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# EVALUATION OF ANKLE MOBILITY IN CROSSFIT PRACTITIONERS WITH AND WITHOUT PATELLOFEMORAL PAIN

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## ABSTRACT

One of the most common knee injuries related to CrossFit is patellofemoral dysfunction. This dysfunction is characterized by an ill-defined pain of insidious onset, located in the anterior retropatellar region and/or peripatellar knee. Its etiology is multifactorial and can lead to a change in patellar alignment or kinematics during knee flexion-extension movements. The aim of this study was to determine whether there is a difference in ankle range of motion in Closed Kinetic Chain in CrossFit practitioners with and without anterior knee pain. This is a quantitative; cross-sectional; observational; analytical and comparative study and was carried out in CrossFit boxes in a city in the southwest of Bahia with the following stages: (1) recruitment of participants, invitation and referral as accepted or not; (2) selection of participants; (3) data collection that was carried out with each research participant; (4) data analysis and systematization of results. The Lunge Test was used to assess participants aged between 18 and 50. From the data collected, it was not possible to state that ankle mobility deficit in dorsiflexion is a risk factor for the development of patellofemoral dysfunction.

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# INTRODUCTION

CrossFit is a sport that consists of performing a variety of functional exercises at high intensity and has grown in popularity since it was founded by former gymnast Greg Glassman in 1995 (Virtuosity Crossfit, 2012). The training provides an increase in muscle mass, gains in strength, power, speed and muscle definition, lowers the body mass index (BMI) and improves cardiorespiratory conditioning (Glassman, 2016). This sport can be practiced by people of any age, as long as it is done in a safe environment and accompanied by a professional (Da Costa et al. 2019). However, the safety of practicing this sport has been questioned because it involves specific high-intensity exercises that result in a high incidence of injuries (Da Costa, 2019). With the increase in the number of athletes, the idea that there is a high incidence of injuries among practitioners of this sport is becoming increasingly widespread (Moreira et al. 2022). Current literature still cautiously associates CrossFit with a higher risk of injury (Mendes, 2015). However, like any other high-intensity sport, there is a likelihood of injury, although it is lower than in other more popular sports.

In general, research shows that the regions most affected by CrossFit are the shoulder, lumbar spine and knee (Gomes and Moreno, 2017; Nunes and Pinheiro, 2018). One of the most common CrossFit-related knee injuries is patellofemoral dysfunction (PFD). This dysfunction is a musculoskeletal condition characterized by the insidious onset of ill-defined pain, located in the anterior retropatellar and/or peripatellar region of the knee (Willy et al. 2019). According to the authors, the symptoms can be acute and progress with worsening pain in lower limb loading activities such as: squatting, sitting for a long time, going up/down stairs, jumping or running, especially on slopes. This can limit participation in physical activities, sports and work, and can persist for years. According to Moreira (2022), there is a scarcity of literature on injuries that occur in CrossFit practitioners and athletes, especially on injuries that affect the knee region. And through current evidence we can see that some relationships have been established between knee injuries and ankle dorsiflexion limitation, emphasizing the importance of this hypothesis for identifying associated risk factors in order to develop preventive strategies (Santos, 2019). According to Santos (2019), the range of motion (ROM) of dorsiflexion and the strength of the plantar flexor muscles are

important in absorbing the impact forces during the landing of the jump, and a change in any of these factors could directly interfere with the absorption and transmission of the ground reaction force in the athlete's body and also in the kinetics and kinematics of the movements involved in the jump. Another theory is that the ankle joint with its proper ADM is essential for the correct execution of the deep squat, otherwise, without proper dorsiflexion, it can generate compensations, including increased hip, lumbar and trunk flexion. It should be noted that the ideal dorsiflexion ADM for those who play sport is 45° and that a reduction in this ankle dorsiflexion ADM has been determined to be a risk factor for some conditions such as patellar tendinopathy and PFD, and a deficit in dorsiflexion ADM is a possible contributor to excessive knee valgus and has been associated with mechanical alterations in landing (Neto et al. 2020). Although CrossFit is a form of training that brings many health and aesthetic benefits, poor execution of the movements ends up resulting in musculoskeletal injuries. Based on this, physiotherapy plays a fundamental role in identifying alterations in the biomechanics of the human body and correcting them before they lead to injury. Based on the above, the aim of this study was to see if there is a difference in ankle dorsiflexion (ADM) in Closed Kinetic Chain (CCF) in CrossFit practitioners with and without anterior knee pain.

