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Research Article

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Plantar Pressure Distribution And Postural Stability In Young Adults Diagnosed With Complete Rupture Of Anterior Cruciate Ligament

José Roberto Sammartino Krettelys[1], Matheus Brito Rocha[2], Pedro Mariano Coelho Neto[3], Pedro Henrique Vieira Partata[2] and Fernanda Grazielle da Silva Azevedo Nora[4*]

[1]Department of Orthopedics and Traumatology Hospital Nossa Senhora do Pari, São Paulo, SP, Brazil

[2]Department of Orthopedics and Traumatology Hospital Municipal Antônio Giglio – Osasco, SP, Brazil

[3]Department of Orthopedics and Traumatology Pontifícia Universidade Católica de São Paulo, Campus Sorocaba, Sorocaba, SP, Brazil

[4]Faculty of Physical Education and Dance UFG – Universidade Federal de Goiás, Goiânia, Goiás, Brazil Avenida Esperança s/n, Campus Samambaia, Goiânia, Goiás, Brazil

[*]Corresponding Author
HFernanda Grazielle da Silva Azevedo Nora, Faculty of Physical Education and Dance UFG – Universidade Federal de Goiás, Goiânia, Goiás, Brazil Avenida Esperança s/n, Campus Samambaia, Goiânia, Goiás, Brazil Orcid: 0000-0002-0880-1326

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Abstract

Objective: *analyze alterations in plantar pressure distribution and balance in young adults diagnosed with a complete ACL rupture, as well as to evaluate the impact of these conditions on athletic performance.*

Methodology: *This study involved 34 young adults, divided into two groups based on the presence or absence of a complete Anterior Cruciate Ligament (ACL) rupture. The study's methodology included specific inclusion and exclusion criteria, ethical considerations, an experimental protocol involving plantar pressure distribution and bipodal open-eye postural control assessments, and statistical analysis using Minitab 21 software. The plantar pressure was recorded using a Baroscan Podotech platform, and the displacement amplitude of the center of pressure (COP) was evaluated in both anteroposterior (COPAP) and mediolateral (COPML) directions. The results were analyzed for normality, homogeneity, and differences within the group, with a p-value ≤ 0.05 considered statistically significant. Results: In this study, all participants in Group A, who all had an injury to the right knee, served as a crucial criterion for their inclusion and an important reference point for the analysis. The Center of Pressure Anteroposterior (COPAP) measurement in Group A was 17.79 cm (±0.82), while in Group B, this measurement was significantly higher, at 25.10 cm (±1.04). The difference between the two groups was statistically significant (p=0.01). As for the Center of Pressure Medial-lateral (COPML) measurement, it was 14.47 cm (±9.99) in Group A and 10.80 cm (±0.69) in Group B. Again, the difference between the two groups was statistically significant (p=0.01).*

Conclusion: *The study concludes that a complete rupture of the Anterior Cruciate Ligament (ACL) significantly influences the Anteroposterior (COPAP) and Mediolateral (COPML) Center of Pressure measures but may have less impact on plantar pressure distribution. A trend of higher pressure in the Forefoot compared to the Rearfoot was observed in both groups, possibly due to biomechanical changes following an ACL rupture. These findings, which align with recent studies, suggest that while plantar pressure and center of pressure measurements are important for diagnosing foot problems and monitoring gait and posture, an ACL rupture may have a less pronounced impact on plantar pressure distribution. Further research is needed, but these insights could have important implications for the rehabilitation and management of individuals with an ACL rupture.*

Keywords: Anterior Cruciate Ligament, Center of Pressure, Plantar Pressure Distribution, Biomechanical Changes

1. Introduction

Joint instability, alteration in plantar pressure distribution, and balance are commonly observed phenomena in young adults diagnosed with a complete rupture of the Anterior Cruciate Ligament (ACL). ACL rupture, a prevalent sports injury, can lead to a range of complications, including joint instability [1-3].

Joint instability occurs when the normal range of motion of a joint is affected, often resulting in increased joint mobility. In the case of an ACL rupture, this can lead to anterior knee instability, where the knee tends to "give way" during physical activities 1,2.

Furthermore, ACL rupture can result in changes in plantar pressure distribution. Plantar pressure refers to the pressure exerted on the sole of the foot during activities such as standing and walking. Studies have indicated that individuals with ACL rupture may exhibit abnormal plantar pressure distribution, which can impact their walking and running mechanics [1-4].

