

An Assessment of the Hip Muscular Imbalance for Patients with Rheumatism

Anthony Bawa, Konstantinos Banitsas

Abstract—Rheumatism is a muscular disorder that affects the muscles of the upper and lower limbs. This condition could potentially progress to impair the movement of patients. This study aims to investigate the hip muscular imbalance in patients with chronic rheumatism. A clinical trial involving a total of 15 participants, made up of 10 patients and five control subjects, took place in KATH Hospital between August and September. Participants recruited for the study were of age 54 ± 8 years, weight 65 ± 8 kg, and height 176 ± 8 cm. Muscle signals were recorded from the rectus femoris, and vastus lateralis on the right and left hip of participants. The parameters used in determining the hip muscular imbalances were the maximum voluntary contraction (MVC%), the mean difference, and hip muscle fatigue levels. The mean signals were compared using a t-test, and the metrics for muscle fatigue assessment were based on the root mean square (RMS), mean absolute value (MAV) and mean frequency (MEF), which were computed between the hip muscles of participants. The results indicated that there were significant imbalances in the muscle coactivity between the right and left hip muscles of patients. The patients' MVC values were observed to be above 10% when compared with control subjects. Furthermore, the mean difference was seen to be higher with $p > 0.002$ among patients, which indicated clear differences in the hip muscle contraction activities. The findings indicate significant hip muscular imbalances for patients with rheumatism compared with control subjects. Information about the imbalances among patients will be useful for clinicians in designing therapeutic muscle-strengthening exercises.

Keywords—Muscular, imbalances, rheumatism, hip.

I. INTRODUCTION

NEUROMUSCULAR diseases represent a group of heterogeneous muscle diseases which include motoneuron disorder of the motor nerve, the peripheral nerve of the neuromuscular transmission disorder, and other muscle diseases [1], [2]. These muscular diseases are quite prevalent among elderly people. The progression of neuromuscular diseases could vary considerably which results in a range of muscle weakness, pain, sensory loss, and automatic dysfunction [3]. Similarly, rheumatism which is quite common for adults above 50 years [4] tends to affect the tendon, joints, muscles, bones, and ligaments which may impair movement. Patients with rheumatic conditions such as osteoarthritis (OA), rheumatoid arthritis (RA), and ankylosis spondylitis could potentially suffer from limited mobility. A reduction in muscle function and functional capacity is quite common among patients with OA of the hip and knee joints [5]. Additionally, rheumatism is also a distortion in the function of the arms and

hip muscles which is associated with muscle weakness. Normally, the muscle on each side of the human body is symmetrical in terms of strength and size but a distortion may create muscular imbalance. Muscle imbalance occurs when one or more muscles on one side of the human body are either stronger, smaller, or weaker when compared with the corresponding muscle on the other side [6]. Muscle imbalance may be due to inactivity, natural development, daily routine activity, injury, or improperly conducting exercises. Furthermore, muscle imbalance could occur when the agonist muscle (primary movers) is outweighed by the antagonist.

Some studies done previously compare muscle activity to determine muscle imbalance among patients and athletes. Wojdala et al. [7] compared the muscle activity between control (CONT) subjects and sling shout assisted (SSA) individuals in a barbell bench press exercise. A post hoc analysis indicated a decrease in the MVC for the SS when compared to the control. Also, Jorge et al. [8] investigated the existence of isokinetic muscle imbalance of professional athletes in various modalities. The results obtained from the comparative analysis indicated that, the Bilateral difference (BD) of the lower limbs were within normal values ($< 10\%$) among the athletics. Alizadehkhayat et al. [9] proposed the combination of fire-wire and surface EMG tools for determining muscle imbalance. The forearm, shoulder, and the wrist muscles were used in determining muscular imbalance for tennis athletes. The MVC at 50% was recorded and analyzed using the median frequency slope as the fatigue assessment indicator. In a similar study, Arab et al. [10] investigated hip abductor weakness for people with low back pain. The hip abductor's muscle strength was compared for subjects with and without lower back pain. A post hoc analysis of muscles indicated that the hip abductor muscle strength was significantly lower among people with lower back pain when compared with those without. Nadter et al. [11] examined the relationship between hip muscle imbalance of the lower back pain among athletes. The findings validated previous studies that affirm hip muscle imbalance associated with lower back pain. A study by Hortobagyi et al. [12] compared the hamstring to quadriceps muscle activities for patients with and without knee OA. The results indicated that patients with knee OA had significantly lower muscle coactivity when compared to the age-matched control.