# MATERIALS & METHODS

This is a quantitative, cross-sectional, observational and analytical study carried out in CrossFit boxes. Data collection took place in CrossFit boxes in a city in the southwest of Bahia and took place in the morning and evening, from September to October 2023. A total of 39 CrossFit athletes from different training boxes took part in the study, 12 men and 27 women, given that the city has at least three training boxes. The volunteers were recruited by convenience.

The following items will be assigned as inclusion criteria: (1) age between 18 and 50 years. This age range was assigned because it takes into account the musculoskeletal changes that can influence the research due to the changes caused by aging beginning after 30 to 40 years of age (Constantino, et al. 2019). (2) anyone who agrees to take part in the study. (3) have a minimum training frequency of 3 times a week. Exclusion criteria will be the following: (1) cognitive limitations that prevent them from understanding the questions set out in the questionnaires; (2) being under the use of pharmacological resources for knee pain; (3) having had intra-articular drugs applied to the knee in the last 6 months; and (4) not signing the ICF.

The following instruments were used for data collection: (1) Socio-demographic questionnaire with questions related to aspects of daily life such as: profession; age (18-50 years); gender; height; frequency of training per week; perception of effort; body weight; how long they have been practicing; whether or not they use anabolic steroids; where they spend most of the day (work, school, home); whether they work standing up or sitting down; history of injury, site of injury and whether they have had surgery. The information obtained from this instrument was used to better characterize the profile of the participants; (2) AKPS questionnaire specific for PFD (Lee et al. 2023); (3) Lunge Test to assess ankle dorsiflexion in a closed kinetic chain. The participants were assessed before training so that there was no interference in the results (Santos, 2019). The Lunge Test is a test that assesses closed kinetic chain (CCF) dorsiflexion. The Lunge Test was used to determine the dorsiflexion ROM of the ankle joint. During the assessment process, a measuring tape line was placed on the floor perpendicular to the wall. The participant with both hands resting on the wall in front of him positioned one foot on the tape, placing the hallux at the 10 cm mark, the other leg to be placed behind in a comfortable position. The participant was asked to lean forward, bringing their knee close to the wall, without lifting their heel off the ground. If the heel rises, the participant must continue moving the foot until the test is completed without lifting it, keeping the heel of the dominant foot in contact with the ground and the knee of the dominant leg fully extended. The test was carried out three times with a 10-second interval, and the results of the second and third assessments were used to calculate the average for the final result. For the assessment, a digital inclinometer was used which is placed at the midpoint of the anterior border of the tibia (15 cm below the anterior tuberosity of the tibia) with a P.A.MED tape measure. The digital inclinometer used was Clinometer version 4.9.4 for the Apple iPhone XR smartphone, whose function is to report the inclination of a segment in real time using the position of the smartphone. The data obtained is used to determine the degree of dorsiflexion ADM of the research participants (Santos, 2019). The data was tabulated and processed using Jamovi software version 2.3.21. The Shapiro Wilk test was used to verify the normality of the data. The paired Student's t-test was used to obtain the correlation between the means of the symptomatic and non-symptomatic groups. For all the tests, a significance level of $p<0.05$ was adopted, with 95% reliability. The tables and graphs were plotted in Microsoft Office® Excel 2013Plus. The work was submitted to the Research Ethics Committee of the Faculdade Independente do Nordeste - FAINOR and approved under protocol No. 73135723.7.0000.5578, following the ethical precepts of research involving human beings.

# RESULTS

The data was analyzed using Jamovi software. The normality of the data was tested using the Shapiro Wilk test. Mean and standard deviation were calculated for anthropometric data and for the results of the Lunge Test and AKPS. This study looked at the demographic data (Table 1) of the participants in order to assess the correlation between variables such as age, weight, height and BMI, where it was possible to see that the sample (n = 39) was divided into 27 women with an average age of 32.7 ± 8.18 (p = 0.162), and 12 men with an average age of 31.3 ± 7.14 (p = 0.442). Females had an average weight of 63.7 kg ± 7.56 (p = 0.931) and males had an average weight of 82.5 kg ± 8.46 (p = 0.660). With regard to height, the mean values for women were 161.3cm ± 7.39 (p = 0.730) and for men 176.4cm ± 4.46 (p = 0.146). BMI showed the following values for women with a mean of 24.5 ± 3.37 (p = 0.010) and men with a mean of 26.3 ± 1.96 (p = 0.314).

