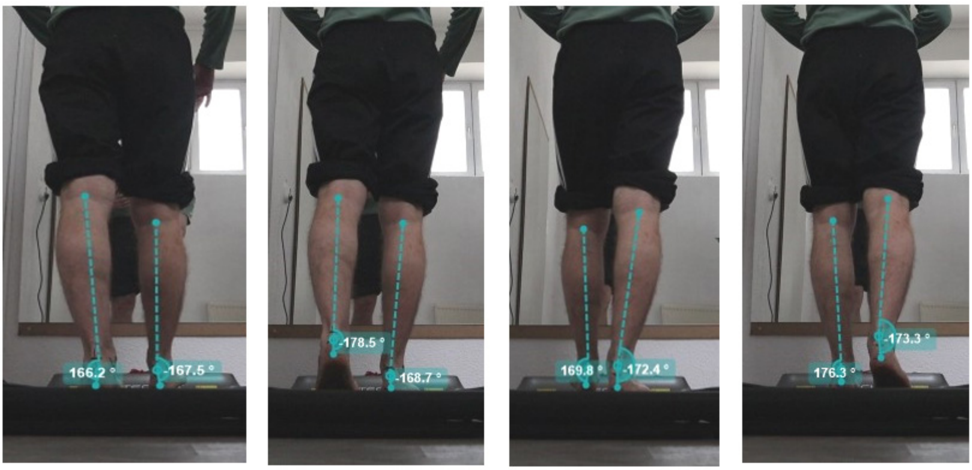
We checked the level of plantar flexion from a frontal plane for each joint in each of the four stages for each of all of the six walking speeds. Thus, the recorded degrees for every color-coded stage: green (figure 4).



a. Green *b. Red* *c. Yellow* *d. Blue*

Figure 4. a, b, c, d

We checked for lateral ankle deviation having a posterior view from a sagittal plane. The recorded degrees for every color-coded stage were: green (figure 5).



a. Green *b. Red* *c. Yellow* *d. Blue*

Figure 5. a, b, c, d

3. Database

We've built the data set in Microsoft Office's Excel. Seeing that the volume of data from the dataset even from such a small number of subjects is so considerable, we needed to manipulate it to make it more manageable (figure 6).

The first two columns will contain the ID and the gender of each subject. The third column will contain the independent variable, the moving speed. Then the later 22 columns will contain the multiple dependent variables.