Currently, to the best of our knowledge there is no available study that has investigated hip muscular imbalances for patients with rheumatism.

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II. MATERIALS AND METHODS

A. Participants

In total, 15 participants made up of 10 patients with chronic rheumatism and five control subjects were recruited from Komfo Anokye teaching hospital in Ghana. The patients were made up of eight females and two males, while the control subjects were three females and two males. The statistics of participants were, age 54 years \pm 7 years, height 175 cm \pm 8 cm, weight 65 kg \pm 12 kg. The participants who met the inclusion criteria did not have any physical injury or deformity. Ethical approval was given by Brunel University London and Komfo Anokye teaching hospital in Ghana.

B. Testbed for Data Collection

Delsys Trigno Avanti EMG sensor was used for the muscle signal data collection. The Avanti sensor provides a flexible and wireless measurement of the high-quality surface EMG signal. It can also provide signal of motion detection via an onboard IMU. The sensor is developed to work with a Trigno Base Station which can be used with Delsys Avanti Android app through a Bluetooth connection. The bandwidth is between 10-850 Hz, and it has 11 mV range [13].

The rectus femoris (RF) and the vastus lateralis (VL) were the specific hip muscles measured. The hair on the hip muscle was shaved and cleaned with muslin to give the sensors accurate readings. The EMG sensors were placed on the right and left hips of the participants concurrently. Participants were first taken through a pre-trial phase before conducting the real exercises. The analysis was based on an average of two successful trials conducted by participants in the gait and knee lifting exercises.

C. Signal Processing and Analysis

The electromyography signals captured from the hip muscles were sampled at 1000 Hz. The signals were processed and filtered using the band pass filter between 20 Hz and 450 Hz, which gives an effective function of the muscle and removes powerline noise [14]. The RMS, MAV, and MEF were used to determine muscle fatigue [15]. The maximum voluntary isometric contraction is the standard method for measuring muscle strength for patients with neuromuscular disease [16]. The MVC at 100% was recorded for the hip muscles. Fast Fourier Transform was conducted for the power spectrum analysis of the recorded EMG signals. SPSS v26 statistical package was used where mean values of the hip muscles were compared using a t-test.

III. RESULTS

In Table I, the mean signal values, the MVC, and mean difference (MD) were computed for the RF and VL from the participants. The statistical difference between the right and left hip muscles were compared using a t-test with $p < 0.001$ in Table I. The MD was calculated as the side-to-side difference for muscle on the right hip and its corresponding muscle on the left hip. This was given by:

$$MD = MRH - MLH \quad (1)$$

where, MRH represents the right hip while MLH is the mean left hip. The mean values of the RF on the right hip (MRH) were subtracted from the left hip (MLH). A positive (+) value indicates the right hip mean value was greater compared to the left hip while a negative (-) value indicates the opposite. The average MVC% on the RH and LH were plotted in Figs. 1 and 2.