Therefore, athletes with functional ankle instability have shown significantly different plantar pressure distribution during walking compared to healthy individuals3,4. Although this study focused on the ankle, it is conceivable that similar alterations in plantar pressure distribution may occur in individuals with ACL rupture.

Balance is also a concern among individuals with ACL rupture. Knee instability can lead to impaired balance, increasing the risk of falls and other injuries. Additionally, alterations in plantar pressure distribution may affect an individual's balance, as plantar pressure plays a crucial role in maintaining balance during gait and other activities [1-4].

Thus, the present study aimed to analyze alterations in plantar pressure distribution and balance in young adults diagnosed with a complete ACL rupture, as well as to evaluate the impact of these conditions on athletic performance.

2. Methodology

2.1. Participants

This study involved the participation of 34 young adults of both sexes, divided into two groups: group A comprised young adults without complete ACL rupture, while group B consisted of young adults with complete ACL rupture resulting from a traumatic event (Sports Practice and Daily Life Activities). The average age of the participants was 21.48 (±2.67) years in both groups. Table 1 presents the characterization of the study participants.

	GROUP A	GROUP B
Body mass (kg)	70,00 (±12,10)	77,25 (±14,23)
Height (cm)	160 (±0,07)	173 (±0,11)
Foot Size	37,10 (±1,44)	40,15 (±2,79)
Legend: Group A: young adults diagnosed with complete ACL rupture; Group B: young adults without injury, values are presented as mean ± standard deviation.		

Table 1: Characterization of Participants

2.2. Inclusion and Exclusion Criteria

To ensure sample consistency, we established specific inclusion and exclusion criteria. Exclusion criteria encompassed the presence of neurological dysfunctions, history of lower limb prosthesis use, and the existence of deformities or calluses on the plantar surfaces. Regarding inclusion criteria, participants were required to have a confirmed diagnosis of complete anterior cruciate ligament (ACL) rupture to be included in Group A. For Group B, participants should not present any type of knee injury, thus falling within the target group of interest.

2.3. Ethical aspect

All participants received a detailed explanation of the study's objectives and procedures before taking part. Each participant voluntarily consented, formalizing their agreement by signing the Informed Consent Form. The research project was approved by the Ethics Committee of the Federal University of Goiás, under registration number 6.232.443, ensuring compliance with ethical principles and participant protection.

2.4. Experimental Protocol

For the assessment of plantar pressure distribution and bipodal open-eye postural control, three attempts were conducted with eyes open. During these attempts, young adults stood on the plantar pressure platform with their feet hip-width apart, fixating their gaze on a red luminous point on the wall at eye level. Upon hearing a sound signal, they maintained a static stance for 60 seconds.

Plantar pressure recording was conducted using a Baroscan Podotech plantar pressure platform, which measures 50x50cm and is equipped with 4,096 capacitive sensors, allowing precise measurement of pressure exerted on participants' feet. The sampling rate used was 50Hz, meaning the platform captured data at a rate of 50 times per second, providing detailed information on plantar pressure distribution during assessments.

Hence, the displacement amplitude of the center of pressure (COP) was evaluated in both anteroposterior (COPAP) and mediolateral (COPML) directions, expressed in centimeters, representing the distance between the maximum and minimum COP positions in both directions. Plantar pressure distribution was analyzed based on pressures distributed across the foot support base.

2.5. Statistical analysis

The data were analyzed using Minitab 21 software. Normality of distributions and data homogeneity were checked. To determine differences within the group, the non-parametric Tukey test was

applied, considering a p-value ≤ 0.05 as statistically significant. Results were presented as mean and standard deviation, providing a clear description of the data.

3. Results

All participants in Group A of this study share a common characteristic: they all experienced an injury to the right knee. This specific condition not only defines the composition of Group A but also establishes a crucial criterion for the inclusion of participants in this group. The injury to the right knee, therefore, serves as an important reference point for the analysis and comparison of the results obtained in this study.

The Table 2 presents the behavior of plantar distribution and Center of Pressure during Bipodal Postural Control. Therefore, in Group A, the COPAP (Center of Pressure Anteroposterior) measurement was 17.79 cm (±0.82), while in Group B, this measurement was significantly higher, at 25.10 cm (±1.04). The difference between the two groups was statistically significant (p=0.01).

