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Research Paper

Maximum Muscle Contraction in Dynamic and Isometric Phases of the Lower Limb Movement Patterns Described by Kabat

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ABSTRACT

Background: *There is little evidence that allows us to establish differences between the types of contraction during the execution of sequential movements and / or movement patterns such as those described by Kabat, which account for the neurophysiological, biomechanical principles and their applicability to the clinical context.*

Objective: *To determine the differences in the maximum muscular contraction between dynamic and isometric phases of the lower limb movement patterns described by Kabat, in healthy people.*

Methods: *An intentional sampling of healthy young adults between 18 and 25 years, 20 men and 20 women with right foot dominance was carried out. Three active repetitions of the two diagonals of the lower limbs were performed, both supine and biped. Maximum contraction was recorded in both the dynamic and isometric phases for each movement pattern by surface electromyography. Homogeneity tests were done for eight muscles.*

Results: *For both positions and for all the muscles evaluated, the average of the maximum contraction was greater in the dynamic phase. The differences were significant ($p<0.05$) mainly in lower limb musculature, but not axial.*

Conclusions: *The dynamic contraction (concentric-eccentric) is more effective than the isometric contraction, to achieve maximum muscular contraction without external resistance, during the execution of the patterns described by Kabat.*

KEYWORDS: *electromyography, muscle strength, isometric contraction, isotonic contraction, lower extremity.*

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I. INTRODUCTION

Movement patterns, defined as the combination of movements in two or more body segments according to a specific spatio-temporal arrangement [1], are key for human body movement and for its motor actions. Throughout history, their analysis has been the basis of therapeutic models for restoring functionality and it has led to strategies such as total body strengthening, which includes the training of a muscle group. This is frequently used in the field of rehabilitation and differs from analytical strengthening, which is directed to a specific muscle [2].

he Kabat method or Proprioceptive Neuromuscular Facilitation (PNF) is a therapeutic model based on movement patterns to execute them through specific treatment techniques. Since its creation, this method describes specific patterns similar to those developed during functional activities [3], consisting of movements that form an X around the joint and projecting diagonals with rotational components [4]. These patterns are used to apply management techniques that include, among others, some aimed specifically at muscle strengthening with an emphasis on force generation and increase from the stimulation of proprioceptive receptors and following a series of neurophysiological principles such as the stretch reflex, the irradiation, among others, that provide effects such as muscle reinforcement.

he different types of muscle contraction, dynamic and isometric, have been used by the techniques developed by Kabat and following specific purposes such as muscle strengthening and relaxing of muscles involved in each pattern. However, no studies have been found in which muscle activity in these types of contraction during the execution of movement patterns is characterized without the mediation of specific techniques that involve external resistance.

Research in PNF related to muscle contractions has been oriented to study the mechanisms of cross activation, irradiation, among others. Gupta et al. applied these patterns by performing isometric contraction in the final and isotonic position throughout the range of joint mobility in the dominant lower limb, finding that the maximum voluntary isometric contraction in the non-dominant lower limb improved significantly while performing the PNF pattern of extension, abduction and medial rotation in the dominant lower limb [5].

These results were explained by the "cross-activation" hypothesis and the excitability of non-decussed descending motor fibers and fibers of the corticospinal tract; mechanisms that may help physical therapists in the prevention of muscle hypotrophy, exercising the healthy limb or other healthy parts to stimulate muscle activity in the affected limb that cannot be directly addressed.

As opposed to the effectiveness of one or another type of muscle contraction, it should be noted that it is more common to find studies not associated with PNF or its movement patterns. Kyun Lee et al. compared muscle strength, mass and functional performance in response to training through isometric, isotonic and isokinetic contractions in the dominant quadriceps, three sessions per week, during eight weeks. They concluded that isometric and isotonic training can be used when gaining muscle mass is desired; however, isotonic shows greater mass gain than isometric and isokinetic training increases functional performance in daily activities and sports [6].

Suri et al. developed an experimental study in which they compared the effectiveness of isometric, isokinetic and isotonic lower left quadriceps strength training in 30 Physiotherapy students, randomly assigned to each type of training for a period of four weeks, with pre- and post-intervention evaluations with an isokinetic device [7]. The authors found that in all three modes of training, quadriceps strength improved significantly over time; however, isokinetic strength training contributed most to improving peak strength and was considered the best form of training, while among the isotonic and isometric training group, isotonic training showed increased functional performance.

