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ORIGINAL ARTICLE

Accuracy of The Acute Effects of Stretching and Heating on Muscle Power in Amateur Athletes

Acuracia dos efeitos agudos do alongamento e aquecimento sobre a potência muscular em atletas amadores

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ABSTRACT

Introduction: It is known that stretching and warming are two widely discussed modalities among health professionals. The two modalities present several effects on variables discussed in the scientific environment, such as: muscular power, flexibility, injury prevention, muscular performance, exercise performance, among others. However, we can see a paucity of studies that elucidate the advantages of stretching and heating in relation to muscular power. **Objective:** To investigate the effects of stretching and heating on muscular power, evaluating the variables with the tests: Counter Movement Jump (CMJ), Squat Jump (SJ) and Drop Jump (DJ). **Method:** The non-probabilistic type of convenience sample consisted of 21 physically active individuals evaluated by the short IPAQ questionnaire. The muscular power was evaluated through the Squat Jump (SQ), Drop Jump (DJ) and Counter Movement Jump (CMJ) tests, before and after the interventions. At first, a randomization was carried out to determine which intervention would be performed first (stretching or heating), and after an interval of at least 24 hours, the second encounter with the other intervention was performed. **Results:** According to the findings, we noticed that there was a significant difference in the heating intervention in the Counter Movement Jump test in the variables of jump height, flight time and speed ($P < 0.05$). For the Drop Jump test, we can see a significant difference in the variables of reactive force index and jump height ($P < 0.05$). In the Squat Jump test, no significant difference ($P > 0.05$) was found in any of the analyzed variables. **Conclusion:** According to the present study, we can conclude that muscle heating had better benefits for the variables evaluated by CMJ and DJ. Not observing changes when the volunteers performed muscle stretching for none of the evaluated tests.

Keywords: Muscle Stretching Exercises; Muscle Contraction; Running.

RESUMO

Introdução: Sabe-se que o alongamento e o aquecimento são duas modalidades bastante discutidas entre os profissionais da área da saúde. As duas modalidades apresentam diversos efeitos em variáveis discutidas no meio científico, como: potência muscular, flexibilidade, prevenção de lesões, performance muscular, desempenho no exercício, dentre outras. Contudo, podemos perceber uma escassez de estudos que elucidam as vantagens do alongamento e do aquecimento em relação à potência muscular. **Objetivo:** Investigar os efeitos do alongamento e do aquecimento sobre a potência muscular, avaliando as variáveis com os testes Counter Movement Jump (CMJ), Squat Jump (SJ) e Drop Jump (DJ). **Método:** A amostra do tipo não

probabilística por conveniência foi constituída por 21 indivíduos fisicamente ativos avaliados pelo questionário curto IPAQ. Foi avaliado também a potência muscular através dos testes Squat Jump (SQ), Drop Jump (DJ) e Counter Movement Jump (CMJ), antes e após as intervenções. Em um primeiro momento, foi realizada uma randomização para saber qual intervenção seria feita primeiro (alongamento ou aquecimento), e após intervalo de, no mínimo, 24 horas, foi realizado o segundo encontro com a outra intervenção. **Resultados:** Segundo os achados, percebemos que houve diferença significativa na intervenção aquecimento no teste Counter Movement Jump nas variáveis de altura do salto, tempo de voo e velocidade (P<0,05). Para o teste Drop Jump, podemos perceber diferença significativa nas variáveis de índice de força reativa e altura do salto (P<0,05). Já no teste Squat Jump não foi encontrado em nenhuma das variáveis analisadas, diferença significativa (P>0,05). **Conclusão:** De acordo com o presente estudo, podemos concluir que o aquecimento muscular obteve melhores benefícios para as variáveis avaliadas pelo teste CMJ e DJ. Não observando mudanças quando os voluntários realizaram alongamento muscular para nenhum dos testes avaliados.

Palavras-chave: Exercícios de alongamento muscular; Treinamento de resistência; Corrida use Carrera.

