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Title Page

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Normalisation method can affect Gluteus Medius electromyography results during weight bearing exercises in people with hip OA: a case control study.

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Abstract

Surface Electromyography (sEMG) is used to assess muscle activation during therapeutic exercise, but data are significantly affected by inter-individual variability and requires normalisation of the sEMG signal to enable comparison between individuals. The purpose of this study was to compare two normalisation methods, a maximal method (maximum voluntary isometric contraction (MVIC)) and non-maximal Peak Dynamic method (PDM), on Gluteus Medius (GMed) activation using sEMG during three weight-bearing exercises in people with hip OA and healthy controls. Thirteen people with hip OA and 20 controls performed three exercises (Squat, Step-Up, Step-Down). Average root-mean squared EMG amplitude based on MVIC and PDM normalisation was compared between groups for both involved and uninvolved hips using Mann-Whitney tests. Using MVIC normalization, significantly higher normalised GMed EMG amplitudes were found in the OA group during all Step-up and down exercises on the involved side ($p=0.02-0.001$) and most of the Step exercises on the uninvolved side ($p=0.03-0.04$), but not the Squat ($p>0.05$), compared to controls. Using PDM normalization, significant between-group differences occurred only for Ascending Squat ($p=0.03$) on the involved side. MVIC normalisation demonstrated higher inter-trial relative reliability (ICCs=0.78-0.99) than PDM (ICCs=0.37-0.84), but poorer absolute reliability using Standard Error of Measurement. Normalisation method can significantly affect interpretation of EMG amplitudes. Although MVIC-normalised amplitudes were more sensitive to differences between groups, there was greater variability using this method, which raises concerns regarding validity. Interpretation of EMG data is strongly influenced by the normalisation method used, and this should be considered when applying EMG results to clinical populations.

1 Introduction

Osteoarthritis (OA) is a degenerative joint disease characterised by cartilage deterioration, which can affect the integrity and function of weight-bearing joints. Gluteus Medius (GMed) muscle is subject to selective atrophy in hip OA [1] and strengthening is an important management strategy. Functional exercises in weight-bearing (WB) positions are recommended for lower limb strengthening [2].

Although surface electromyography (sEMG) can quantify muscle activity, it can be influenced by cross-talk from other muscles [3], joint angle, velocity, muscle length, contraction type, fatigue [4] and activity in antagonist and synergist muscles [5]. Normalisation is a method of reporting EMG data as a percentage of a reference contraction and allows comparisons between individuals, different muscles and times. Different methods exist, with normalisation to a maximum voluntary isometric contraction (MVIC) most commonly used [6]. However, pain commonly present in hip OA may limit the ability to generate maximum contraction, thus restricting interpretation of MVIC normalisation in people with OA.

Alternative normalisation methods include sub-maximal isometric contractions, peak dynamic method (PDM) or mean dynamic method (MDM) [7]. PDM expresses the sEMG signal amplitude throughout an activity as a percentage of the peak EMG amplitude from the same activity, whilst MDM uses the mean EMG amplitude from the same task [8]. Dynamic normalisation may reduce the inter-individual variability that can increase signal variance [6, 9]. Reliability refers to the extent to which measurements are consistent over time and has been investigated for various normalisation methods with conflicting results [6] [10] [11] [12]. Specifically, for GMed, MVIC is more reliable than PDM and MDM in healthy controls [13]. However MDM and PDM methods have been recommended to reduce inter-individual variation [6] but the optimal methods have not been sufficiently researched in a symptomatic population.

Measurement of GMed sEMG activity during therapeutic exercises has been previously investigated, predominantly in young healthy people [14, 15]. This limits extrapolation to people with symptomatic OA. Two studies have been conducted on hip OA populations. Sims et al found greater GMed activation in 19 people with unilateral hip OA compared with 19 healthy controls during a rapid step-up task using sub-maximal isometric normalisation [16]. Dwyer et al compared GMed amplitude during gait, step-up and step-down tasks between people awaiting joint replacement and symptom-

free controls. They also found increased GMed activity bilaterally, using MVIC normalisation. However, the authors acknowledged that pain may have been a factor during MVIC testing [17]. With consideration for the findings of these studies, our aim was to examine the effect of two normalisation methods, a maximal (MVIC) method and non-maximal method (PDM), on the interpretation of EMG activity generated from GMed during three weight-bearing exercises on people with hip OA and a symptom-free control group.