Based on the literature reviewed, it is observed that there are studies focused on specific muscles, but there is little evidence that allows us to establish differences between the types of contraction during the execution of sequential movements and/or movement patterns such as those described by Kabat, which account for the neurophysiological, biomechanical principles and their applicability to the clinical context. The use of technologies such as surface electromyography (EMGs) can contribute to the analysis of the electrical activity of the muscles involved in these movement patterns which, in the case of the lower limbs, are useful for activities such as locomotion, dynamic balance control, among others, offering contributions and clinical implications that could be projected into different fields of action of physiotherapy. The objective of this study was to determine the differences in maximum muscle contraction between dynamic and isometric phases of the movement patterns of lower limbs described by Kabat, in healthy people, both in supine and bipedal positions.

II. MATERIALS AND METHODS

2.1 Study design

An empirical-analytical study was carried out, in which the maximum muscle contraction between dynamic and isometric phases of the lower limbs measured with surface electromyography (EMG) was compared (homogeneity analysis), in the supine and bipedal positions of healthy persons. The guidelines of Resolution 8430 of 1993 of the Colombian Ministry of Health, which establishes the scientific, technical and administrative standards for health research, were followed. It complies with the principles set forth in the Declaration of Helsinki of the World Medical Association and was approved by the Bioethics Committee of the university where the study was conducted (Act 080 of 2018). It was conducted between August 2018 and October 2019.

2.2 Sample size

An intentional sampling of healthy young adults between 18 and 25 years old, with right foot dominance and who accepted their participation in the study by signing the informed consent, was carried out. Students from a Colombian university were taken as the sample unit. The sample size was determined using the formula for comparison of means from a pilot test with twenty participants and with the rectus femoris muscle in the supine position. It was calculated with a 95% confidence level, a statistical power of 80%, an expected difference between phases of 100 μV and a standard deviation of 156 μV at maximum contraction, resulting from the average of the deviations in the four movement patterns, both in dynamic and isometric contraction, for a minimum sample of 38 participants. We excluded those with health conditions or injuries that prevented the movement patterns from being performed and those with severe iliopsoas and hamstrings retractions.

2.3 Participants

20 men and 20 women were evaluated, the average age was 20 years, 75% with a normal weight, the great majority without considerable muscle retractions of hip flexors and hamstrings (tables 1 and 2). Severe retractions were observed in hip adductors in 65% of the cases, but these did not interfere with the correct execution of the movement patterns.

Table 1. Descriptive of qualitative sociodemographic and functional variables

Test	Rating	Frequency	
Gender	Female	20	50,0%
	Male	20	50,0%
Weight condition	Underweight	3	7,5%
	Normal Weight	30	75,0%
	Obesity	6	15,0%
	Overweight	1	2,5%
Right hip flexors flexibility	Normal	2	5,0%
	Slight retraction	36	90,0%
	Moderate retraction	1	2,5%
Left hip flexors flexibility	Normal	5	12,5%
	Slight retraction	33	82,5%
	Moderate retraction	2	5,0%
Rear train flexibility	Normal	29	72,5%
	Retraction	11	27,5%
Right hip adductors flexibility	Normal	1	2,5%
	Slight retraction	7	17,5%
	Moderate retraction	8	20,0%
	Severe retraction	24	60,0%
Left hip adductors Flexibility	Normal	2	5,0%
	Slight retraction	5	12,5%
	Moderate retraction	7	17,5%
	Severe retraction	26	65,0%

Table 2. Descriptive of qualitative sociodemographic and functional variables

Variable	n	Mean	Standard Deviation	Minimum	Maximum
Age (years)	40	20	1,36	19,00	24,00
Weight (k)	40	63	11,20	39,90	85,00
Stature (cm)	40	167	10,49	143,00	190,00
Thomas Test for right (degrees)	39	10	7,01	0,00	40,00
Thomas Test for left (degrees)	40	8	7,93	0,00	40,00
Wells Test (cm)	40	2	8,37	-15,00	17,00
Test for elasticity of right hip adductors(cm)	40	18	6,91	5,00	29,50
Test for elasticity of left hip adductors(cm)	40	18	7,46	4,00	37,00
Body Mass Index (k/m2)	40	22	2,86	17,57	30,09

2.4 Procedure

Three active repetitions of the two lower limb diagonals described by Kabat were performed, performing consecutively the flexor and extensor patterns, both in supine and bipedal. Each pattern contained a dynamic phase at normal rhythm and an isometric phase of three seconds at the end of the movement pattern. No external resistance was applied; the knee was always kept in extension (figure 1). Half of the participants started in supine, the other half in bipedal.