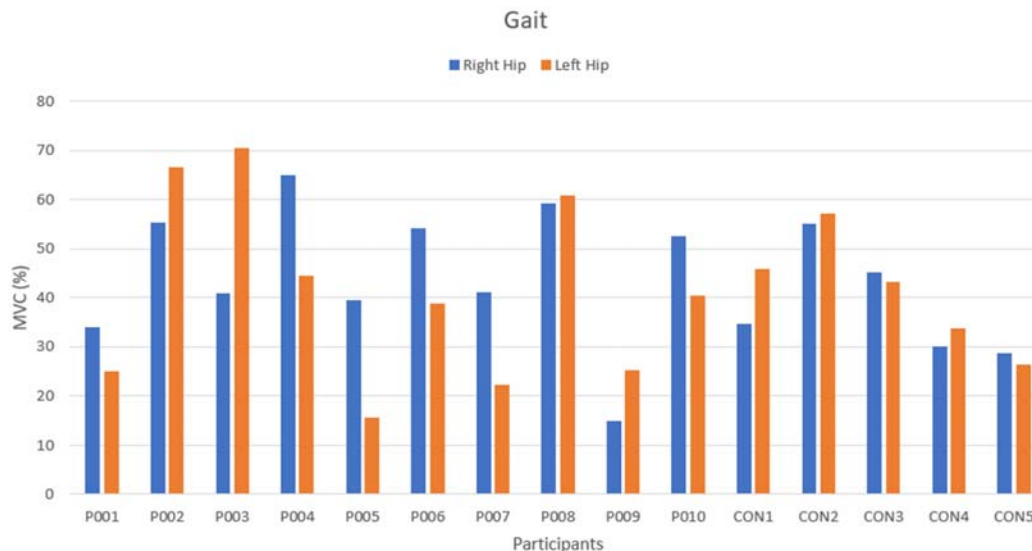


Fig. 1 MVC Graph of Gait

TABLE I
 SUMMARY OF THE HIP MUSCLES MEASUREMENT

ID	Exercise	M_Right Hip (RF)	MVC	M_Left Hip (RF)	MVC	MD	M_Right Hip (RF)	MVC	M_Left Hip (VL)	MVC	MD	Avg MVC RH LH
P001	Gait	0.0056	35.89	0.0002	16.67	0.0036	0.0047	31.97	0.0005	33.30	0.0042	33.93 > 24.98
	Knee Lift	0.0052	34.21	0.0010	9.09	0.0042	0.0062	38.27	0.0008	44.54	0.0054	36.24 > 25.81
P002	Gait	0.0152	60.31	0.0210	68.74	-0.0058	0.0102	50.49	0.0154	64.62	-0.0052	55.4 < 66.68
	Knee Lift	0.0102	50.49	0.0263	72.45	-0.0161	0.0145	59.18	0.0220	68.75	-0.0181	54.84 < 70.60
P003	Gait	0.0107	51.69	0.0257	71.98	-0.015	0.0043	30.07	0.0224	69.13	-0.0184	40.88 < 70.55
	Knee Lift	0.0105	50.25	0.0124	65.35	-0.0022	0.0107	51.69	0.0254	64.03	-0.0147	50.95 < 65.08
P004	Gait	0.0241	70.67	0.0415	72.58	-0.0174	0.0147	59.51	0.0178	16.54	-0.0031	65.09 > 44.56
	Knee Lift	0.0156	60.93	0.0243	65.84	-0.0102	0.0056	45.89	0.0152	15.31	-0.0096	53.41 > 40.56
P005	Gait	0.0054	35.06	0.0017	14.52	0.0026	0.0079	44.13	0.0020	16.67	0.0059	39.60 > 15.59
	Knee Lift	0.0038	27.53	0.0012	10.71	0.0057	0.0078	37.18	0.0015	13.04	0.0063	32.35 < 11.89
P006	Gait	0.0253	71.67	0.0196	66.21	0.0031	0.0095	36.86	0.0013	11.50	0.0082	54.26 > 38.85
	Knee Lift	0.0182	64.53	0.0151	60.15	0.0034	0.0086	32.26	0.0005	10.22	0.0062	63.39 < 35.32
P007	Gait	0.0059	37.10	0.0021	29.34	0.0038	0.0082	45.05	0.0018	15.25	0.0064	41.07 > 22.30
	Knee Lift	0.0046	31.50	0.0025	34.00	0.0021	0.0053	34.64	0.0015	13.04	0.0038	33.07 > 23.50