2 Methods

2.1 Participants

This was a case-control study. Cases were individuals with radiographically confirmed hip OA who were recruited from primary care in Dublin, Ireland. The control group was a convenience sample of healthy controls recruited from staff and acquaintances at a third-level institution in Dublin. Ethical approval for all participants was obtained from the college Research Ethics Committee. Written informed consent was obtained from all participants prior to testing. All testing took place in the college Movement Laboratory in a single session. Participants with OA completed the Visual Analogue Scale (VAS) for pain severity and the Western Ontario and McMaster University Osteoarthritis (WOMAC) index [18] to measure disability levels prior to testing.

2.2 Electromyography

A multichannel EMG system (MA-300, Motion Lab Systems, Baton Rouge, LA, USA) was used to acquire sEMG data using bipolar, preamplified, circular electrodes with a fixed interelectrode distance of 18 mm and a common mode rejection ratio of at least 100 decibels (dB) at 65 Hz. Signals were collected across a bandwidth of 20-500 Hz with a signal to noise ratio of >50 dB sampled at 1000 Hz using a 32 channel Di-720 analogue to digital convertor with a 12-bit resolution (DATAQ Instruments Inc, Akron, Ohio, USA).

After skin was shaved and cleaned with isopropyl alcohol, EMG electrodes were placed on left and right GMed in accordance with SENIAM (Surface EMG for Non-Invasive Assessment of Muscles) guidelines [19]. A reference electrode was placed over C7. Electrodes were connected to a receiver unit worn on the subject's back. Electrodes and wires were secured to prevent slippage and

movement artefact. Accurate electrode positioning was visually confirmed by inspecting sEMG activity during manual muscle testing using Windaq Prodata acquisition system software (DATAQ Instruments Inc, Akron, OH, USA).

2.3 MVIC Testing

Three MVIC were obtained for GMed, with measurement of concurrent force production using a hand-held dynamometer (Microfet 2, Hoggan Health, Utah, USA) to allow interpretation of EMG results in relation to force generation. Participants were tested in side-lying with the hip to be tested placed uppermost in 20° abduction. Participants were asked to abduct the leg against resistance applied using a handheld dynamometer placed proximal to the lateral femoral condyle. Verbal encouragement was used to enhance performance. Test-retest reliability of dynamometry was measured in nine healthy controls (2 male, 7 female; mean age =36.7 years (SD =9.60)) over a 1-week interval, controlling for time of day and activity levels in the preceding 24 hours.

2.4 Motion Analysis

A VICON® 250 5-camera Motion Analysis System (VICON, Oxford Metrics Ltd., Oxford, UK) and a Kistler multi-component force plate (Kistler Group, Winterthur, Switzerland) were used to track movements and identify phases of the exercises. On completion of MVIC testing, fifteen reflective markers (25mm) were placed over anatomical landmarks using the Modified Helen Hayes method [20].

2.5 Exercise testing

Participants practiced each exercise to a frequency of 60 beats per minute for familiarisation, followed by exercise testing in random order. The Step exercises were performed on both sides (exercise descriptions available as supplemental information). Three trials were recorded for each exercise and trials were discarded if the markers could not be visualised or the participant did not strike the force plate cleanly. The involved limb, defined as the symptomatic limb, with radiographically confirmed OA, was compared to the dominant limb in the control group.

2.6 Data Processing

The start and end-point of each exercise was identified in Vicon workstation using force plate data or by identifying the position of heel and toe trajectories. The squat exercise was divided into descending and ascending phases at maximal knee flexion. Raw EMG data were band pass filtered at 10-500Hz, full wave rectified and linear smoothed with a low pass filter of 5Hz using custom software (Motion Lab Systems, Baton Rouge, LA, USA). The peak amplitude of the rectified filtered EMG signal from MVIC trials, averaged over three trials, was taken as the MVIC normalisation reference. Similarly, the peak amplitude of the EMG signal during the exercise trials, averaged over three trials, was defined as the PDM normalisation reference. To measure EMG amplitude during exercise, the root mean square amplitude (RMS) of the EMG signal over consecutive periods of 150 ms was calculated for the duration of the exercise trial and each RMS value was expressed as a percentage of both MVIC and PDM normalisation reference values.