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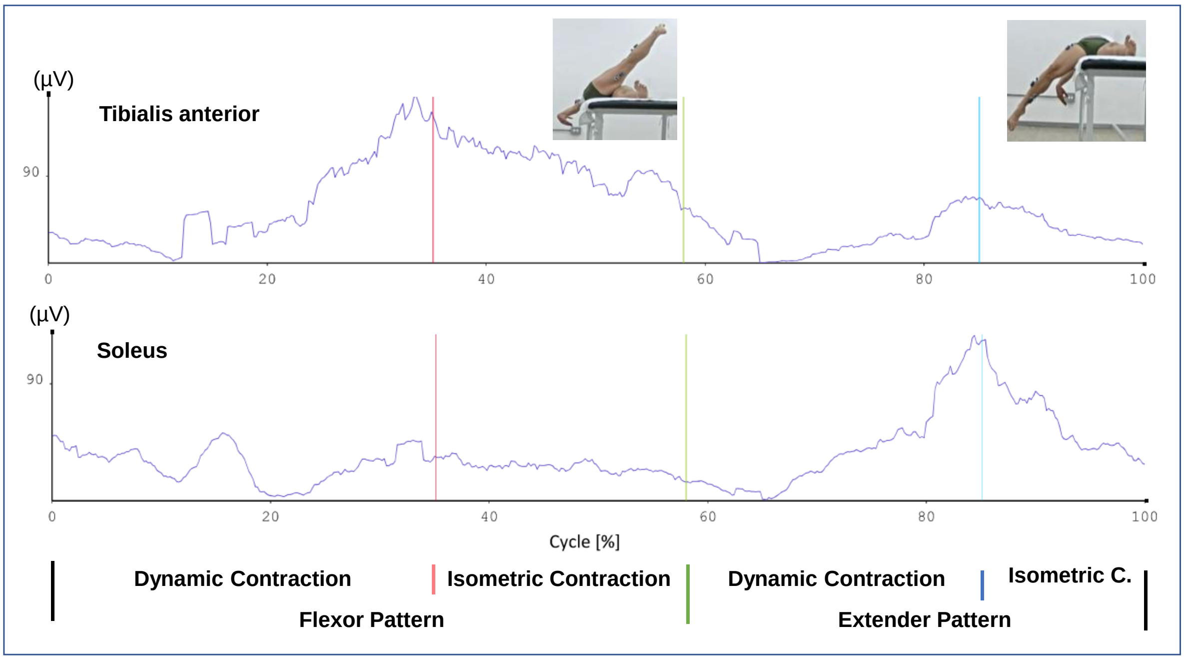

Figure 1. Electromyographic tracing in dynamic and isometric phases, first Kabat diagonal, tibialis anterior and soleus muscles

2.5 Measurements

The maximum contraction was recorded both in the dynamic and isometric phases for each movement pattern (figure 1). Three surface EMG recordings were made in each of the eight channels (rectus abdominis, ipsilateral spinal erector, contralateral spinal erector, gluteus maximus, rectus femoris, biceps femoris, tibialis anterior and soleus), the best trace was filed and the remaining two were discarded. Thus, eight EMG records per movement pattern were documented for a total of 64 per participant (eight patterns: four in bipedal and four in supine). The protocol defined for the EMG team at the Motion Analysis Laboratory of the host university was followed: BTS FREEEMG1000 dynamic surface electromyograph, 4G technology device for surface EMG analysis.

2.6 Bias control

The participants were physiotherapy students knowledgeable about the movement patterns described by Kabat, who were retrained for the procedure. A commercial electromyograph and standardized laboratory procedures were used. The person who made the EMG records was not a member of the research team. The procedure was guided by previously trained and calibrated master neurorehabilitation therapists.

2.7 Statistical Analysis

The information was processed in the SPSS Statistical Package for the Social Science version 22.0 for Windows. A description is made through univariate analysis of socio-demographic, functional and EMG characteristics for each muscle. Most EMG records did not exceed the assumption of normality ($p<0.05$), so in the comparison of means of maximum contraction, in dynamic and isometric phases, we worked with non-parametric statistics (Mann-Whitney test). Hypothesis tests for comparison of means are performed at a 95% confidence level (≤ 0.05) by applying the two-tailed test. No data was lost in data processing and analysis.