P008	Gait	0.0102	50.49	0.0212	67.94	-0.011	0.0208	67.53	0.0116	53.70	-0.0092	59.21 > 60.82
	Knee Lift	0.0118	54.12	0.0322	76.30	-0.0204	0.0258	72.05	0.0124	55.35	-0.0137	63.08 > 65.82
P009	Gait	0.0020	16.67	0.0032	24.25	-0.0012	0.0015	13.04	0.0036	26.47	-0.0021	14.86 > 25.36
	Knee Lift	0.0036	26.47	0.0045	31.03	-0.0009	0.0029	22.48	0.0047	31.97	-0.0018	24.48 < 31.50
P010	Gait	0.0158	65.24	0.0107	43.69	0.0051	0.0067	40.12	0.0059	37.10	0.0008	52.68 > 40.39
	Knee Lift	0.0142	58.67	0.0069	40.83	0.0073	0.0098	49.48	0.0087	46.52	0.0011	54.08 > 43.32
CON1	Gait	0.0054	35.06	0.0067	40.12	-0.0013	0.0052	34.21	0.0106	51.45	0.0012	34.63 < 46.03
	Knee Lift	0.0082	45.05	0.0091	47.63	-0.0009	0.0058	36.75	0.0127	55.94	-0.0069	40.9 < 51.78
CON2	Gait	0.0112	52.83	0.0126	55.75	0.0014	0.0136	57.62	0.0143	58.84	-0.0007	55.23 > 57.29
	Knee Lift	0.0126	54.75	0.0115	53.48	0.0006	0.0108	51.92	0.0121	54.75	-0.0013	53.34 < 54.12
CON3	Gait	0.0090	47.36	0.0085	45.94	0.0014	0.0076	43.18	0.0068	40.48	0.0008	45.27 < 43.21
	Knee Lift	0.0056	38.54	0.0045	35.03	-0.0012	0.0062	39.27	0.0058	36.70	0.0004	38.90 < 35.86
CON4	Gait	0.0044	30.55	0.0058	36.70	-0.0010	0.0035	29.67	0.0018	15.42	0.0007	30.12 < 33.86
	Knee Lift	0.0038	25.82	0.0052	25.37	-0.0014	0.0048	32.43	0.0031	23.66	0.0017	29.13 < 24.51
CON5	Gait	0.0035	25.92	0.0032	24.25	0.0003	0.0046	31.50	0.0040	28.57	0.0006	28.71 > 26.41
	Knee Lift	0.0041	35.06	0.0029	22.48	0.0012	0.0072	42.86	0.0061	37.88	0.0011	38.46 > 30.18

