The analysis of COP and joint position sense in university soccer players with and without ankle instability

Antônio Francisco de ALMEIDA NETO*  
Alex CASTRO*  
Luciano Fernandes CROZARA*  
Márcio Fagundes GOETHEL*  
Pedro Vieira Sarment MOREIRA*  
Mauro GONÇALVES*  
Adalgiso Coscrito CARDOZO*  

*Instituto de Biociências, Universidade Estadual Paulista, Rio Claro, SP, Brasil.

CDD. 20.ed. 796.023  
796.024  
796.33  
http://dx.doi.org/10.1590/1807-55092016000300601

Abstract

The aim of the study was to compare the behavior of COP and passive ankle position sense in subjects with and without functional ankle instability. Took part in this study 20 subjects, divided into two groups: stable group (SG) and unstable group (UG). The COP evaluation was made with the single-leg balance test, with eyes opened and closed, on a force plate. The passive ankle position sense test was performed with subjects blindfolded. The ankle was positioned in a target angle (10° and 20°) and the dynamometer moved passively the ankle, then the subjects were instructed to push the stop button when they feel that the ankle was on the target angle, obtaining the absolute angular error (AAE). The following variables were obtained: total displacement (TD); antero-posterior (SDap) and medio-lateral standard deviation (SDml); total mean velocity (TMV); antero-posterior (MVap) and medio-lateral mean velocity (MVml). The comparison between the data with normal distribution was made with the Student’s t test, while to the TD and SDml was used the Mann-Whitney test. The correlations were performed with the Pearson and Spearman tests. We adopted $\alpha < 0.05$. We observed difference between AAE-10° (p < 0.05). Strong correlations were found between: AAE-10° and TMV (p < 0.01 $r = -0.867$); AAE-10° and MVap (p < 0.01 $r = -0.854$); AAE-10° and MVml (p < 0.01 $r = -0.771$), with eyes opened, and AAE-10° and TD (p < 0.05 $r = -0.666$); AAE-10° and SDap (p < 0.05 $r = -0.685$) and AAE-10° and MVml (p < 0.05 $r = -0.766$) with eyes closed. Ankle sprains harm the joint position sense without affecting the balance.

Key Words: Ankle sprain; Proprioception; Balance; Biomechanics.

Introduction

The soccer is one of the most popular sport modality around the world, with millions of practitioners of different levels, and thus, the incidence of injuries are expressive. Among these injuries, the ankle sprain is the one that stands out. Repeated episodes of ankle sprains may negatively affect the proprioception, which correspond to the perception of position and movement (i.e., synesthesia) of the body and its segments. These information are provided by mechanoreceptors in the muscles, tendons, skin, joint capsules and ligaments. These mechanoreceptors are sensitized by mechanics energy imposed to the joint and it is transmitted to the central nervous system by afferent impulses. As a consequence to sprains, the afferent fibers of the
mechanoreceptors joints become damaged, impairing particularly the joint position sense, resulting in a situation known as the functional ankle instability (FAI)\(^{14-16}\), which is defined by Freeman\(^{17}\) as a complain of “false subjective perception”. Hertel\(^{18}\) attributed its causes to deficits in the joint position sense, reduced muscle strength, delay in fibular muscles activation, equilibrium deficits, alterations in the activity of the fibular nervous and decrease in the dorsiflexion range of the movement, and its residuals symptoms may remain for long periods\(^{19}\).

Due to its proximity with the base of support, the ankle is essential to the balance maintenance, and the proprioceptive deficit evoked by the FAI tends to worst the postural stability control, as a consequence to the larger displacement of the center of pressure (COP) and also resulting in a longer time to recovery the stability\(^{13}\). Garn and Newton\(^{23}\) observed that individuals with FAI present losses in the joint position sense, which could be one of the reasons for the lower performance in the COP stabilization.

The aims of the present study were to compare the behavior of the COP displacement and the passive ankle position sense between practitioners of field- and indoor-soccer with and without FAI, as well as to verify the relationship/correlation between the passive ankle position sense and the displacement of the COP variables.