2.7 Statistical Analysis

Data were analysed using the PASW Statistical Package for the Social Sciences, version 18 (SPSS Inc, Chicago, IL), with a significance level of $p < 0.05$. Data were visually inspected for normality and due to skewed data, medians and interquartile ranges normalised EMG and dynamometry were presented. Mann-Whitney tests were used to determine between-group differences in EMG activity across the three exercises. Data were sorted into uninvolved and involved limbs for the OA group and dominant/non-dominant for the controls. Maximal hip and knee flexion angles were extracted for each exercise and a mean value over the three repetitions of each exercise used for analysis. Between-group differences in peak hip and knee flexion angles during the exercises were calculated using Mann-Whitney U tests. Inter-trial reliability was calculated using Intraclass correlation co-efficients (ICCs) (two way random-effects) for both PDM and MVIC methods. Reliability co-efficients < 0.4 =poor; $0.4-0.75$ =fair to good; > 0.75 =excellent were used [21]. Absolute reliability was calculated using standard error of measurement (SEM) [22]. Differences in force production were measured using linear regression, controlling for Body Mass Index (BMI). Associations between pain severity and force were determined using Pearson's correlation co-efficient. Test-retest reliability of hand-held dynamometry was calculated using ICCs for the mean of three measures.

3 Results

Thirty-three participants, 20 controls and 13 with hip OA, were recruited. Participant characteristics are shown in Table 2.

3.1 EMG Amplitudes

Median EMG amplitudes were greater in the OA group than controls on both sides during the Step-up and down exercises (Table 2). Considerably higher IQRs were observed in the involved GMed, particularly during the Step-up and down exercises, indicating high inter-person variance. Amplitudes of >100% MVIC were recorded for three OA participants during at least one of the exercises. A significant between-group difference occurred for involved GMed in all Step-up and Step-down exercises. There was also a significant between-group difference for uninvolved GMed during Right Step-up ($p=0.001$), Right Step-down ($p=0.03$) and Left Step-down ($p=0.04$) (Table 2).

There were significant between-group differences using PDM normalisation in involved ($p=0.03$) and uninvolved GMed ($p=0.04$) during ascending Squat. Although higher amplitudes were recorded for the OA group, these were more comparable with the IQRs for the control group (Table 2).

3.2 Reliability of Normalisation methods

Table 3 shows the inter-trial reliability results for the MVIC and PDM normalisation methods. ICC values ranged between 0.37-0.95 for PDM normalisation and between 0.78-0.99 for the MVIC normalisation. Using the Shrout and Fleiss criteria, all 12 MVIC trials (representing four muscles across three exercises) demonstrated excellent reliability, whilst two PDM trials demonstrated poor reliability, six demonstrated fair to good, and four demonstrated excellent reliability, indicating that overall MVIC produced greater inter-trial reliability than PDM. However, higher SEM values occurred for MVIC normalisation, ranging from 2.97-12.87%. Values ranged from 1.91-6% for GMed using PDM normalisation (Table 3).

3.3 Peak Hip and Knee Angles

The only significant between-group difference in peak hip and knee ROM, measured with 3D motion analysis, occurred for hip flexion (mean difference = 26.52° ; $p<0.001$), which was greater for the controls during the squat exercise (Data available as supplemental information).

3.4 Dynamometry results

There was significant difference in abductor and extensor isometric force generation between the two groups, but no side- to- side differences within groups (Table 4). Reliability values (ICCs) varied from 0.76-0.94, indicating excellent reliability.

4 Discussion

Numerous studies have attempted to compare EMG normalisation methods, the majority of which have been conducted on healthy controls [6, 10] so extrapolation to populations with pathology is limited. Although, there appears to be no consensus regarding the best methods, a comprehensive review by Burden [6] recommended that task normalization methods such as PDM and MDM methods were preferable to MVIC methods to reduce inter-individual variation in healthy controls, but of limited value when comparing across studies or when reapplication of electrodes is required. There is insufficient research in individuals with pain or pathology to give clear recommendations but generation of maximal force has been identified as a potential limitation [23].

Results showed that although both normalisation methods resulted in predominantly higher normalised EMG amplitude in the hip OA group, a greater number of significant between-group differences were identified using MVIC normalisation, particularly in the Step exercises. Amplitudes were more comparable between groups using PDM normalisation, resulting in significant between-group differences only in the Squat exercise. Therefore, MVIC and PDM normalisation produce considerably different results, when comparing EMG of exercises of people with hip OA and healthy controls. Greater variability in amplitudes using MVIC, coupled with amplitudes of >100% MVIC in three of the OA group compromise the validity of MVIC normalisation.

