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 rheumatism conditions, specifically polymyalgia rheumatica. A clinical trial involving a total of 15 participants, made up of 10 patients and 5 control subjects, took place in KATH Hospital between August and September. Participants recruited for the study were of age 54 ± 7years, weight 65± 12kg and height 175 ± 8cm. Muscle signals were recorded from the rectus femoris and vastus lateralis on the right and left hips of participants. The parameters used in determining the hip muscular imbalances were the maximum voluntary contraction (MVC%), the mean difference and the hip muscle fatigue levels. The mean signals were compared using t-test and the metrics for muscle fatigue assessment were based on the root mean square (RMS), mean absolute value (MAV), and the mean frequency (MEF). The results indicated that there were significant imbalances in the muscles 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 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 heterogenous muscle diseases which includes 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 among adults above 50 years [4], turns 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 osteoarthritis of the hip and knee joints. [5] Additionally, polymyalgia rheumatica, a common rheumatism condition also creates 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 (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) and sling shout assisted (SS) in a barbell bench press exercise. A post hoc analysis indicated a decrease in the maximum voluntary contraction (%MVC) for the SS when compared to the control. 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. Alizadehkhaiyat 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 maximum voluntary contraction (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 muscle 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 Osteoarthritis. The results

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indicated that patients with knee osteoarthritis had significantly lower muscle coactivity when compared to the age-matched control.

From current studies, there is no specific work on muscular imbalances for patients with polymyalgia rheumatica and therefore we do not know if this condition creates an imbalance in the hips muscle during movement. Presently, to the best of our knowledge, this will be the first study of its kind aiming to investigate the hip muscular imbalance for patients with rheumatism.

II. Materials And methods

A. Participants

In total 15 participants made up of 10 patients with chronic rheumatism and 5 control subjects were recruited from Komfo Anokye teaching hospital in Ghana. The patients were made up of 8 females and 2 males, whiles the control subjects were 3 females and 2 males. The demography of participants was age 54 ± 7, height 175cm ± 8, and weight 65kg ± 12kg. 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 sensor provides a flexible and wireless measurement of the high-quality surface EMG signal. Furthermore, it can also provide a signal of motion detection via an onboard IMU. The sensor is developed to work with a Trigno Base Station which can be used with the Delsys Avanti Android app through a Bluetooth connection. The bandwidth is between 10-850Hz, and it has 11mV 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 1000Hz. The signals were processed and filtered using the band pass filter between 20Hz and 450Hz, which gives an effective function of the muscle and removes powerline noise. [14] The root mean square (RMS), mean absolute value (MAV) and mean frequency (MEF) was 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 maximum voluntary contraction (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 1, the mean signal values, the maximum voluntary contraction (MVC), and mean difference (MD) were computed for the rectus femoris (RF) and vastus lateralis (VL) from the participant. The statistical difference between the right and left hip muscles were compared using a t-test with $p<0.001$ in Table 1. The mean difference (MD) was calculated as the side-to-side difference between the muscles on the right hip and its corresponding muscle on the left hip. This was given by MD = MRH – MLH --eqn (1) where the MRH represents the right hip whiles MLH is the mean left hip. The mean values of the rectus femoris 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 whiles a negative (-) value indicates the opposite. The average MVC% on the RH and LH were plotted in figures 1 and 2.

TABLE I
SUMMARY OF THE HIP MUSCLES MEASUREMENT

ID	Exercise	M_Right Hip(RF)	MVC	M_Left Hip(RF)	MVC	MD	M_Right Hip(VL)	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	-0.001	0.0062	39.27	0.0058	36.70	0.0004	38.90<35.86
CON4	Gait	0.0044	30.55	0.0058	36.70	-0.001	0.0025	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.1 MVC Graph of Gait