We color coded the four key stages observed, and from that we had noted in column H the distance between the two ankles from the green stage and the same thing in column Q but for the yellow coded stage.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	ID	Gender	Speed	L Back	L Profile	R Back	R Profile	Distance	L Back	L Profile	R Back	R Profile	L Back	L Profile	R Back	R Profile	Distance	L Back	L Profile	R Back	R Profile	L standing	L swing	R standing	R swing
2	V.P	m	1.00	166.20	98.00	167.50	105.80	24.75	178.50	105.50	168.70	103.30	169.80	113.30	172.40	93.50	27.82	176.30	114.50	173.30	103.20	118.00	41.00	167.00	69.00
3	V.P	m	2.00	179.30	99.40	174.50	99.40	33.64	177.70	112.30	-177.10	107.10	179.10	110.90	171.40	97.30	40.84	178.20	113.40	180.00	108.90	77.00	34.00	73.00	37.00
4	V.P	m	3.00	179.50	97.10	179.10	103.50	38.89	-179.90	111.10	-179.50	108.00	179.00	108.20	172.00	99.40	50.01	-177.00	115.40	176.80	118.90	51.00	34.00	49.00	32.00
5	V.P	m	4.00	179.40	96.20	-178.20	108.00	49.45	-169.00	130.70	178.40	105.40	-177.90	110.80	170.00	97.40	52.22	-179.10	112.30	174.10	125.50	45.00	29.00	42.00	29.00
6	V.P	m	5.00	175.60	99.80	177.50	108.10	53.34	-173.20	117.70	175.80	107.80	179.00	111.40	177.90	112.80	57.89	-178.50	106.40	167.70	119.00	36.00	26.00	35.00	24.00
7	V.P	m	6.00	179.10	103.00	176.90	102.00	58.62	-177.90	131.70	165.70	105.90	-179.00	111.60	175.80	101.30	62.51	-177.10	106.00	-175.80	119.90	31.00	24.00	31.00	23.00
8	I.B	f	1.00	174.80	108.60	173.80	107.30	16.62	-179.10	106.40	178.30	105.40	178.60	113.40	173.90	97.80	18.69	-177.80	108.20	172.20	99.50	63.00	21.00	65.00	23.00
9	I.B	f	2.00	179.60	105.00	178.10	111.60	29.22	177.40	125.10	179.80	107.10	176.50	115.40	177.80	97.40	22.44	-172.60	107.30	170.70	98.50	47.00	21.00	46.00	22.00
10	I.B	f	3.00	176.50	108.80	172.30	105.72	29.21	180.00	113.90	173.60	108.30	179.00	123.70	173.60	108.70	31.74	175.40	113.10	179.90	119.50	36.00	18.00	34.00	19.00
11	I.B	f	4.00	173.40	115.00	173.70	108.20	43.41	176.70	131.90	173.40	104.40	171.60	109.70	172.70	101.70	32.04	179.00	103.30	178.00	117.60	27.00	20.00	29.00	18.00
12	I.B	f	5.00	180.00	105.70	180.00	105.70	40.16	180.00	125.70	175.50	112.30	179.00	123.00	178.50	117.00	46.50	177.60	110.40	-176.50	126.50	27.00	21.00	27.00	17.00
13	I.B	f	6.00	180.00	115.60	174.30	110.80	41.96	180.00	126.00	175.40	104.80	-179.00	126.70	178.00	126.50	49.91	-179.30	100.70	180.00	122.10	21.00	20.00	26.00	18.00
14	M.O	f	1.00	178.10	111.30	178.40	109.60	21.33	-178.70	114.80	173.70	107.10	-178.60	120.10	173.90	99.10	27.86	178.20	118.00	176.40	100.00	103.00	44.00	103.00	46.00
15	M.O	f	2.00	178.40	108.00	-178.00	107.30	33.13	175.20	110.60	178.50	106.40	-173.80	123.40	170.60	100.10	38.89	174.60	121.20	-177.00	98.80	58.00	29.00	55.00	33.00
16	M.O	f	3.00	178.80	104.10	175.70	109.20	37.14	179.20	122.00	173.00	106.70	177.60	113.40	175.70	92.00	41.15	178.30	117.60	-176.90	100.90	45.00	25.00	46.00	25.00
17	M.O	f	4.00	179.50	101.90	177.30	110.30	41.65	-179.60	114.10	178.30	100.80	-178.10	115.20	178.10	92.40	48.94	177.70	117.50	177.30	109.00	36.00	22.00	36.00	25.00
18	M.O	f	5.00	178.20	103.20	177.40	111.50	45.44	179.20	117.30	177.90	103.20	-176.40	117.10	177.80	99.80	54.98	177.90	117.30	-173.30	114.90	33.00	21.00	33.00	23.00
19	M.O	f	6.00	175.30	109.10	-176.90	110.20	52.46	179.90	114.10	178.90	99.50	176.30	123.80	-177.20	101.20	57.25	-177.60	110.60	-176.70	119.50	29.00	20.00	30.00	19.00
20	C.T	m	1.00	178.80	109.10	179.90	106.70	14.35	-175.30	104.80	179.20	102.00	-175.60	119.60	174.90	97.60	18.63	178.40	113.00	175.80	96.80	63.00	34.00	66.00	26.00
21	C.T	m	2.00	177.70	109.70	177.20	109.30	31.52	-164.90	106.20	-179.20	100.90	-177.50	125.30	175.40	103.50	31.18	-178.80	116.70	-162.50	117.40	52.00	22.00	55.00	25.00
22	C.T	m	3.00	177.40	106.90	173.10	110.60	34.29	177.00	101.60	176.90	128.00	177.20	117.90	174.80	101.00	37.20	-177.90	109.50	160.10	116.50	40.00	26.00	42.00	24.00
23	C.T	m	4.00	178.50	110.90	176.40	113.10	39.14	180.00	125.80	179.80	103.90	-175.70	120.00	-178.20	109.90	47.08	179.60	117.60	-174.10	125.10	37.00	23.00	36.00	23.00
24	C.T	m	5.00	177.20	127.50	171.10	108.30	49.72	-176.30	128.90	175.90	104.30	177.10	124.10	180.00	116.90	50.61	179.30	116.80	-179.30	126.80	33.00	21.00	33.00	22.00
25	C.T	m	6.00	177.90	132.20	175.30	106.80	51.87	-160.40	129.60	168.30	103.50	-171.70	118.00	178.50	121.50	57.60	179.90	111.20	173.80	125.50	28.00	20.00	29.00	20.00
26	G.A	m	1.00	179.40	106.30	177.80	111.40	31.42	-178.30	121.30	175.10	112.55	-172.40	118.10	168.30	99.80	23.46	179.80	117.80	177.60	108.10	180.00	50.00	148.00	47.00