BMI is a known risk factor for OA and was higher in the OA group which may have implications for EMG measurement [24]. However, this should not affect the within-subject comparison of normalisation methods. Self-report pain and disability scores in the hip OA group at the time of testing indicated mild to moderate severity levels. Two of the hip OA group presented with more severe symptoms and used walking sticks.

The MVIC normalisation method produced lower percentage activation in the control group, compared with PDM normalisation, which was expected. Higher percentage activation for the MVIC than PDM method was observed in the OA group during the Step, but not the Squat exercises. This resulted in significant between-group differences for all four Step exercises on the involved side and three Step exercises on the uninvolved side, using MVIC normalisation. The amplitudes of greater than 100% on the involved side in three hip OA participants was similarly found in measurement of EMG activity of GMed during WB and NWB exercise in 15 people following hip replacement surgery. This suggests an inability to generate maximal effort during MVIC, which may be related to pain, fear avoidance or true muscle weakness associated with joint disease and has been identified as one of the limitations of using MVIC normalisation in people with symptoms and pathology [23].

Between-group differences occurred in the unilateral stance exercises (Step-up and down), which was not detected using PDM normalisation. GMed is an important stabiliser of the hip during unilateral stance activities such as walking and stairs to prevent the pelvis dropping on the unsupported side [25]. Clinically, deficits of weakness in GMed manifests as a Trendelenburg sign which is a hallmark of hip OA. Therefore, it is reasonable to expect that muscle deficits would be more apparent during the stepping exercises compared with bilateral stance exercises such as Squat. Whether or not the muscles exhibit increased or reduced EMG activity remains unclear in the literature. Higher EMG activity was identified in a hip OA group compared with healthy controls in two different studies during stepping tasks, one used MVIC normalisation [17] and one used sub maximal normalisation [16]. Increased GMed activity may occur in a weakened muscle as a result of compensatory increased neural drive in an attempt to generate the required force [16]. However, the extent of atrophy may depend on OA severity, as GMed atrophy has been demonstrated in advanced hip joint pathology but hypertrophy can occur in early OA [1]. The effect of disease severity on GMed EMG activity warrants further investigation.

In determining which normalisation methods are preferred, the activity under investigation should be considered. MVICs are determined in non-functional positions using isometric force. Dynamic normalisation has been recommended for dynamic activities such as gait or exercise as it is more representative of functional tasks [26]. PDM normalisation is related to the level of activity compared

to the maximum activity during the same task, while MVIC relates to the maximum activation during static contraction [8].

Differences in ROM due to muscle length-tension relationships during dynamic EMG measurement may also influence results, therefore 3D motion analysis was used to measure maximal hip and knee joint angles during the three exercises. Only the Squat exercise showed significant between-group differences during hip flexion and a trend towards significance in knee flexion, due to greater flexion occurring in the control group. The only exercise which detected between-group differences in EMG activation using PDM was the ascending Squat which may have been due to differences in peak flexion angles. Non-significant between-group differences in joint angles during Step-up and down exercises means that joint range is unlikely to explain the differences in EMG activation detected during those exercises using MVIC normalisation.

Inter-trial reliability based on three trials of the two normalisation methods showed conflicting results. ICCs relate the measurement error to the variability between study participants, whilst SEM quantifies the precision between individual scores in the original units. A combination of methods is recommended to establish reliability [27]. Relative reliability (ICCs) was higher for the MVIC normalisation, but higher ICC values can be due to high variability between persons [28], as observed in this study. The SEM represents measurement error and may be more useful as it informs of the error between the three trials. It may also be more clinically meaningful as the error is expressed in the same units as the original measurement [22]. Dynamic normalisation methods reduce variability between people and therefore may remove the true variation that may exist [7, 8].

Dynamometry results provided information regarding the force generated during MVIC testing, as force was measured concurrently with collection of EMG data. Pain did not appear to influence force generation in the symptomatic group. A positive linear relationship has been demonstrated between isometric force and EMG amplitude [29], so it is reasonable to expect that higher forces would be associated with higher EMG amplitudes during isometric contraction. However, these measurements were not specific to GMed and other abductor muscles may have contributed to the results.