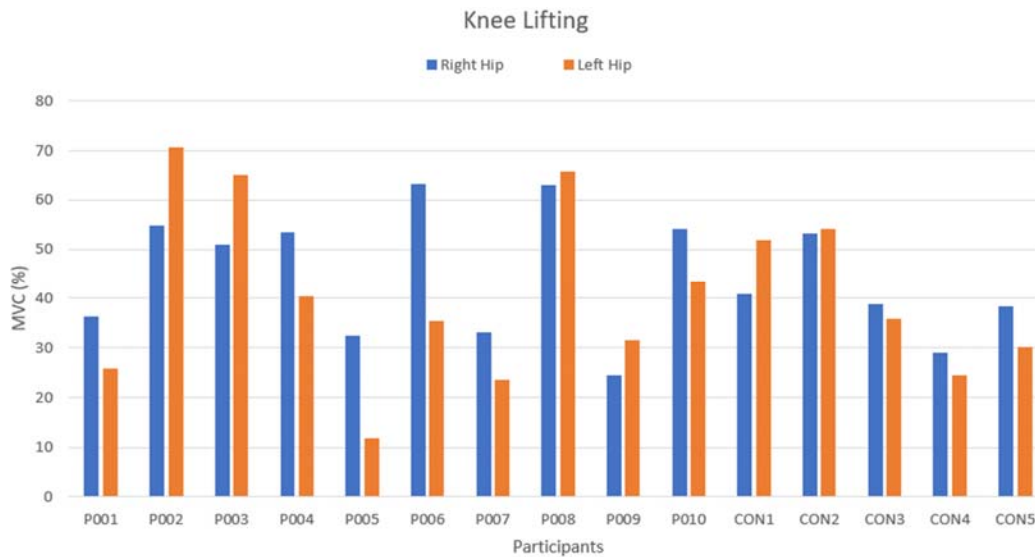


Fig. 2 MVC Graph of Knee Lifting

TABLE II
 METRICS FOR MUSCLE FATIGUE ASSESSMENT

ID	Exercise	Right Hip (RF) RMS	Right Hip (RF) MAV	Right Hip (RF) MEF	Left Hip (LF) RMS	Left Hip (LF) MAV	Left Hip (LF) MEF	Right Hip (VL) RMS	Right Hip (VL) MAV	Right Hip (VL) MEF	Left Hip (VL) RMS	Left Hip (VL) MAV	Left Hip (VL) MEF
P001	Gait	0.012	0.006	86.20	0.003	0.012	54.68	0.010	0.009	75.68	0.015	0.016	56.79
	Knee Lift	0.011	0.018	75.26	0.015	0.016	46.42	0.013	0.022	67.30	0.019	0.015	67.35
P002	Gait	0.015	0.012	26.32	0.004	0.005	92.40	0.011	0.002	61.86	0.024	0.021	50.24
	Knee Lift	0.010	0.017	83.27	0.018	0.015	47.82	0.012	0.017	72.84	0.017	0.025	59.79
P003	Gait	0.015	0.014	28.52	0.022	0.016	92.43	0.010	0.018	51.34	0.024	0.022	61.86
	Knee Lift	0.010	0.008	48.27	0.014	0.006	87.35	0.016	0.014	64.28	0.022	0.009	64.28
P004	Gait	0.011	0.012	44.81	0.016	0.012	59.47	0.004	0.010	48.97	0.018	0.018	75.78
	Knee Lift	0.013	0.007	72.78	0.021	0.009	46.56	0.014	0.008	58.84	0.012	0.015	54.45
P005	Gait	0.034	0.009	60.62	0.002	0.011	75.52	0.029	0.007	27.31	0.011	0.016	30.42
	Knee Lift	0.010	0.012	92.87	0.008	0.025	74.15	0.015	0.015	80.24	0.026	0.014	62.60
P006	Gait	0.025	0.020	58.15	0.019	0.017	26.12	0.009	0.016	61.94	0.010	0.012	69.17
	Knee Lift	0.024	0.018	52.76	0.015	0.016	28.59	0.017	0.012	57.65	0.018	0.015	52.43
P007	Gait	0.001	0.010	84.68	0.021	0.012	45.71	0.009	0.017	67.78	0.012	0.019	60.59
	Knee Lift	0.004	0.012	59.64	0.010	0.019	95.06	0.014	0.024	68.54	0.005	0.018	64.17
P008	Gait	0.042	0.021	23.07	0.011	0.018	27.30	0.016	0.016	120.58	0.022	0.012	92.64
	Knee Lift	0.008	0.007	82.56	0.032	0.012	75.46	0.018	0.015	64.94	0.008	0.021	51.90
P009	Gait	0.003	0.015	67.84	0.015	0.021	77.06	0.034	0.010	35.74	0.002	0.015	68.15
	Knee Lift	0.011	0.028	68.64	0.042	0.022	72.65	0.004	0.008	58.40	0.004	0.009	81.90
P010	Gait	0.010	0.016	47.40	0.008	0.010	85.92	0.036	0.017	62.69	0.011	0.012	65.04
	Knee Lift	0.015	0.012	74.95	0.007	0.005	87.46	0.012	0.015	75.78	0.018	0.008	51.90
CON1	Gait	0.010	0.004	78.24	0.008	0.006	85.92	0.007	0.005	94.85	0.011	0.006	71.02
	Knee Lift	0.009	0.011	94.26	0.015	0.010	82.25	0.008	0.008	78.12	0.005	0.009	65.90
CON2	Gait	0.011	0.008	89.45	0.012	0.007	90.67	0.009	0.012	120.60	0.007	0.007	84.69
	Knee Lift	0.014	0.007	105.56	0.020	0.010	110.72	0.011	0.009	80.58	0.015	0.012	78.52
CON3	Gait	0.009	0.006	90.24	0.010	0.004	112.85	0.005	0.005	95.46	0.007	0.007	90.72
	Knee Lift	0.007	0.011	85.46	0.005	0.006	80.46	0.006	0.005	78.56	0.004	0.005	82.54
CON4	Gait	0.005	0.003	75.26	0.007	0.002	86.25	0.007	0.006	87.82	0.006	0.004	79.56
	Knee Lift	0.003	0.005	82.83	0.002	0.006	62.53	0.005	0.004	76.97	0.007	0.007	82.07
CON5	Gait	0.008	0.004	82.75	0.001	0.005	86.25	0.009	0.003	87.12	0.012	0.004	84.72
	Knee Lift	0.005	0.009	75.21	0.004	0.007	76.30	0.008	0.011	80.32	0.005	0.008	87.18

In Table II, the RMS, MAV, and MEF for the RF and VL on the right and left hip were calculated for each exercise. These metrics were used to measure muscle fatigue levels to

determine muscular imbalances. In assessing muscle fatigue, higher RMS and MAV values show higher muscle exertion [17], while lower MEF shows higher muscle fatigue levels [18].