Figure 6. Raw dataset

Column V, W, X, and Y represent the total time for an entire walking cycle for each lower limb in part, where V is the total time spent on the ground for the left leg in support phase and W is the total time spent in the air for the left leg in swing phase. The same principle applies for columns X and Y but transferred for the right lower limb. As can simply be observed, these last columns were color coded gray.

To make the data set more accessible using Python for automatization, we converted it into degrees. Since the values obtained are relatively high because of the possibilities of kinovea software, we will take as a neutral reference point the value 180^{o}, and then we shall subtract the value obtained from initial dataset. Thus, we can observe the degree of deviation as it were if they started from 0^{o} (figure 7).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Speed	Lbackgree	Lprofilegre	Rbackgree	Rprofilegre	Lbackred	Lprofilered	Rbackred	Rprofilere	Lbackyello	Lprofileyel	Rbackyello	Rprofileye	Lbackblue	Lprofileblu	Rbackblue	Rprofileblue
2	1	13.8	12.5	8	15.8	1.5	11.3	15.5	13.3	10.2	7.6	23.3	3.5	3.7	6.7	24.5	13.2
3	2	0.7	5.5	9.4	9.4	2.3	2.9	22.3	17.1	0.9	8.6	20.9	7.3	1.8	0	23.4	18.9
4	3	0.5	0.9	7.1	13.5	0.1	0.5	21.1	18	1	8	18.2	9.4	3	3.2	25.4	28.9
5	4	0.6	1.8	6.2	18	11	1.6	40.7	15.4	2.1	10	20.8	7.4	0.9	5.9	22.3	35.5
6	5	4.4	2.5	9.8	18.1	6.8	4.2	27.7	17.8	1	2.1	21.4	22.8	1.5	12.3	16.4	29
7	6	0.9	3.1	13	12	2.1	14.3	41.7	15.9	1	4.2	21.6	11.3	2.9	4.2	16	29.9
8	1	5.2	6.2	18.6	17.3	0.9	1.7	16.4	15.4	1.4	6.1	23.4	7.8	2.2	7.8	18.2	9.5
9	2	0.4	1.9	15	21.6	2.6	0.2	35.1	17.1	3.5	2.2	25.4	7.4	7.4	9.3	17.3	8.5
10	3	3.5	7.7	18.8	15.72	0	6.4	23.9	18.3	1	6.4	33.7	18.7	4.6	0.1	23.1	29.5
11	4	6.6	6.3	25	18.2	3.3	6.6	41.9	14.4	8.4	7.3	19.7	11.7	1	2	13.3	27.6
12	5	0	0	15.7	15.7	0	4.5	35.7	22.3	1	1.5	33	27	2.4	3.5	20.4	36.5
13	6	0	5.7	25.6	20.8	0	4.6	36	14.8	1	2	36.7	36.5	0.7	0	10.7	32.1
14	1	1.9	1.6	21.3	19.6	1.3	6.3	24.8	17.1	1.4	6.1	30.1	9.1	1.8	3.6	28	10
15	2	1.6	2	18	17.3	4.8	1.5	20.6	16.4	6.2	9.4	33.4	10.1	5.4	3	31.2	8.8
16	3	1.2	4.3	14.1	19.2	0.8	7	32	16.7	2.4	4.3	23.4	2	1.7	3.1	27.6	10.9
17	4	0.5	2.7	11.9	20.3	0.4	1.7	24.1	10.8	1.9	1.9	25.2	2.4	2.3	2.7	27.5	19
18	5	1.8	2.6	13.2	21.5	0.8	2.1	27.3	13.2	3.6	2.2	27.1	9.8	2.1	6.7	27.3	24.9
19	6	4.7	3.1	19.1	20.2	0.1	1.1	24.1	9.5	3.7	2.8	33.8	11.2	2.4	3.3	20.6	29.5
20	1	1.2	0.1	19.1	16.7	4.7	0.8	14.8	12	4.4	5.1	29.6	7.6	1.6	4.2	23	6.8
21	2	2.3	2.8	19.7	19.3	15.1	0.8	16.2	10.9	2.5	4.6	35.3	13.5	1.2	17.5	26.7	27.4
22	3	2.6	6.9	16.9	20.6	3	3.1	11.6	38	2.8	5.2	27.9	11	2.1	19.9	19.5	26.5
23	4	1.5	3.6	20.9	23.1	0	0.2	35.8	13.9	4.3	1.8	30	19.9	0.4	5.9	27.6	35.1
24	5	2.8	8.9	37.5	18.3	3.7	4.1	38.9	14.3	2.9	0	34.1	26.9	0.7	0.7	26.8	36.8
25	6	2.1	4.7	42.2	16.8	19.6	11.7	39.6	13.5	8.3	1.5	28	31.5	0.1	6.2	21.2	35.5
26	1	0.6	2.2	16.3	21.4	1.7	4.9	31.3	22.55	7.6	11.7	28.1	9.8	0.2	2.4	27.8	18.1