**Table 1. Demographic data**

| | SEX | N | Mean | Median | Standard deviation | W | P |
|---|---|---|---|---|---|---|---|
| AGE | FEM | 27 | 32.7 | 32 | 8.18 | 0.945 | 0.162 |
| | MALE | 12 | 31.3 | 29.5 | 7.14 | 0.936 | 0.442 |
| WEIGHT | FEM | 27 | 63.7 | 64.0 | 7.56 | 0.983 | 0.931 |
| | MASC | 12 | 82.5 | 82.3 | 8.46 | 0.952 | 0.660 |
| HEIGHT | FEM | 27 | 161.3 | 160 | 7.39 | 0.975 | 0.730 |
| | MALE | 12 | 176.4 | 177.0 | 4.46 | 0.897 | 0.146 |
| BMI | FEM | 27 | 24.5 | 24.0 | 3.37 | 0.894 | 0.010 |
| | MALE | 12 | 26.3 | 26.5 | 1.96 | 0.923 | 0.314 |

Table 2 shows the data from the Lunge Test evaluation with a sample (n = 39) of males and females in general, with values for the right side showing an average of 36.1 ± 8.42 (p = 0.017), and the left side an average of 35.9 ± 9.08 with a significance value of (p = 0.005).

**Table 2. Raw data from the Lunge Test results**

| | N | Mean | Median | Standard deviation | W | P |
|---|---|---|---|---|---|---|
| Lunge Test D | 39 | 36.1 | 39.0 | 8.42 | 0.929 | 0.017 |
| Lunge Test E | 39 | 35.9 | 38.5 | 9.08 | 0.913 | 0.005 |

Table 3 below shows the Lunge Test results for women (n = 27), with the right side averaging 34.8 ± 8.63 (p = 0.009) and the left side averaging 34.5 ± 9.57 (p = 0.008), and for men (n = 12), with the right side averaging 39.0 ± 7.46 (p = 0.833) and the left side averaging 39.3 ± 7.14 (p = 0.745). Given the results of the Lunge Test for all the participants, it was not possible to identify a significant difference when comparing side D and E, as the mean values were approximately the same.

**Table 3. Lunge Test data between men and women**

| | SEX | N | Mean | Median | Standard deviation | W |
|---|---|---|---|---|---|---|
| Lunge Test D | FEM | 27 | 34.8 | 37.5 | 8.63 | 0.892 |
| | MALE | 12 | 39.0 | 39.3 | 7.46 | 0.964 |
| Lunge Test E | FEM | 27 | 34.5 | 38.0 | 9.57 | 0.890 |
| | MALE | 12 | 39.3 | 40.0 | 7.14 | 0.957 |

By analyzing the data, it was possible to correlate the presence and absence of pain in men and women with the Lunge Test. For women without pain (n = 15) with a mean of 32.1 ± 8.46 (p = 0.517), and with pain (n = 12), a mean of 33.5 ± 8.13 (p = 0.334). For men without pain (n = 9) with a mean of 32.9 ± 7.15 (p = 0.342), with pain (n = 3), and a mean of 26.7 ± 5.69 (p = 0.510), shown in Table 4.

**Table 4. Shows the relationship between the presence of pain in men and women**

| PAIN | SEX | N | Mean | Median | Standard deviation | W | p |
|---|---|---|---|---|---|---|---|
| NO | FEM | 15 | 32.1 | 32 | 8.46 | 0.950 | 0.517 |
| | MALE | 9 | 32.9 | 31 | 7.15 | 0.914 | 0.342 |
| Yes | FEM | 12 | 33.5 | 32.5 | 8.13 | 0.925 | 0.334 |
| | MALE | 3 | 26.7 | 25 | 5.69 | 0.936 | 0.510 |

The data from the participants who had knee pain was plotted with the Lunge Test data and compared with the E and D sides. Table 5 shows that the p-values were not significant.