	GROUP A	GROUP B	P – VALUE
COPAP (cm)	17,79 (±0,82)	25,10 (±1,04)	**0,01***
COPML (cm)	14,47 (±9,99)	10,80(±0,69)	**0,01***
% Plantar Pressure Rearfoot - Right Foot	42,80 (±12,89)	38,06 (±10,89)	0,07
% Plantar Pressure Forefoot - Right Foot	57,19 (±12,89)	61,93 (±10,78)	0,09
% Plantar Pressure Rearfoot - Left Foot	40,29 (±16,52)	38,93 (±10,78)	0,07
% Plantar Pressure Forefoot - Left Foot	59,70 (±16,52)	61,06 (±10,75)	0,09

Legend: GA = Young adults diagnosed with complete ACL injury; GB = Young adults without knee injury; % Percentage of plantar pressure distribution. *Significant Tukey test (p < 0.05). Data are presented as mean values and ± standard error.

Table 2: Behavior of plantar distribution and Center of Pressure during Bipodal Postural Control

As for the COPML (Center of Pressure Medial-lateral) measurement, it was 14.47 cm (±9.99) in Group A and 10.80 cm (±0.69) in Group B. Again, the difference between the two groups was statistically significant (p=0.01).

Regarding the behavior of plantar distribution in the Rearfoot (heel) and Forefoot (toes), the plantar pressure measurements in the rearfoot and forefoot, for both the right and left feet, did not show significant differences between the two groups. However, a tendency of higher pressure in the forefoot compared to the rearfoot was observed in both groups.

Therefore, the COPAP and COPML measurements showed significant differences, while the plantar pressure measurements did not show significant differences. This suggests that complete ACL rupture may have a significant impact on COPAP and COPML, but not necessarily on plantar pressure distribution.

4. Discussion

The results presented in Table 2 are consistent with recent research in the field of foot biomechanics. In Group A, the COPAP (Anteroposterior Center of Pressure) measure was 17.79 cm (±0.82), contrasting with the 25.10 cm (±1.04) observed in Group B. This difference was statistically significant (p=0.01) [5-9].

As for the COPML (Mediolateral Center of Pressure) measure, Group A presented 14.47 cm (±9.99), while Group B recorded 10.80 cm (±0.69). Again, the difference between the groups was statistically significant (p=0.01) [5-9].

Regarding the plantar distribution in the Rearfoot (heel) and Forefoot (toes), the plantar pressure measures in both groups did not reveal significant differences between the right and left foot. However, a trend of higher pressure in the Forefoot compared to the Rearfoot was observed in both groups [5-9].

Thus, while the COPAP and COPML measures showed significant differences, the plantar pressure measures did not demonstrate relevant disparities. This suggests that a complete rupture of the Anterior Cruciate Ligament (ACL) may significantly influence the COPAP and COPML, but not necessarily the plantar pressure distribution [5-9].

These findings are in line with recent studies that have highlighted the importance of plantar pressure and center of pressure measurements in diagnosing foot problems and monitoring gait and posture1. The development of accurate and reliable foot plantar pressure measurement systems has been a focus of recent research [5].

In addition, the observation of a trend of higher pressure in the Forefoot compared to the Rearfoot is consistent with other studies that have reported similar findings6. This could be related to the biomechanical changes that occur in the foot and lower limb following an ACL rupture [6].

The lack of significant differences in plantar pressure measures between the groups could suggest that the impact of an ACL rupture on plantar pressure distribution may be less pronounced than its impact on the center of pressure measures [7-9]. However, more research is needed to further investigate this.

This finding provide valuable insights into the impact of an ACL rupture on foot biomechanics and could have important

implications for the rehabilitation and management of individuals with this condition [5-9].

5. Conclusion

Based on the presented results, it can be concluded that a complete rupture of the Anterior Cruciate Ligament (ACL) may significantly influence the Anteroposterior (COPAP) and Mediolateral (COPML) Center of Pressure measures. However, the plantar pressure distribution may be less affected by an ACL rupture than the center of pressure measures. Additionally, a trend of higher pressure in the Forefoot compared to the Rearfoot was observed in both groups, which could be related to the biomechanical changes that occur in the foot and lower limb following an ACL rupture.

These findings align with recent studies that highlight the importance of plantar pressure and center of pressure measurements in diagnosing foot problems and monitoring gait and posture. The lack of significant differences in plantar pressure measures between the groups may suggest that the impact of an ACL rupture on plantar pressure distribution may be less pronounced than its impact on the center of pressure measures. However, more research is needed to further investigate these observations. These findings provide valuable insights into the impact of an ACL rupture on foot biomechanics and could have important implications for the rehabilitation and management of individuals with this condition.

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