Hip abductor force was lower in the OA group compared with controls, with no side-to-side difference. Sims et al similarly found comparable hip abductor strength between sides in people with unilateral

hip OA [16]. GMed atrophy on the contralateral side in unilateral hip OA has been demonstrated in histology samples [30].

There are some study limitations. Cross-talk which is a potential limitation of sEMG, but was minimised by standardising electrode placement and skin preparation. Subcutaneous tissue may have affected signal integrity, which may be a factor in the hip OA group who had a higher BMI. Although, a similar age group of over 40 years was used for the control group, each subject in the hip OA group was not age and gender matched to the control group. However, as the aim of the study was to compare two normalisation methods across the same group, this was not considered by the authors to impact on results. Although inter-trial reliability was established, inter-session reliability of the EMG trials was not determined. The sample size did not allow for subgroup analysis to explore factors which may affect variability in EMG signal amplitude such as disease severity or symptoms.

5 Conclusion

This study compared EMG normalisation methods of GMed during therapeutic exercises between people with hip OA and healthy controls. Although both methods resulted in higher amplitudes in the OA group, more between-group differences were reported using MVIC normalisation. Fewer significant between-group differences occurred using the PDM, with more comparable amplitudes and less inter-subject variation in the OA group, relative to the control group. Higher inter-trial measurement error occurred using the MVIC method. Consequently, different interpretation of results could occur depending on the method used. Caution is advised when only using MVIC normalisation in clinical populations and we recommend comparing results with an alternative dynamic normalisation such as PDM. The sensitivity of PDM normalisation may also require future investigation in symptomatic populations.

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Conflict of Interest: none

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Table 1: Characteristics of the study population

	Control (n=20)	Hip OA (n=13)
Male	11 (55%)	4 (30.7%)
Female	9 (45%)	9 (69.3%)
	Mean (SD)	Mean (SD)
Age (years)	49.65 (7.79)	56.62 (8.70)
Height (cm)	171 (0.11)	165 (0.08)
Weight (kg)	73.28 (13.88)	76.01 (17.82)
BMI (kg/m²)	24.90 (2.70)	27.92 (7.00)
Pain Severity (0-100 VAS)	N/A	19.77 (27.15)
WOMAC physical function (0-68)	N/A	27.54 (13.73)

SD= Standard Deviation; BMI= Body Mass Index; N/A= Not Applicable; VAS=Visual Analogue Scale; cm= centimetres; kg=kilograms

Table 2: Average Root- Mean Squared Amplitude for Gluteus Medius represented as a Percentage of Maximum Voluntary Isometric Contraction (MVIC) and Peak Dynamic Method (PDM)

		Control	Hip OA		Control	Hip OA	
		Non-Dominant	Uninvolved	p-value*	Dominant	Involved	p-value*
		Median (IQR)	Median (IQR)		Median (IQR)	Median (IQR)	
Descending Squat	MVIC	8.99 (9.30)	8.56 (12.36)	0.05	6.28 (10.87)	9.77 (14.89)	0.29
	PDM	7.57 (6.40)	7.29 (7.52)	0.55	6.91 (5.32)	8.32 (6.40)	0.74
Ascending Squat	MVIC	11.94 (9.86)	8.61 (15.17)	0.77	7.84 (10.86)	9.99 (15.57)	0.8
	PDM	10.03 (8.8)	7.15 (6.95)	0.04	9.59 (7.94)	5.84 (4.52)	0.03
Right Step- up	MVIC	13.86 (9.87)	33.05 (23.53)	0.03	21.42 (13.73)	38.05 (54.77)	0.001
	PDM	11.18 (8.97)	12.48 (5.73)	0.68	12.42 (4.32)	12.68 (3.71)	0.87
Left Step- up	MVIC	19.07 (21.38)	29.40 (26.99)	0.08	14.49 (9.77)	47.07 (77.3)	0.001
	PDM	10.90 (5.66)	12.21 (3.88)	0.25	10.69 (4.5)	12.76 (3.87)	0.18
Right Step-down	MVIC	13.57 (14.45)	22.97 (34.28)	0.03	8.51 (23.03)	35.58 (34.14)	0.02
	PDM	12.02 (7.97)	16.76 (8.83)	0.06	9.93 (6.44)	12.95 (7.65)	0.84
Left Step-down	MVIC	10.25 (9.14)	24.92 (20.76)	0.04	14.42 (12.86)	39.59 (61.37)	0.002
	PDM	9.77 (5.76)	10.60 (4.68)	0.39	14.25 (7.23)	17.73 (12.08)	0.46