Figure 7. Converted dataset into simpler degrees

4. Data analysis

Once the new data set is created, it will be coded once more into python. This new coding framework will use simple digits (figure 8). Regardless of direction of deviation, for angles within 0^{o}-9.99^{o} the code attributed shall be 1. For 10^{o}-24.99^{o}, the code attributed shall be 2, and lastly for $\geq 25^{o}$ the code attributed shall be 3.

This third new dataset will again be color coded this time into Excel for each of the three codes. For 1 (0^{o}-9.99^{o}) we used green, for 2 (10^{o}-24.99^{o}) we used yellow and for 3 ($\geq 25^{o}$) we used red.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Speed	Lbackgr	Lprofile	Rbackgr	Rprofile	Lbackre	Lprofile	Rbackre	Rprofile	Lbackye	Lprofile	Rbackye	Rprofile	Lbackbl	Lprofile	Rbackbl	Rprofile
2	1	2	2	1	2	1	2	2	2	1	1	2	1	1	1	2	2
3	2	1	1	1	1	1	1	2	2	1	1	2	1	1	1	2	2
4	3	1	1	1	2	1	1	2	2	1	1	2	1	1	1	2	3
5	4	1	1	1	2	2	1	3	2	1	1	2	1	1	1	2	3
6	5	1	1	1	2	1	1	3	2	1	1	2	2	1	2	2	3
7	6	1	1	2	2	1	2	3	2	1	1	2	2	1	1	2	3
8	1	1	1	2	2	1	1	2	2	1	1	2	1	1	1	2	1
9	2	1	1	2	2	1	1	3	2	1	1	2	1	1	1	2	1
10	3	1	1	2	2	1	1	2	2	1	1	3	2	1	1	2	3
11	4	1	1	2	2	1	1	3	2	1	1	2	2	1	1	2	3
12	5	1	1	2	2	1	1	3	2	1	1	3	3	1	1	2	3
13	6	1	1	2	2	1	1	3	2	1	1	3	3	1	1	1	3
14	1	1	1	2	2	1	1	2	2	1	1	3	1	1	1	3	1
15	2	1	1	2	2	1	1	2	2	1	1	3	1	1	1	3	1
16	3	1	1	2	2	1	1	3	2	1	1	2	1	1	1	3	1
17	4	1	1	2	2	1	1	2	1	1	1	2	1	1	1	3	2
18	5	1	1	2	2	1	1	3	2	1	1	3	1	1	1	3	2
19	6	1	1	2	2	1	1	2	1	1	1	3	2	1	1	2	3
20	1	1	1	2	2	1	1	2	2	1	1	3	1	1	1	2	1
21	2	1	1	2	2	2	1	2	1	1	1	3	2	1	2	3	3
22	3	1	1	2	2	1	1	2	3	1	1	3	2	1	2	2	3
23	4	1	1	2	2	1	1	3	2	1	1	3	2	1	1	3	3
24	5	1	1	3	2	1	1	3	2	1	1	3	3	1	1	3	3
25	6	1	1	3	2	2	2	3	2	1	1	3	3	1	1	2	3
26	1	1	1	2	2	1	1	3	2	1	2	3	1	1	1	3	2
27	2	1	1	2	2	1	1	3	2	1	1	2	2	1	1	2	3

Figure 8. The 1,2 & 3 codes for degrees of deviationi

In simple terms, following the variables this way, we can easily see the colored representation, of how speed influences the amount of deviation. If the influence truly exists, we should see that once we raise the walking speed, we shall move from green to yellow or even red. So, it is fairly simple to see the utility of handling the data as such

What is also extraordinarily useful in this whole process is the utility of the programing language interface, having implemented the lines already and the pattern being established, whenever I introduce new data, al the conversions that were previously made, will be automatically be done. So that is beneficial for us as specialists because this greatly reduces time and energy costs. This is a relatively small database, but if we were to continue adding to it and have a big database, without having such resources at our disposal, our work could be greatly impeded.