INTRODUCTION

It is known that the option of stretching or warming up muscles as preparation for physical exercise is the focus of much discussion among sports professionals[1,2,3]. The techniques are widely used from recreational activities to high-level sports, aiming at preventing injuries[4], improving muscular performance[5], increasing joint range of motion [6], among other objectives[2].

Static stretching aims to increase mobility and ROM[7]. The ideal stretching time to acquire these gains is still much debated and according to Bandy et al., 1997[8], the time needed is 30 to 60s for a more effective result.

In line with these findings, Gonçalves et al., 2012[9], evaluated the acute and chronic effects of a stretching program on flexibility and horizontal impulsion, realizing that stretching brought deficits in the muscle strength variable, however, it has benefits in the impulsion and flexibility variables. About stretching time in strength performance, according to Paulo et al., 20121[10], exercises that increase muscular flexibility, consequently, tend to decrease maximum strength capacity, both in the upper and lower limbs.

Another modality is muscle warm-up, which is a great option for improving muscle power[12], always seeking benefits such as preparation for the exercise to be practiced and reducing injuries, which is a factor widely discussed in the scientific community[2,4, 13,16].

Although some evidence reports disagreements about which type of warm-up is most beneficial, there are conclusions that warm-up performed aerobically tends to improve the speed of chemical reactions in the human body, however, one should focus on the principle of specificity[14,15].

A meta-analysis performed by Fradkin et al., 2010[16], showed that after muscle warm-up, there was an improvement in performance and sports performance. Warming up before practicing sports is effective for better physical performance, allowing the body to better adapt to the stress of physical exercise[17].

According to Wojtys et al., 1996[18] and Emery et al., 2005[19], the warm-up proved to be effective in muscular power, in which athletes participated in a warm-up program, resulting in an improvement in side jumping and static balance in female soccer players, however, there is an obstacle during clinical practice and a lack of studies regarding the comparison of stretching and warming up on muscle power. The present study aims to compare the effects of warming up and stretching on muscle power, evaluating through the Counter Movement Jump (CMJ), Squat Jump (SJ), and Drop Jump (DJ) tests.

METHODS

This respective randomized clinical trial experimental study performed in a university at Juiz de Fora - MG, after approval by the Research Ethics Committee aimed to analyze the effects of warming up and muscle stretching on muscular power. The study used the following inclusion criteria (patients aged 18 to 60 years, both genders, practicing some type of sport and with no previous history of surgery) and exclusion (reporting osteomyoarticular pain, obese (= or >30kg/m^2), pregnant women, patients with heart problems). 21 individuals were recruited and initially instructed to read and sign the Informed Consent Form, in accordance with Resolution 466/12.

An interview was performed to complete the validated International Physical Activity Questionnaire (IPAQ), where we assessed the level of physical exercise practiced by the individuals. Muscle power was also evaluated using the tests: Squat Jump (SJ), Drop Jump (DJ), and Counter Movement Jump (CMJ). The SJ is described as follows: volunteers squat to start the test, then they

must jump once as high as they can, keeping their knees straight while jumping and finishing the movement in a squat position again. In relation to the DJ test, the participant will begin a fall with the dominant lower limb onto a 50 centimeters high box, then he must jump from the surface of the box towards the ground, when he touches his feet to the ground he must jump once as much as possible. as high as he can while keeping his knees straight during the jump and, when returning, he should keep his knees bent in a squat position. In the CMJ test, the participant will start the test in an orthostatic position, then flex his knees, performing a small squat followed by a maximum jump, keeping his knees straight and arms hanging during the flight, and the test must be completed in orthostatic position. Participants will be instructed to perform all tests before and after the interventions, being evaluated using the MYJUMP application[2].