**Table 5. Comparison between Lunge Test values and knee pain**

| | | Statistic | gl | p |
|---|---|---|---|---|
| Lunge Test D | t de Student | -0.0786 | 37.0 | 0.938 |
| Lunge Test E | t de Student | -0.3858 | 37.0 | 0.702 |

# DISCUSSION

The study sought to draw up an overview of athletes with and without anterior knee pain to try to correlate with ankle dorsiflexion mobility, and one of the main findings of the demographic data was a greater number of women (27) than men with (12) participants. The study by Mokos and Huber (2021), which looks at the main motivations for practicing the sport in a CrossFit box, corroborates a prevalence of women joining of 63% compared to men 37% of a total of 81 people, where it points out that health and aesthetics are the main motivational factors, and showed that the main motivation for women was the search for weight loss and muscle tone aimed at aesthetics. In relation to the Lunge Test data between men and women, it was possible to observe a higher average for men compared to women who presented values below normal, where the values found were 39.15º and 34.65º for men and women respectively. The literature recommends an ADM of 36º above normal for healthy people and 45º as the ideal value for athletes (Konor et al. 2012). Regarding the presence of knee pain, the results showed no difference between symptomatic and asymptomatic women in relation to the Lunge Test. This finding contradicts the study by Window et al. (2018), where it was possible to identify that women aged 40 years and above have lower ankle dorsiflexion ADM and greater foot mobility compared to age-matched controls. However, reduced ankle mobility in dorsiflexion may be one of the factors contributing to the development of PFD in the context of greater dynamic valgus (Hassan et al. 2022). In addition, studies assessing the three-dimensional kinematics of the lower limb and trunk of individuals with PFD during some weight-bearing activities have reported excessive ipsilateral trunk tilt, pelvic drop, hip adduction and internal rotation, knee abduction and hindfoot pronation (Dos Reis et al. 2022). It was possible to observe a greater number of symptomatic women than men. It is important to note that the number of men was limited compared to women. However, the literature shows that women between the ages of 18 and 35 have a higher prevalence of developing this type of dysfunction (Dos Reis et al. 2022). According to Coburn (2018), this condition is one of the most frequent lower limb dysfunctions in orthopaedic clinics, with a prevalence of 23%, and an incidence of 1 in 5 in the general population, with women being affected twice as often as men (Smith et al. 2018). Some studies have correlated hindfoot kinematics with hip kinematics in women suffering from patellofemoral pain, reporting delays in peak and increased eversion of the foot (at the moment of initial contact during gait) and increases in internal rotation of the tibia, generating a predisposition to the development of PFD (Dos Reis et al. 2022). It was possible to identify that participants of both sexes had knee pain in relation to the Lunge Test data. This means that it is not possible, based on our findings, to state that the individuals who had knee pain had a limitation related to ankle dorsiflexion ROM. However, reduced ankle mobility in dorsiflexion may be one of the factors contributing to the development of PFD in the context of greater dynamic valgus (Hassan et al. 2022). In addition, studies assessing the three-dimensional kinematics of the lower limbs and trunk of individuals with PFD during some weight-bearing activities have reported excessive ipsilateral trunk tilt, pelvic drop, hip adduction and internal rotation, knee abduction and hindfoot pronation (Dos Reis et al. 2022). During the collection of demographic data, women predominated over men, resulting in a heterogeneous sample. This was due to the fact that women were more likely to take part in the study, since participation was by convenience. Time was a limiting factor in getting a larger number of people to take part in the assessment, given that most of the participants arrived at training time. The logistics of getting to the place where the research was carried out was an issue that ended up making it difficult for us to get from one place to another. During data collection, we realized that the limb dominance factor could be an additional variable to include in the study.

# CONCLUSION

According to the results found, this study cannot state that ankle dorsiflexion ROM deficit is directly related to knee pain because the sample was heterogeneous, which influenced the results, and because there are other risk factors that can develop PFD, such as posterolateral hip complex (PLC) strength deficit, quadriceps weakness, hamstring shortening and changes in knee biomechanics. Therefore, more studies are needed with a larger, homogeneous sample and the application of more specific functional tests for the lower limbs to identify the possible factors that can trigger the development of PFD.

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