III. RESULTS

Table 3 shows the mean, standard deviation and range of maximum muscle contraction in the supine position, both in the dynamic phase and in the isometric phase. In table 4 they are presented for the bipedal position. For both positions and for all the muscles evaluated, the mean of the maximum contraction was greater in the dynamic phase. These differences were significant ($p<0.05$) for each muscle in the following patterns (table 5):

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- Rectus abdominis: D1 Supine Extensor
- Ipsilateral Spinal Erector: D1 Supine Extensor and D2 Bipedal Flexor
- Contralateral Spinal Erector: D1 Supine Extensor and both Flexor Biped Patterns.
- Gluteus maximus: in all patterns, except in D2 Bipedal flexor.
- Femoral rectus: in all extensor patterns and in D1 flexor supine.
- Biceps femoris: in all flexor patterns and in D1 flexor supine.
- Anterior Tibial: in all extensor patterns and in D1 bipedal flexor.
- Soleus: in all flexor patterns.

Table 3. Mean and range of maximum dynamic and isometric contraction in supine position (n-40)

Muscle	Test	Dynamic Contraction				Isometric Contraction			
		D1F	D1E	D2F	D2E	D1F	D1E	D2F	D2E
Rectus Abdominis	Mean (µV)	393	420	467	507	342	268	359	396
	SD	481	481	530	546	444	433	379	526
	Lower (µV)	13	13	0	15	13	14	22	10
	Upper (µV)	1590	1549	1796	1718	1717	1602	1239	1667
Ipsilateral spinal erector	Mean (µV)	417	439	472	488	286	221	353	297
	SD	422	442	502	470	353	328	411	374
	Lower (µV)	13	31	0	12	12	11	12	10
	Upper (µV)	1457	1681	1634	1700	1497	1376	1760	1634
Contralateral spinal erector	Mean (µV)	316	342	250	290	175	183	159	231
	SD	414	403	401	475	230	287	325	379
	Lower (µV)	11	1	0	0	1	0	13	0
	Upper (µV)	1564	1597	1754	2174	777	1237	1842	1689
Gluteus maximus	Mean (µV)	682	764	566	646	353	359	324	181
	SD	652	616	476	563	570	507	453	270
	Lower (µV)	14	17	3	3	9	7	3	3
	Upper (µV)	2062	1872	1976	1819	1898	1726	1942	1302
Rectus femoris muscle	Mean (µV)	252	180	179	152	195	67	168	97
	SD	242	255	107	130	208	107	132	70
	Lower (µV)	61	44	0	51	53	11	53	21
	Upper (µV)	1419	1493	543	712	1077	660	805	414
Biceps Femoris	Mean (µV)	421	422	440	469	210	214	241	318
	SD	520	555	543	540	351	342	351	449
	Lower (µV)	15	13	0	11	11	8	12	1
	Upper (µV)	1898	1977	2126	2070	1683	1805	1528	1532
Tibialis anterior muscle	Mean (µV)	199	199	180	123	161	143	183	71
	SD	172	138	125	77	137	86	147	63
	Lower (µV)	46	36	0	33	19	25	33	8
	Upper (µV)	1026	808	533	348	648	373	760	276
Soleus muscle	Mean (µV)	134	173	113	146	72	95	65	97
	SD	244	249	262	211	100	55	131	86
	Lower (µV)	18	18	0	19	12	18	10	10
	Upper (µV)	1526	1424	1675	1313	629	255	814	435

Abbreviations. SD: standard deviation; D1F: flexor pattern, first diagonal; D1E: extender pattern, first diagonal; D2F: flexor pattern, second diagonal; D2E: extender pattern, second diagonal.

Table 4. Mean and range of maximum dynamic and isometric contraction in standing position (n-40)

Muscle	Test	Dynamic Contraction				Isometric Contraction			
		D1F	D1E	D2F	D2E	D1F	D1E	D2F	D2E
Rectus Abdominis	Mean (µV)	453	489	562	560	392	398	461	439
	SD	508	548	536	542	464	48	490	472
	Lower (µV)	14	12	12	13	13	11	13	11
	Upper (µV)	1593	1888	1912	1823	1461	1743	1602	1667
Ipsilateral spinal erector	Mean (µV)	478	422	489	504	316	296	404	273
	SD	447	402	449	435	368	322	387	281
	Lower (µV)	25	23	23	27	11	17	23	23
	Upper (µV)	1536	1347	1638	1516	1569	1165	1419	1259
Contralateral spinal erector	Mean (µV)	182	185	151	153	112	99	87	106
	SD	238	242	182	174	169	105	116	97
	Lower (µV)	18	22	4	18	1	20	3	21
	Upper (µV)	1026	1081	851	937	680	452	523	558
Gluteus maximus	Mean (µV)	358	404	339	331	193	257	205	219
	SD	402	448	421	356	290	365	323	295
	Lower (µV)	13	14	13	17	12	10	12	9
	Upper (µV)	1727	1965	1621	1709	1140	1657	1512	1240
Rectus femoris	Mean (µV)	244	187	224	194	208	125	197	95