Initially, a randomization was performed to identify which intervention would be performed first, and after an interval of at least 24 hours for the physiological variables to return to resting conditions[20]. The second meeting with the other intervention was performed. The warm-up intervention was performed on the treadmill for 5 minutes and the intensity was according to the maximum HR, according to the target zone calculated by age[21]. The intervention with static stretching consisted of 3 sets of 30 seconds on the hamstring muscles, triceps surae, rectus femoris, hip adductors, and hip abductors, being performed bilaterally[2]. The study was approved by the Research Ethics Committee of the School of Medical and Health Sciences of Juiz de Fora – SUPREMA (FCMS/JF-SUPREMA), under CAAE 91937018.4.0000.5103. Initially, for data analysis, the normality of the data was tested, validating the use of parametric statistics.

Data were presented as mean ± standard deviation, minimum, and maximum for descriptive statistics. To compare the effect of stretching and warm-up on the CMJ, DJ, and SJ tests, before and after the interventions, the paired t-test was performed. To compare the stretching versus warm-up groups for jump height in the CMJ test, the one-way ANOVA test was used. All analyses were performed using the GraphPad Prism Software[5] (2015), adopting a significance level of 5%.

RESULTS

The present study aimed to evaluate stretching and warming up on the variables of three tests from the MYJUMP application[2]. The CMJ and SJ analyze the variables of jump height, flight time, speed, strength, and muscular power, while the DJ analyzes the variables of reactive force index, jump height, flight time, contact time, and stiffness. To this end, the study variables were analyzed on the pre- and post-intervention period for comparison at the end.

According to the findings, we noticed that there was a significant difference in the warm-up intervention in the CMJ test in the variables of jump height, flight time, and speed ($P<0.05$). For the DJ test, we could identify a significant difference in the reactive strength index and jump height variables, since $P<0.05$. Finally, in the SJ test, no significant difference was found in any of the variables analyzed ($P>0.05$). The descriptive analysis of the sample can be seen in table 1.

Table 1. Demographic characteristics of individuals in the sample (n= 21).

Variable	Mean ± Standard deviation; (Minimum and Maximum)
Age	32.48 ± 13.01 (18 and 60)
Weight	71.06 ± 12.70 (46 and 98.50)
Height	1.67 ± 0.08 (1.52 and 1.80)
BMI	25.70 ± 3.93 (17.90 and 31.40)

BMI= Body Mass Index.

Of these participants, 75% were classified as very active, according to the IPAQ questionnaire. These data are observed in Table 2.

Table 2. Frequency of distribution of individuals according to the IPAQ short form questionnaire.

Variable	(n=21)	%
Insufficiently active	1	5
Active	5	20
Very active	15	75

Legend: AF= Absolute Frequency; PF= Percentage Frequency.

After analyzing the data using the one-way ANOVA test, the stretching versus warm-up groups were compared for the jump height variable in the CMJ test. We observed that the variable post-warm-up jump height was significantly different for all other groups evaluated: pre- and post- warm-up jump height and pre- and post-stretching.

After analysis using the paired-T test, we verified that muscle warm-up was significant for the variables: jump

height, flight time, and speed. These data are observed in table 3.

In the analysis of the paired-T test, it was found that muscle warm-up was not significant in any of the variables analyzed in the SJ test. These data are observed in table 4.

In the analysis of muscle warm-up for the DJ test, we found that muscle warm-up was significant only for the variables reactive strength index and jump height. These data are observed in table 5.

For the analysis of muscle stretching, we verified that it was not significant in any of the variables analyzed in the CMJ test. These data are observed in table 6.

For the SJ and DJ test, muscle stretching was not significant in any of the variables analyzed in the SJ test. These data are observed in tables 7 and 8.

DISCUSSION

This study aimed to evaluate the effects of stretching and warming up on muscle power through the CMJ, SJ, and DJ evaluation tests. The secondary aim was also to verify the frequency of physical exercise of individuals using the IPAQ short-form questionnaire (Table 2).

Table 3. Pre- and post-warming-up CMJ.

CMJ variables	Warm-up		p - value
	Pre	Post	
Jumping height	23.88 -9.09	26.48 - 10	0.0099*
Flight time	433.05 - 86.59	456.43 - 87.04	0.005*
Speed	1.06 - 0.21	1.12 - 0,21	0.0041*
Strength	2173.5 -1107	2107.9 -1056.6	0.9556
Power	2311.6 -1488.2	2445.5 -1365.2	0.2266

Table 4. Squat Jump pré e pós aquecimento.