*based on Mann-Whitney U tests; IQR= Interquartile Range; OA = Osteoarthritis

Table 3: Reliability data for GMed for MVIC and PDM

Exercise		Uninvolved			Involved *		
		ICC	95% CI	SEM (%)	ICC	95% CI	SEM (%)
Descending Squat	MVIC	0.78	(0.64, 0.88)	6.92	0.98	(0.96, 0.99)	2.35
	PDM	0.74	(0.59, 0.86)	3.31	0.84	(0.73, 0.91)	2.84
Ascending Squat	MVIC	0.89	(0.81, 0.94)	5.04	0.75	(0.60, 0.86)	8.49
	PDM	0.76	(0.61, 0.86)	2.41	0.76	(0.61, 0.87)	3.42
Right Step- up	MVIC	0.99	(0.997, 0.999)	5.19	0.991	(0.98, 0.99)	4.06
	PDM	0.69	(0.52, 0.82)	3.02	0.56	(0.37, 0.75)	3.06
Left Step- up	MVIC	0.99	(0.993, 0.998)	6.76	0.994	(0.98, 0.99)	3.92
	PDM	0.49	(0.27, 0.70)	2.83	0.69	(0.51, 0.83)	4.11
Right Step-down	MVIC	0.96	(0.92, 0.98)	3.44	0.994	(0.99, 99)	2.10
	PDM	0.37	(0.13, 0.61)	3.87	0.85	(0.74, 0.92)	2.70
Left Step-down	MVIC	0.99	(0.98, 0.99)	6.45	0.98	(0.97, 0.99)	5.35
	PDM	0.55	(0.29, 0.70)	4.18	0.37	(0.15, 0.60)	8.64

CI=Confidence Interval; MVIC= Maximum Voluntary Isometric contraction, PDM=Peak dynamic method; SEM=Standard Error of Measurement

*Involved side refers to the hip OA group

Table 4: Force generation in hip OA and control group using hand held dynamometry

	Control (n=20)		Hip OA (n=13)						
	Median (IQR) (Newtons)*	p-value ¹	Median (IQR) (Newtons)*	p-value ¹	p-value ²	Reliability (ICC)	p-value ²	Correlation Pain and force (n=13)	p-value ³
L Abd	75.65 (13.43)		37.57 (21.65)		<0.001	0.94	<0.001	-0.43	0.14
R Abd*	73.03 (18.20)	0.98	44.27 (21.0)	0.21	<0.001	0.76	<0.001	-0.32	0.28
L Ext	64.90 (14.04)		40.53 (13.14)		<0.001	0.87	<0.001	-0.04	0.90
R Ext*	65.25 (10.27)	0.37	37.4 (16.35)	0.21	<0.001	0.84	<0.001	-0.27	0.37

Abd=Abduction; Ext=Extension; L=Left; R=Right; ICC=Intraclass Correlation Co-efficient; IQR=Interquartile Range

P value¹ represents difference between sides in each group; P-value² represents differences between hip OA and controls; P-value²; P-value³ represents association between pain severity and force in Hip OA group only; ^{1,2} Statistically significant at p<0.05; *controlled for Body Mass Index (BMI).