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muscle	SD	180	186	173	250	153	187	124	226
	Lower (µV)	63	47	45	45	31	13	64	9
	Upper (µV)	739	1041	999	1496	721	975	619	1393
Biceps Femoris	Mean (µV)	344	335	355	393	240	303	240	251
	SD	410	397	432	424	377	378	418	292
	Lower (µV)	22	38	27	34	11	34	11	9
	Upper (µV)	1760	1782	1874	1955	1620	1808	1587	1636
Tibialis anterior muscle	Mean (µV)	197	168	234	146	160	120	191	84
	SD	140	92	158	81	149	91	142	68
	Lower (µV)	21	34	48	40	25	22	23	18
	Upper (µV)	866	421	844	368	786	390	697	325
Soleus muscle	Mean (µV)	97	121	95	162	66	94	44	137
	SD	93	105	80	184	82	92	22	148
	Lower (µV)	23	19	17	16	16	15	13	18
	Upper (µV)	504	453	461	1204	506	491	111	925

Abbreviations. SD: standard deviation; D1F: flexor pattern, first diagonal; D1E: extender pattern, first diagonal; D2F: flexor pattern, second diagonal; D2E: extender pattern, second diagonal.

Table 5. Difference in means of maximum dynamic and isometric contraction in supine and standing (n-40)

Muscle	Test	Supine position				Standing Position			
		D1F	D1E	D2F	D2E	D1F	D1E	D2F	D2E
Rectus Abdominis	Mean Diff (µV)	50	151	108	111	61	91	101	121
	Test (Z)	0,625	2,281	0,529	1,896	0,625	0,924	1,114	1,114
	Significance	0,532	0,023*	0,597	0,058	0,532	0,356	0,265	0,265
Ipsilateral spinal erector	Mean Diff (µV)	131	218	175	135	162	126	85	231
	Test (Z)	1,636	3,349	1,732	1,463	1,665	1,655	2,415	1,058
	Significance	0,102	0,001**	0,083	0,144	0,096	0,098	0,016*	0,290
Contralateral spinal erector	Mean Diff (µV)	141	159	91	59	70	85	64	47
	Test (Z)	1,564	2,249	1,494	1,009	2,503	1,070	2,888	0,805
	Significance	0,118	0,025*	0,135	0,313	0,012*	0,285	0,004**	0,421
Gluteus maximus	Mean Diff (µV)	329	405	242	465	165	147	134	111
	Test (Z)	3,203	3,643	2,613	4,441	3,173	2,214	1,828	2,261
	Significance	0,001**	0,000**	0,009**	0,000**	0,002**	0,027*	0,068	0,024*
Rectus femoris muscle	Mean Diff (µV)	57	113	11	55	36	61	26	99
	Test (Z)	2,290	5,620	1,020	3,041	0,751	3,377	0,635	5,360
	Significance	0,022*	0,000**	0,308	0,002**	0,453	0,001**	0,525	0,000**
Biceps Femoris	Mean Diff (µV)	211	208	198	150	104	32	116	142
	Test (Z)	2,665	2,271	2,146	1,925	2,483	0,279	3,301	1,742
	Significance	0,008**	0,023*	0,032*	0,054	0,013*	0,780	0,001**	0,082
Tibialis anterior muscle	Mean Diff (µV)	38	55	-2	52	37	49	43	62
	Test (Z)	1,703	2,030	0,269	3,830	2,175	2,858	1,645	4,090
	Significance	0,089	0,042*	0,788	0,000**	0,030*	0,004**	0,100	0,000**
Soleus muscle	Mean Diff (µV)	62	78	48	49	31	27	51	25
	Test (Z)	2,858	1,578	3,147	1,107	2,925	1,530	4,811	1,251
	Significance	0,004**	0,115	0,002**	0,268	0,003**	0,126	0,000**	0,211

Abbreviations. Mean diff: mean difference; Z: Mann-Whitney test; D1F: flexor pattern, first diagonal; D1E: extender pattern, first diagonal; D2F: flexor pattern, second diagonal; D2E: extender pattern, second diagonal.
Note: the difference is obtained from subtracting the mean from the maximum isometric contraction to the dynamic; * $p<0.05$; ** $p<0.01$

IV. DISCUSSION

In both supine and bipedal position and for the eight muscles assessed (rectus abdominis, ipsilateral spinal erector, contralateral spinal erector, gluteus maximus, rectus femoris, biceps femoris, tibialis anterior and soleus), the mean of the maximum contraction was greater in the dynamic phase. The differences were significant mainly in limb musculature (four or more movement patterns), but not in the axial one.