SJ variables	Warm-up		p - value
	Pre	Post	
Jump height	21.30 - 8.14	22.55 - 8.64	0.1975
Flight time	410.10 - 79.39	418.48 - 81.26	0.2784
Speed	1942.55 - 910.09	1976.58 - 925.94	0.1906
Strength	2173.5 -1107	2107.9 -1056.6	0.3447
Power	1959.68 - 1046.46	2021.01 - 1191.39	0.4792

Table 5. Pre- and post-warm-up DJ test.

DJ variables	Warm-up		p - value
	Pre	Post	
Reactive force index	0.60 - 0.20	0.68 - 0.22	0.0159*
Jump height	21.73 - 8.52	24.25 - 9.64	0.0075*
Flight time	413.14 - 83.63	404.72 - 126.63	0.7389
Contact time	721.57 - 141.17	678.95 - 150.74	0.9507
Stiffness	2.46 - 1.17	2.69 - 1.23	0.1737

Table 6. Pre- and post-stretching CMJ.

CMJ variables	Alongamento		p - value
	Pre	Post	
Jump height	23.38 - 7.51	24.21 - 6.97	0.1244
Flight time	430.76 - 73.50	439.81 - 63.93	0.1019
Speed	1.06 - 0.18	1.08 - 0.16	0.0892
Strength	2102.18 - 1062.74	2002.20 - 1085.91	0.5395
Power	2312.66 - 1417.39	2192.21 - 1275.92	0.5427

Table 7. Pre- and post-stretching SJ.

SJ variables	Stretching		p - value
	Pre	Post	
Jump height	21.25 - 6.88	21.38 - 6.09	0.8554
Flight time	397.58 - 106.47	413.52 - 58.74	0.3655
Speed	1.01 - 0.17	1.01 - 0.14	0.717
Strength	1922.17 - 1008.41	1924.08 - 992.78	0.9871
Power	1992.37 - 1222.70	1999.47 - 1110.09	0.9564

Table 8. *Drop Jump* pré e pós alongamento.

DJ variables	Stretching		p - value
	Pre	Post	
Reactive force index	0.64 - 0.18	0.63 - 0.16	0.9498
Jump height	22.62 - 7.77	22.21 - 7.94	0.6713
Flight time	422.95 - 76.2	418.52 - 76.62	0.629
Contact time	688.05 - 97.93	674.24 - 78.55	0.4551
Stiffness	2.85 - 1.37	2.74 - 1.14	0.5605

According to the findings, we could find that the majority of volunteers depend on a large amount of time during the week to perform physical exercises, being considered in the present study as very active. We evidenced a significant difference in the warm-up intervention in the CMJ test, in the variables of jump height, flight time, and speed. For the DJ test, we found a significant difference in the Reactive Strength Index and Jump Height variables after the warm-up and finally, in the SJ, no significant difference was found in the analyzed variables.

We can observe in the literature that muscle warm-up has physiological effects that can promote improvement in physical capacity, such as increased temperature[22], increased blood flow[23], altered sensitivity of the Golgi tendon organ [24], increased synovial fluid [25]. Pagaduan et al., 2012[26], evaluated the jumping performance in the CMJ test in 29 healthy football players, performing different warm-up protocols (which consisted of five minutes of running at a pre-defined pace, dynamic static stretching, and passive static stretching). The results revealed that the five-minute run, whether or not associated with dynamic stretching, showed greater gains than static stretching in CMJ scores. According to the authors, a possible mechanism for this superiority is a better ability to form cross-bridges and better activation of the central nervous system with an increased firing rate for motor units during running. In line with these results, Healy and Harrison, 2014[27], evaluated a gluteal activation protocol

based on a standardized dynamic warm-up, seeking to analyze performance in the vertical jump, and noticed in their results that on the 1st and 2nd days, there was a significant difference in contact time, flight time and vertical ground reaction force scores. However, in a study performed by Franco and Reyes 2016[28], which aimed to verify the specificity of a warm-up for muscular performance, they found that specific high-intensity warm-up training resulted in a worsening of the vertical jump score. One explanation for these findings is the tendency for volunteers to enter into the anaerobic glycolytic pathway, thus increasing the concentration of blood lactate and thus decreasing the availability of ATP[29].