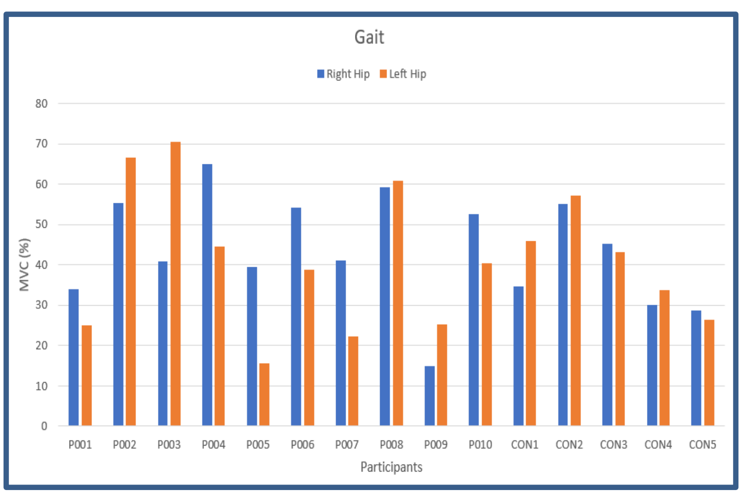


Fig.2 MVC Graph of Knee Lifting

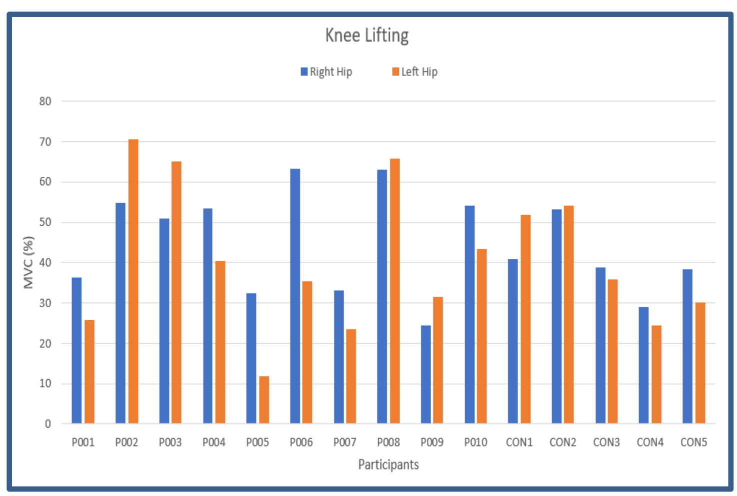


TABLE II
METRICS FOR MUSCLE FATIGUE ASSESSMENT

ID	Exercise	Right Hip (RF) RMS	Right Hip(RF) MAV	Right Hip(RF) MEF	Left Hip(RF) RMS	Left Hip(RF) MAV	Left Hip(RF) 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 2, the RMS, MAV, and MEF for the rectus femoris and vastus lateralis 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] whiles lower MEF shows higher muscle fatigue levels.[18]