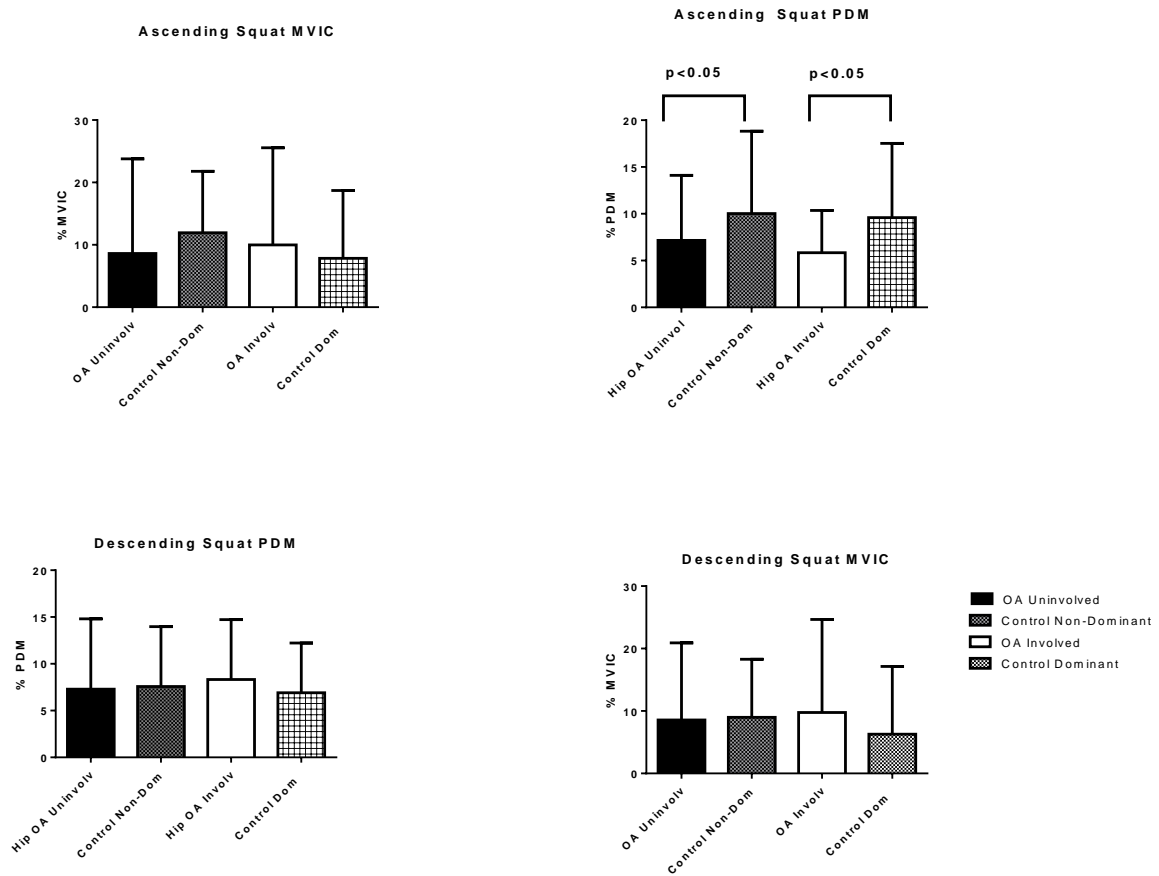


Figure 1: Squat Exercises (Medians and Interquartile Ranges) comparing EMG amplitude normalised to Maximum Isometric Voluntary Contraction (MVIC) and Peak Dynamic Method (PDM)