Given the different forms of warm-up, the increase in load has been observed in programs to improve vertical jump, however, no difference was observed for the groups analyzed[30]. In this way, the present study intended not to use a load for the volunteers, minimizing the possibility of them increasing the concentration of blood lactate. It seems satisfactory for improving performance in jumping, consistent running programs lasting four to five minutes at a submaximal pace associated with specific exercises aiming at improving the athletes' neural factor[31]. It is commonly observed in recent literature, the muscle warm-up programs combining static and dynamic stretching exercises[32]. Although several pieces of evidence report that muscle stretching can promote loss of performance [33,34,35], investigations report that it can be beneficial for muscle power, agility, and increased muscle activity[36,37]. It is noted that musculotendinous stiffness has an impact on force transmission and can be fundamental for performance in the vertical jump[38], thus, the inclusion of muscle stretching can become essential in a performance improvement program.

In our results, we did not observe differences in the stretching intervention for the tests applied. A plausible explanation for our findings is the change in the length-tension curve of the muscle after stretching, because when the sarcomeres move to a greater length, the overlap zone decreases drastically, generating a decrease in muscle tension due to the reduction in the formation of cross bridges[3]. Thus, new studies are suggested with greater limitations in relation to the sport to be practiced, age group of participants, level of conditioning, longer and shorter durations of different stretches, new pre-defined warm-up intensities, longer time to familiarize themselves with the evaluative tests, and larger sample.

The present study used passive stretching in its methodology in 3 series of 30 seconds, corroborating the methodology imposed by Pinto et al., 2014[39]. In a meta-analysis, the acute effects of passive static stretching on muscular strength, power, and explosive muscular performance were observed, and the authors demonstrated that passive stretching had negative effects on the three variables, however, they reported that the shorter the stretching time lengthening, the lower the negative effects on the variables analyzed.

In this same context, Robbins and Scheuermann, 2008[40], investigated three different static stretching times at jump height and noticed that performance decreased after the intervention of 6 sets of 15 seconds, with no difference during other interventions with less number of series. Static stretching, when compared to dynamic stretching, can contribute differently to muscular power, with reports of losses in performance up to 24 hours after intervention with static stretching and even in recovery intervals between exercise sets in athletes[41], corroborating the idea that shorter stretching times can contribute to improved performance [42].

Torres et al.[43], showed that the time of five minutes or more after stretching causes the body to dissipate its possible effects, thus, the present study adopted in its methodology the application of the CMJ, DJ and SJ, immediately after performing the stretches, intending to assess acutely and minimize any possibility of having the effects of the stretching neutralized. Chronic effects of muscle stretching were noticed in a study performed by Hunter and Marshall 2002[11], whose vertical jump performance in a 10-week training program consisting of flexibility exercises was able to increase performance in the CMJ test by factors such as increased use of elastic energy in muscles and greater contribution from contractile components. Therefore, the present study can contribute significantly to individuals who perform jumping exercises, highlighting the implementation of warm-up exercises with running at a submaximal pace and the use of low-duration stretching exercises, although this study has not compared different stretching times. However, the literature is not conclusive, so exercisers should be cautious when using long-term stretching before certain tasks that require improved jumping performance.

CONCLUSION

The results of the present study suggest that muscle warm-up is capable of promoting benefits in the jump height variable in the CMJ and DJ tests, with no changes being observed when the volunteers performed muscle stretching for any of the variables in the evaluated tests. Thus, new studies are suggested with greater limitations about the sport to be practiced, age group of participants, level of conditioning, longer and shorter durations of different stretches, new pre-defined warm-up intensities, longer time to familiarize themselves with the evaluative tests, and larger sample.

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