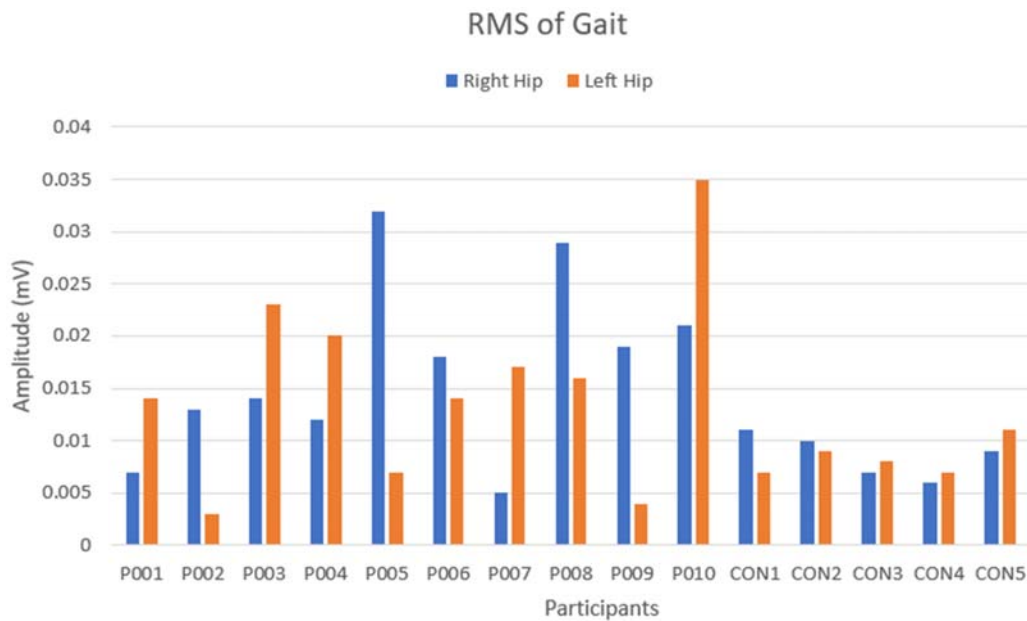


Fig. 3 RMS Graph of Gait

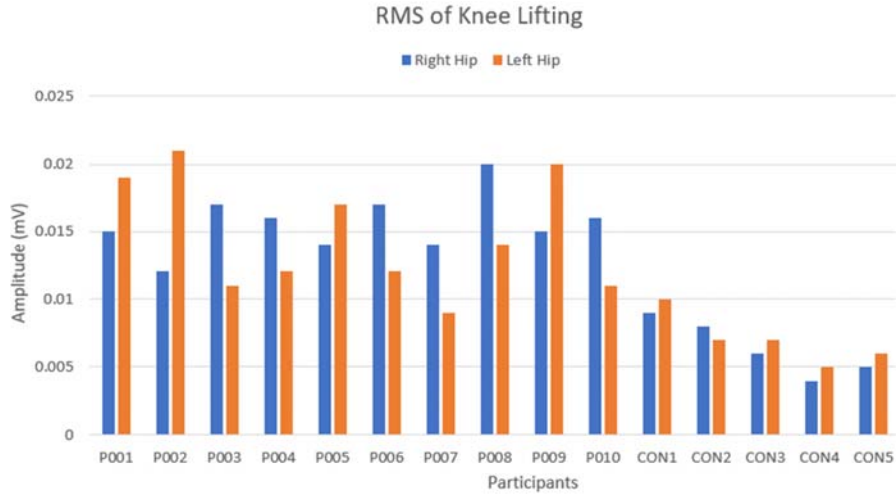


Fig. 4 RMS Graph of Knee Lifting

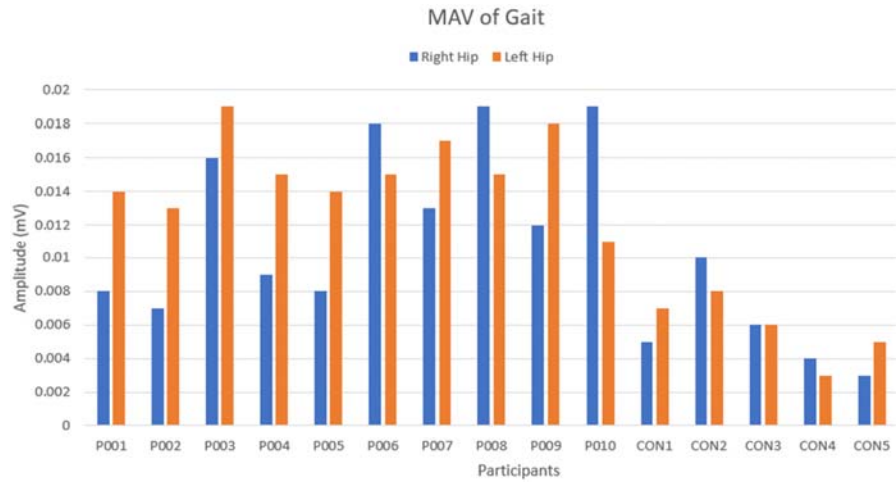


Fig. 5 MAV of Gait

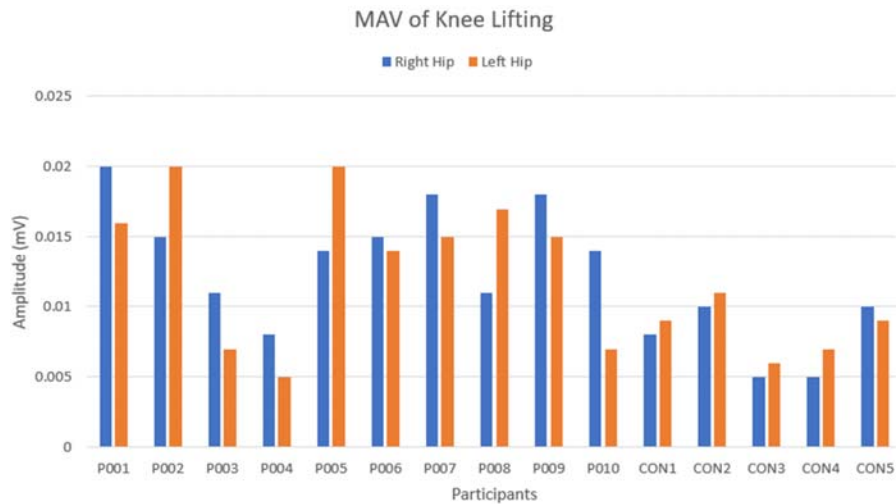


Fig. 6 MAV of Knee Lifting

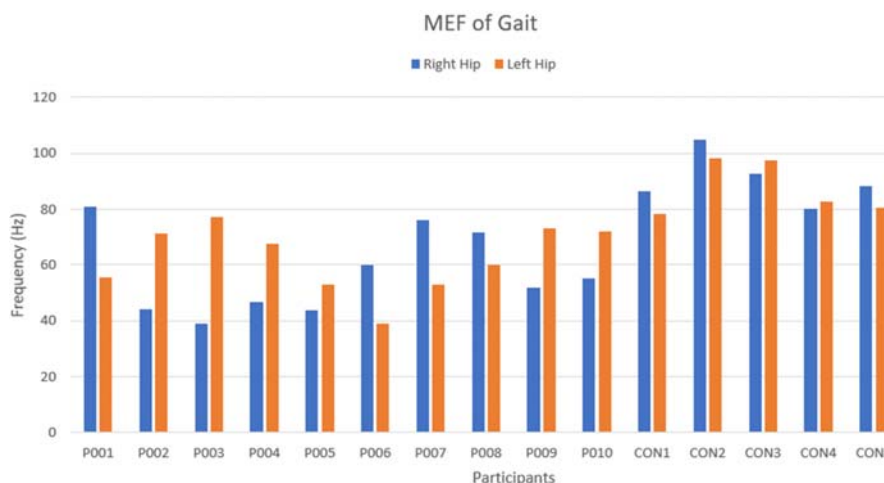


Fig. 7 MEF of Gait

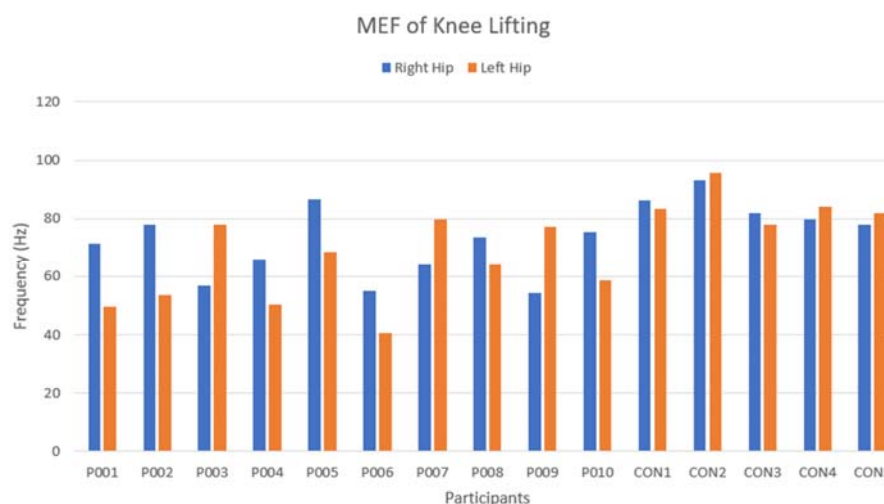


Fig. 8 MEF of Knee Lifting

IV. DISCUSSION

The aim of the study was to investigate the hip muscular imbalance for patients with rheumatism compared to control subjects. We considered three parameters in determining the hip muscle imbalances which were the MD, MVC and the fatigue muscle levels. From Table I, we observed that patients had the MVC difference between the right and left hip to be well above 10%. Therefore, the muscle strength between the right hip and the left hip were disproportionate. They were significant imbalances between the hip muscles for all patients except for patient with ID P008. With the healthy control subjects the MVC were seen to be lower than 10% except for control subject with ID CON1, where the average MVC was noted to be above 10%. Figs. 1 and 2 represented the MVC graphs plot of the gait and knee lifting exercises, respectively. There were notable imbalances between the hip muscles of patients when compared with the control subject.