Understanding the previous results implies distinguishing the different types of contraction that are promoted when executing the Kabat patterns, taking into account that the effectiveness in muscle activation depends on the physiological role of each of them and the production of different movement mechanics [8]. Isometric contractions are promoted from static actions. These were performed at the end of the path of the movement pattern, while dynamic contractions (that comprise all the eccentric and concentric muscular actions during which changes in muscle length, angle and range of movement are generated) were evident throughout the pattern, both agonist and antagonist.

The results in favor of dynamic contraction in the present study are consistent with those shown in the literature, which suggest greater activity during the dynamic phase when assessing different muscles through diverse activities. Warnock et al. found that, when using upper limb movement protocols from different contractions, maximum contraction levels and higher muscle activation averages were obtained for the concentric contraction protocols in contrast with the ones that used isometric contractions, with statistically significant differences in most cases [9].

For their part, Pincivero et al. analyzing the electromyographic activity at the level of the quadriceps femoris, obtained a record from highest to lowest electrical activity in the concentric, isometric and eccentric phases, respectively [10]. Kallio et al., using surface electromyography, found that concentric contractions of the soleus muscle required greater activation than isometric or eccentric contractions, with a higher rate of motor unit discharge [11]. The previous results are consistent with those of the present investigation.

In contrast, Folland et al. Argue that there is little evidence to show results of isometric contractions independent of specific muscle length; conclude that isometric training at a variety of angles could be more effective than dynamic training, although they acknowledge that smaller increases in muscle strength are generated in the latter, but throughout the entire range of motion [12].

The differences in favor of dynamic contractions in the present investigation, as in other studies [9,10,11], could be explained from the physiological foundations of the neuromuscular system, which include recruitment and de-recruitment processes of motor units that during dynamic contractions do not allow progress towards synaptic fatigue. Furthermore, the recruitment of fast-contracting fibers that occurs during dynamic contractions once the movement pattern begins, given their low resistance to fatigue, start to show a reduced effect on activation levels as this persists through isometric contraction at the end of the movement path, as it happened in the sequence of contractions executed in the present study.

The previous argument allows to explain why the main differences in the case of the present research occur at the level of the limbs and not at the level of the axial muscles, since the axial muscles are mainly composed of muscle fibers with high resistance to fatigue, meaning that the differences between the isometric and concentric phases are not statistically significant.

Another causal factor of differences between static and dynamic contractions could be changes in muscle blood flow due to these types of contraction, understanding that during isometric contraction there is greater intramuscular pressure that prevents blood flow and favors accumulation of metabolic by-products such as lactic acid, while dynamic contraction, which includes stretching and shortening of the muscle, maintains blood flow through better venous return as a result of the muscle pump [13].

On the other hand, Khanade et al. compared the different types of dynamic contractions in specific muscles such as the abdominals [14]. They found that there are no significant differences in the activity of the abdominal muscle from traditional exercises that involve concentric versus eccentric contractions without external resistance; however, they report an increase in abdominal muscle activity during the course of exercises with less activity through the eccentric phase compared to the concentric phase, which was explained from the vertical lifting against the gravitational force that provides enough resistance to require a substantial muscle recruitment in concentric contraction, different from minimal abdominal muscle recruitment while performing the downward movement in the supine position. Likewise, they suggest that, in order to provide a greater overload to the abdominal musculature in a traditional exercise, additional resistance should be provided.

In contrast to the aforementioned study, the results of the present research show, with respect to the rectus abdominis muscle, a greater dynamic activation in the eccentric phase when the lower limb diagonal is executed in the supine position, since the highest register is in an extensor pattern. These results could be attributed to the weight of the lower limb which generates a greater recruitment of fibers by acting as an external resistance, added to an important lever arm given the length of the limb.

This result can be supported by the findings already presented by Norris since 1993, who analyzed an abdominal contraction in a supine position with leg lowering, keeping the knee in extension, found that the infraumbilical portion of the rectus abdominis generates a maximum dynamic contraction in order to avoid lumbar hyperextension and guarantee stabilizing function at the pelvic level [15].