5. Statistics

The statistical package for the social sciences (SPSS) version IBM SPSS Statistics 20, was of great use for visual graphics as well as for the tests (Yang, Zhao, Liu, Zhou & Zhao 2015).

For testing normality of variable distribution, we used the Shapiro Wilk test. Seeing that the significance reveals a value of under 0.005 for every analyzed dependent variable (Donlin, Pariser, Downer 2022), skewness and kurtosis calculations were necessary. These aspects offer a perspective on the width of distribution. But these, however, do not offer us any information regarding characteristics of the shape of distribution frequency.

In the used tests for the normality of dependent variables distribution, we found out that it presents itself as ellipsoid, hence the skewness and kurtosis calculations. If values go above +1.0 are skewed right and the ones that go under -1.0 are skewed left. Those closer to 0 we cand say that they don't present themselves skewed. For kurtosis, values that go above +1.0 are called leptokurtic and values that go under -1.0 are called platykurtic, and closer to 0 we do not have kurtosis (Barrett, Mills & Begg 2010).

The main purpose of the multivariate analysis is to establish if every level of the independent variable, meaning that the walking speeds from 1 to 6 km/h, have a statistically significant effect on any or all of the dependent variables, which constitutes the deviations from ankle level.

"Pillai's Trace" represents a value from 0 to 1. The closer you get to 1 the more we can state that the independent variable has an effect on the dependent variable.

Seeing the variables do not find themselves in a linear relationship and the values are not normally distributed, the correlation test chosen was Spearman.

RESULTS

Out of 16 variables, 8 present themselves visibly skewed to right, 1 to left, and the other 6 either to left or right only closer normal compared to the first 9. Now when we tested kurtosis, we found out that from the 16 variables, for 10 of them we will se that they will have a bigger tail, so they are leptokurtic. Another 3 will be platykurtic and the last 3 will get closer to normal when compared to the previous ones.

In “Pillai’s Trace” analysis, we observe that the value has a significance of 0.230. It is obvious that it is not enough to be able to state that our independent variable is not without effect on the dependent variable.

Because the dependent variable distribution was not linear, we used Spearman’s test, for establishing a correlation. Only 3 values proved a moderate relationship within 0.40. and 0.69. The rest of the variables did not show any strong relationship with the other variables. But this can be clearly observed by any specialist with experience by just watching the color coded “1,2,3” values tables.

DISCUSSION

Having considered the results of the statistical analysis the null hypothesis can be dismissed. So, we cannot state that just by raising walking speed, we increase the amount of ankle deviations.

The most important part after establishing this pattern of work, is that just by introducing new data, everything is automatized and the values shall be converted instantly. This is the benefit of having honed automatization in any programing language skills.

If the markers, as anatomical landmarks, are placed correct, the work for anyone that extracts data in the whole process gets greatly improved (Fernández-González, P., et all 2020).

In future studies it would be interesting to check out if by introducing another independent variable such as the subject’s comfort zone and establishing if that between this and the degree of ankle deviation as well as a comparison between it and the remaining other walking speed.

CONCLUSIONS

In this whole endeavor we have shown that just by utilizing accessible resources, that just cost you time, but not necessarily more financial ones, we can obtain a more objective tool for assessment, even comparable to other ones already on the market. We see an importance in alphabetizing movement specialists in creating, using, and improving these tools. Once we get to that stage the existing limits of all existing products will start to disappear, because new functions and patterns will always be conceived and implemented. Thus, every new study and work in this direction may lead to a torrent of new questions and investigations.

LIMITATIONS

Although we mostly achieved what we set out to do, there were inevitable limitations. The subject sample was fairly small, even though the dataset was considerable. In future studies this volume must increase considerably.

Also walking was monitored on a treadmill. This always inhibits results if we want to consider closer to "normal" conditions. But on the other part of this equation, having the test of an "in-field" walk would greatly impair our chances to control for speed intensity and the constancy of the exercise.

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