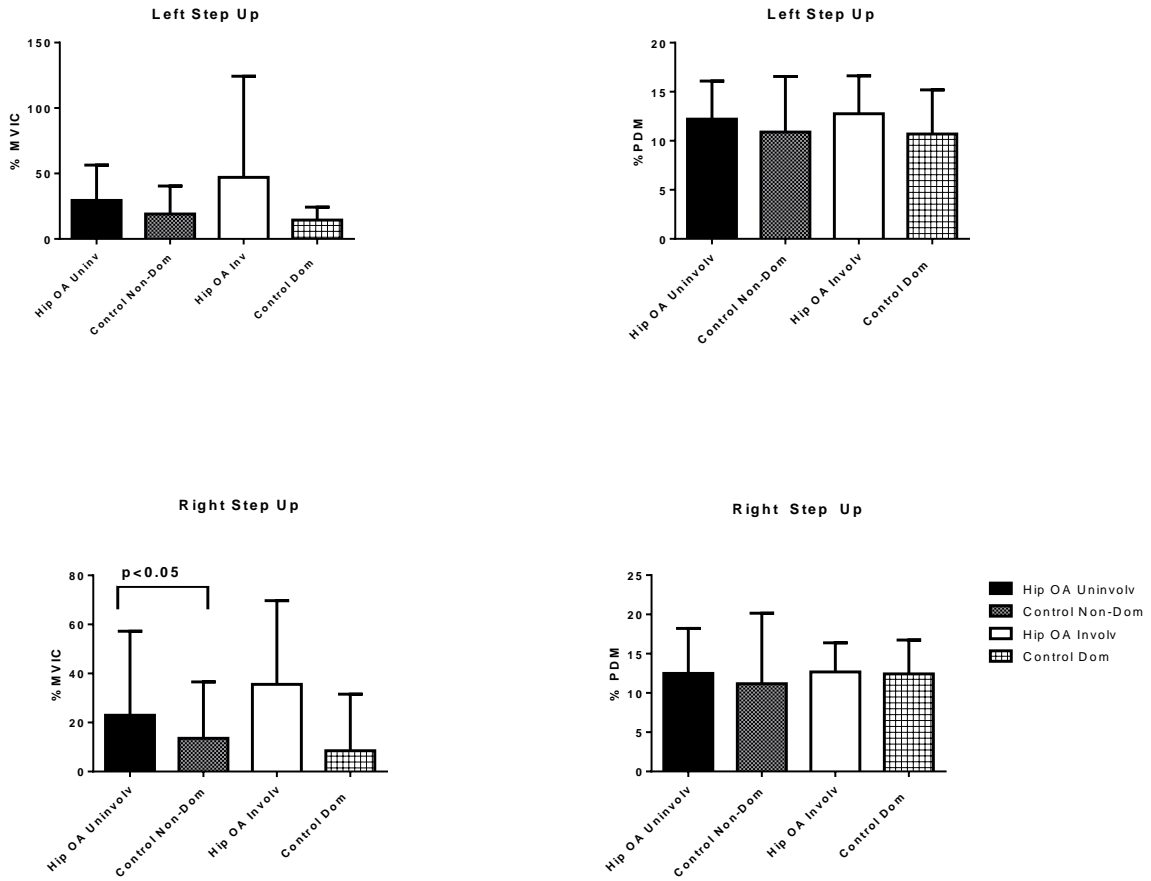


Figure 2: Step-Up Exercises (Medians and Interquartile Ranges) comparing EMG amplitude normalised to Maximum Isometric Voluntary Contraction (MVIC) and Peak Dynamic Method (PDM)

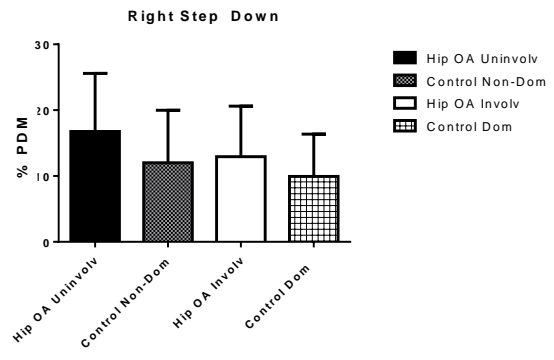
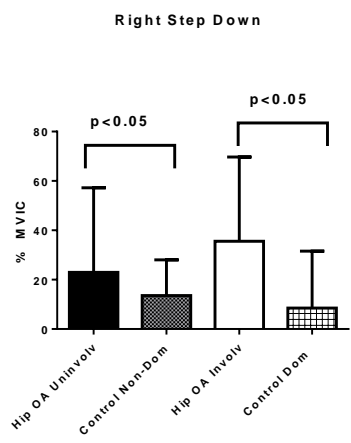
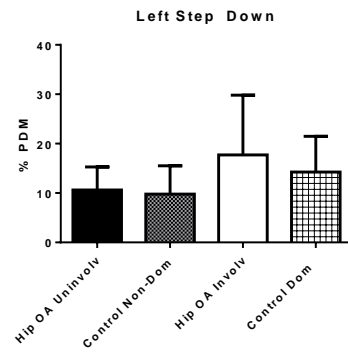
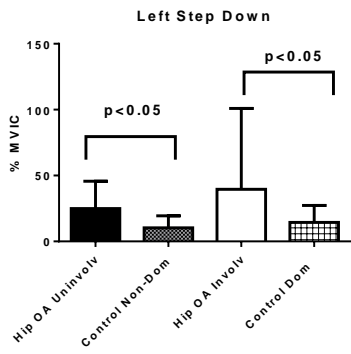


Figure 3: Step-Down Exercises (Medians and Interquartile Ranges) comparing EMG amplitude normalised to Maximum Isometric Voluntary Contraction (MVIC) and Peak Dynamic Method (PDM)