It can then be inferred that the repeated execution of Kabat diagonals of the lower limb ensures important activity for the proximal muscles, such as the abdominal ones, even without external resistance, since when working the antagonistic components of the diagonal (flexor and extensor pattern), dynamic contractions of different types are guaranteed.

With respect to the analysis of the electrical activity of muscles acting in a chain and not of specific muscles in the face of different types of contraction, as is the case of the present study, no research was found in the literature reviewed in this regard. However, Choi and Lee compared the electrical activity of the external oblique and bilateral multifidus muscles from concentric, isometric and eccentric muscle contraction of the gluteus maximus. They found that there were no statistically significant differences between the trunk muscles [16]. Despite the results in statistical terms, the researchers found that the muscular activity of the multifidus was greater during the concentric contraction of the gluteus maximus and the external oblique during the

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eccentric contraction; in addition, they found that the greatest amount of muscle activity occurred in the dominant lateral multifidus during all types of gluteus maximus contraction [16].

In another study, Lee et al. identified the influence of the activation of the gluteus maximus, from the extension of the hip and knee in the prone position, on the activation of the muscles of the posterior chain, finding that in this position the gastrocnemius also contracts [17]. This was explained by the synergistic action of the muscle and myofascial chains, which are expressed in the interdependent relationship between the muscle components, fasciae, joint capsules and bone constituents in order to maintain the stability of the lumbo-pelvic region, with the generation of muscle contractions that extend to other components.

Results such as these allow us to corroborate the importance of work in movement patterns. This is a clear example of the irradiation and reinforcement resulting from the execution of different types of contraction at the level of synergistic muscles or those not directly involved in the action, principles that are widely worked when the Kabat movement patterns are executed within the framework of specific strengthening techniques described by the method.

The facilitation techniques executed from the Kabat method include dynamic (concentric and eccentric) and static (isometric) muscle contractions that at the central nervous system level generate facilitation, increasing motor potentials and thus improving the effectiveness of movement [18]. Additionally, if the work is carried out through the diagonals, it implies an elongated path of movement that crosses the midline of the body, simulating movements performed in daily life [19].

From the above, it is concluded that in order to reach the maximum contraction without the application of external resistance in the muscles involved in each Kabat pattern, dynamic contractions (mainly concentric type) are more effective than isometric contractions in response to increased fiber recruitment, constant oxygenation of muscle cells and less chance of fatigue.

These results contribute to clinical practice and evidence that muscle reeducation through Kabat patterns, for muscles whose score is less than or equal to 3 according to scales such as Daniels', is more effective when performed in the frame of dynamic contractions without sustained phases. Likewise, they support the use of isometric contractions when the desired effect is to decrease the maximum contraction in order to achieve muscle relaxation and/or stretching effects by supporting the widely known neurophysiological principle of synaptic fatigue.

However, further studies are desirable to analyze results on dynamic and isometric strengthening with the use of PNF techniques, such as inversion of antagonists, external resistance and different types of contraction through the movement patterns described by Kabat and compared to less complete training.

V. STUDY LIMITATIONS AND RECOMMENDATIONS

There was an EMG kit with eight channels, which limited the exploration of a greater number of lower limb muscles. Future studies could explore maximum muscle contraction using external resistance in order to observe performance in dynamic and isometric phases under conditions of muscle strengthening protocols.

REFERENCES

[1]. González, A.P. and Pérez, J.E. Diseño de un instrumento para la evaluación de patrones básicos de movilidad para adultos con lesión de neurona motora superior - UAM 2002. Revista Iberoamericana de Fisioterapia y Kinesiología, 2005. **8**(2):48-58. Doi: 10.1016/S1138-6045(05)72782-9

[2]. Gain, H., Hervé. J.M., Hignet, R. and Deslandes, R. Fortalecimiento muscular en rehabilitación. EMC - Kinesiterapia - Medicina Física, 2003. **24**(3):1-10. Doi: 10.1016/S1293-2965(03)71942-2

[3]. Voss, D., Ionta, M. and Myers, B. Proprioceptive neuromuscular facilitation: patterns and techniques. Philadelphia (USA): Harper & Row; 1986.

[4]. Adler, S., Beckers, D. and Buck, M. Proprioceptive neuromuscular facilitation [Facilitación neuromuscular propioceptiva en la práctica. Guía ilustrada]. Madrid (Spain): Médica Panamericana; 2002. Spanish.