Fig3. RMS Graph of Gait

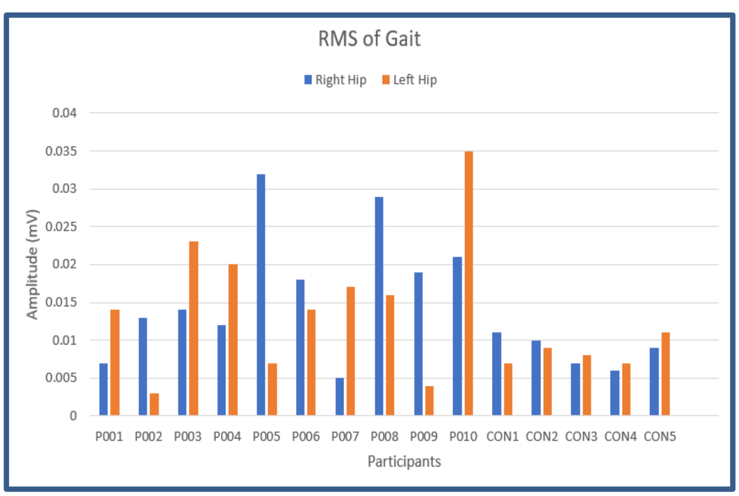


Fig4. RMS Graph of Knee Lifting

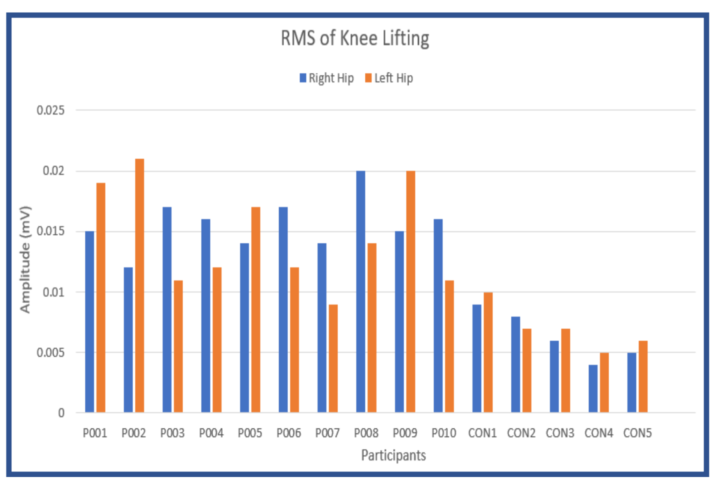


Fig5. MAV of Gait

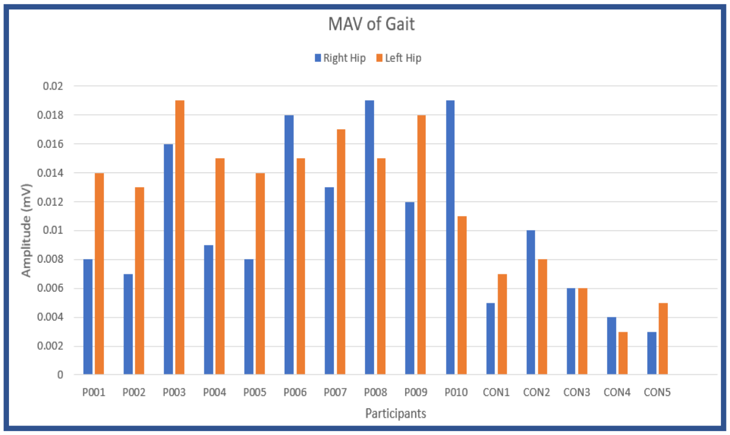


Fig6. MAV of Knee Lifting

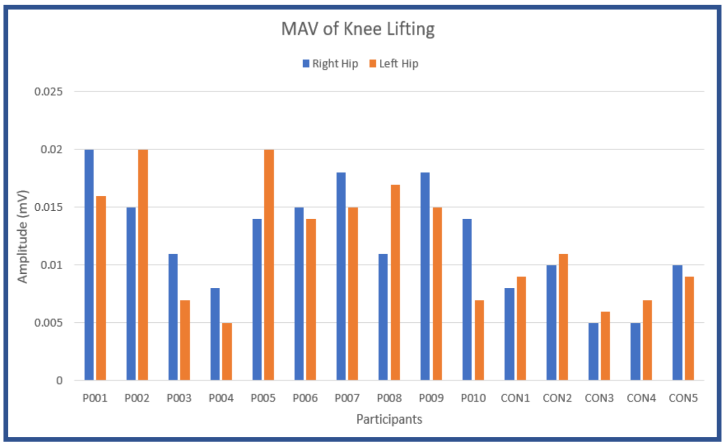


Fig7. MEF of Gait

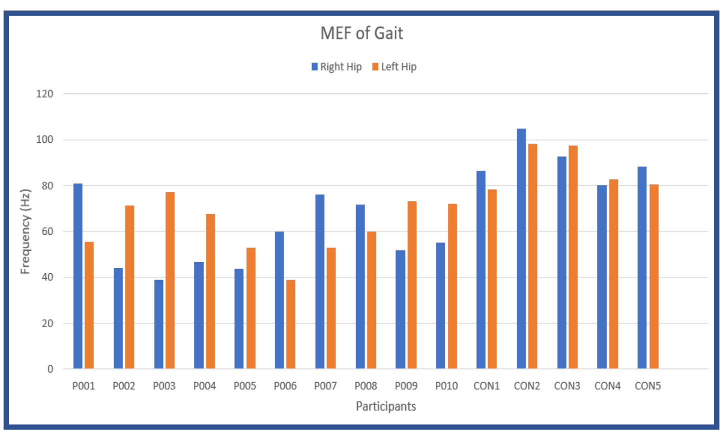
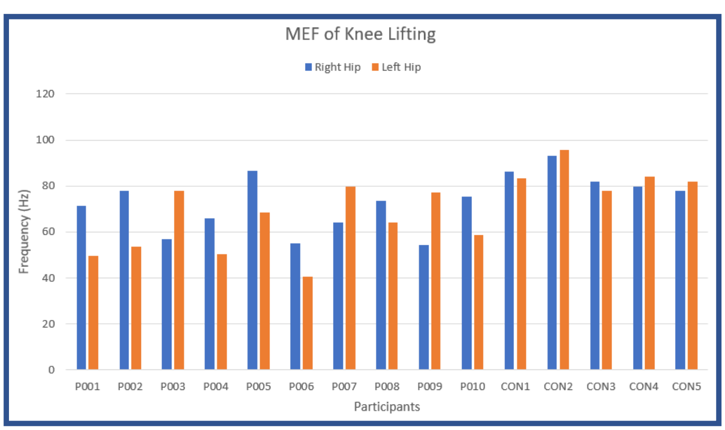


Fig8. MEF of Knee Lifting



IV. DISCUSSION

The aim of the study was to investigate the hip muscular imbalance in patients with polymyalgia rheumatica compared to control subjects. We considered three parameters in determining the hip muscle imbalances which were the mean difference (MD), maximum voluntary contraction (MAV) and the fatigue muscle levels. From Table 1, we observed that patients had the MVC difference between the right and left hip to be 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 the patient with ID P008. With the healthy control subjects the MVC were seen to be lower than 10% except for the control subject with ID CON1, where the average MVC was noted to be above 10%. Figures 1 and 2 represented the MVC graphs plot of the gait and knee lifting exercises respectively. They were notable imbalances between the hip muscles of patients when compared with control subject.

For the mean difference (MD), the right and left hip muscle values were compared and the mean difference was noted. From Table 1, we observed there were slight 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. The mean difference (MD) illustrates the differences in hip muscle coactivity among patients compared to control subjects.

For the muscle fatigue levels in Table 2, the RMS, MAV, and MEF were observed to vary among the participants. We noted the were higher muscle fatigue levels for patients compared to control subjects based on the fatigue metrics recorded. From figures 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 figures 7 and 8, with lower frequency values for patients compared to the higher values in control subjects. Therefore, patients experienced greater hip muscle fatigue which resulted in higher muscular imbalances compared to 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 conditions, specifically polymyalgia rheumatica has not been explored, and the disorder of the hip muscle is unclear. In this study, we investigated the imbalance between the hip muscles of patients with polymyalgia rheumatica 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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