For the MD, the right and left hip muscle values were compared where the MD was noted to be significant. From Table I, we observed there were notable differences between the right and the left hip for the patients. Some patients had MD

above (-0.002), where the left hip mean values were greater than the right hip mean values, and others had MD above (+0.002) where the right hip was greater than the left hip. For the control subjects, the MD value was lower compared to the patients. Therefore, the MD illustrates the clear differences in hip muscle coactivity among patients compared to control subjects.

For the muscle fatigue levels in Table II, the RMS, MAV, and MEF were observed to vary greatly among the participants. We noted the were higher muscle fatigue levels for patients compared to control subjects based on the fatigue metrics recorded. From Figs. 3-6, we observe higher RMS and MAV values for patients which varied considerably between the left and right hip which resulted in imbalances. The higher MAV and RMS values showed that the was higher muscle exertion which created hip muscle fatigue for patients and resulted in imbalances among patients. In addition, there was a clear difference in the MEF shown in Figs. 7 and 8, with lower frequency values for patients compared to the higher values found in control subjects. Therefore, patients experienced greater hip muscle fatigue which resulted in higher muscular imbalances compared control subjects. Overall, there were

significant hip muscular imbalances among patients compared to healthy control subjects.

V.CONCLUSION

There have been some clinically consistent imbalances identified between synergistic and antagonistic muscles which have proven to be essential for rehabilitation. However, muscular imbalance in patients with rheumatism has not been explored, where the disorder of the hip muscle was unclear. In this study, we investigated the imbalance between the hip muscles of patients with chronic rheumatism compared with control subjects. The findings from the study indicated that there were significant imbalances between the right and left hip of patients compared to control subjects. The findings from this study will be useful for clinicians in designing therapeutic exercises to strengthen hip muscles and improve movement.

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