[5]. Gupta, S., Hamdani, N. and Sachdev, H.S. Effect of irradiation by proprioceptive neuromuscular facilitation on lower limb extensor muscle force in adults. Journal of Yoga and Physical Therapy, 2014. **5**(2):1-7. Doi: 10.4172/2157-7595.1000192

[6]. Kyung Lee, S., Barbosa, C.A., Andree, V.L., Vancini, R.L. and Santos, M. Do isometric, isotonic and/or isokinetic strength trainings produce different strength outcomes? Journal of Bodywork and Movement Therapies, 2018. **22**(11):430-437. Doi: 10.1016/J.Jbmt.2017.08.001

[7]. Suri, N., Pattnaik, M. and Mohanty, M. Comparative effectiveness of isometric, isotonic, isokinetic exercises on strength and functional performance of quadriceps muscle in normal subject. IOSR – Journal of Dental of Medical Science, 2017. **16**(6):66-74. Doi: 10.9790/0853-1606056674

[8]. Habibzadeh, N. Physiology of distinct modes of muscular contraction. International Physiology Journal, 2018. **1**(3):1-5). Doi: 10.14302/issn.2578-8590.ipj-18-2441.

[9]. Warnock, B., Gyemi, D., Brydges, E., Stefanczyk, J.M., Kahelin, C., Burkhart, T.A. and Andrews, D.M. Comparison of upper extremity muscle activation levels between isometric and dynamic maximum voluntary contraction protocols. International Journal of Kinesiology and Sports Science, 2019. **7**(2):21-29. Doi: 10.7575/aiac.ijkss. v.7n.2p.21

[10]. Pincivero, D.M., Gandhi, V., Timmons, M.K. and Coelho, A.J. Quadriceps femoris electromyogram during concentric, isometric and eccentric phases of fatiguing dynamic knee extensions. Journal of Biomechanics, 2006. **39**(2):246–254. Doi: 10.1016/j.jbiomech.2004.11.023

[11]. Kallio, J., Søgaard, K., Avela, J., Komi, P.V. Selänne, H. and Linnamo, V. Motor unit firing behaviour of soleus muscle in isometric and dynamic contractions. PLoS ONE, 2013. **8**(2):1–7. Doi: 10.1371/journal.pone.0053425

[12]. Folland, J.P., Hawker, K., Leach, B., Little, T. and Jones, D.A. Strength training: Isometric training at a range of joint angles versus dynamic training. Journal of Sports Science, 2005. **23**(8):817–24. Doi: 10.1080/02640410400021783

[13]. Masuda, K., Masuda, T., Sadoyama, T., Mitsuharu, I. and Katsuta, S. Changes in surface EMG parameters during static and dynamic fatiguing contractions. Journal of Electromyography and Kinesiology, 1999. **9**(1):39–46. Doi: 10.1016/S1050-6411(98)00021-2

[14]. Khanade, R., Kumar, S., Adhir, U., Ghodeshwar, K. and Singh, K. Electromygraphycal comparison of concentric and eccentric phase during selected abdominal exercise. International Journal of Physical Education and Sports Science, 2012. **3**(2):1–4. URL: http://ignited.in/I/a/1933

[15]. Norris, C.M. Abdominal muscle training in sport. British Journal of Sports Medicine, 1993. **27**(1):19–27. Doi: 10.1136/bjsm.27.1.19

[16]. Choi, HS. and Lee, S.Y. Comparison of multifidus and external oblique abdominis activity in standing position according to the contraction patterns of the gluteus maximus. Physical Therapy Rehabilitation Science, 2016. **5**(1):40–6. Doi: 10.14474/ptrs.2016.5.1.40

[17]. Lee, J.K., Hwang, J.H., Kim, C.M. and Park, J.W. Influence of muscle activation of posterior oblique sling from changes in activation of gluteus maximus from exercise of prone hip extension of normal adult male and female. Journal of Physical Therapy Science, 2019. **31**(2):166–69. Doi: 10.1589/jpts.31.166

[18]. Moreira, A.R., Lial, L., Teles, M.G., Arag, A., David, L.S., Silva, F.L. et al. Diagonal movement of the upper limb produces greater adaptive plasticity than sagittal plane flexion in the shoulder. Neuroscience Letters, 2017. **643**:8-15. Doi: 10.1016/j.neulet.2017.02.022

[19]. Shiratani, T., Arai, M., Kuruma, H. and Masumoto, K. The effects of opposite-directional static contraction of the muscles of the right upper extremity on the ipsilateral right soleus. Journal of Bodywork and Movement Therapies, 2017. **21**(3):528-33. Doi: 10.1016/j.jbmt.2016.08.004

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