**Method**

**Sample**

Twenty male individuals that take part in field- and indoor-soccer at the university level, with a minimum of three years of experience, were allocated in one of two groups: without functional ankle instability (stable group - SG) or with functional ankle instability (unstable group - UG). For the SG the ankle were classified as dominant (D) and non-dominant (ND); for the UG the ankle were classified as stable (E) or instable (I), despite dominance. For between groups comparison purpose the dominant ankle of the SG were paired with the unstable ankle of the UG, given that previous studies did not demonstrate significant difference on COP behavior between the dominant and non-dominant lower limbs of healthy individuals\(^{25-26}\).

Both groups had a training frequency of three times a week, and participated in three championship during the whole year. The individuals’ characteristics are presented in TABLE 1. The perceptual of body fat were measured with the skinfolds method\(^{27}\) and the body density was calculated accordingly\(^{28}\).

<table>
<thead>
<tr>
<th>TABLE 1 - Groups’ characteristics.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SG (n = 10)</strong></td>
</tr>
<tr>
<td>Age (years)</td>
</tr>
<tr>
<td>Height (m)</td>
</tr>
<tr>
<td>Body mass (kg)</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
</tr>
<tr>
<td>Body fat (%)</td>
</tr>
<tr>
<td>Time experience (years)</td>
</tr>
</tbody>
</table>

The groups were divided according to the Cumberland Ankle Instability Tool (CAIT) score, proposed by Hiller et al.\(^{29}\), which was adapted to the Brazilian population by Noronha et al.\(^{30}\). The questionnaire is composed by nine multiple-choice questions, with scores between zero to 30, whereas the higher the score the better the ankle condition. The threshold that separate individuals with higher risk to develop FAI was 27, and scores ≤ 24 indicates moderate FAI\(^{29,31-32}\). For the present study, a score of 24 was adopted as a cut point, whereas individuals with values lower or equal to 24 were classified as unstable. The scores for both groups are presented in TABLE 2.

The present study did not include individuals with sprains of degree I or II in the last six months, ankle sprains of degree III, fractures in the lower limbs, surgical procedures to the lower limbs, vestibular disorders, and/or mechanic instability evaluated by the test of anterior laxity and talus inclination.
TABLE 2 - Cumberland Ankle Instability tool (CAIT) score for both groups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>D/U</th>
<th>ND/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG (n = 10)</td>
<td>27.50 ± 1.84</td>
<td>27.10 ± 1.60</td>
</tr>
<tr>
<td>UG (n = 10)</td>
<td>20.30 ± 4.03</td>
<td>26.00 ± 2.87</td>
</tr>
</tbody>
</table>


Evaluations

Initially, the anamnesis, ankle sprain historic, physical characteristics and anthropometric data were collected. Additionally, it was performed the

TABLE 3 - Goniometry (degrees) of inversion and eversion for both groups.

<table>
<thead>
<tr>
<th>INV</th>
<th>D/U (º)</th>
<th>ND/S (º)</th>
<th>D/U (º)</th>
<th>ND/S (º)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SG (n = 10)</td>
<td>28.80 ± 4.34</td>
<td>30.20 ± 4.16</td>
<td>18.20 ± 3.19</td>
<td>19.00 ± 4.24</td>
</tr>
<tr>
<td>UG (n = 10)</td>
<td>27.80 ± 5.03</td>
<td>28.40 ± 3.24</td>
<td>16.60 ± 4.53</td>
<td>18.80 ± 5.98</td>
</tr>
</tbody>
</table>

After anamnesis, the subject was familiarized with the single-leg balance test. The subject was positioned in the center of the force platform (OR6-6; AMTI®), with an acquisition frequency of 2000 Hz, and it was instructed to hold on the single-leg position for 20 seconds. Data were collected throughout the ForceNet (AMTI®) software. The lower limb that maintained contact with the force platform was held with a small knee flexion and a neutral position for the ankle, whereas the lower limb suspended hold on with the hips and knee flexed (FIGURE 1). The single-leg balance test was performed with the eyes open and with eyes closed (blindfolded), with both the lower limbs. During the test with the eyes open a circular target were positioned in front of the subjects. Three attempts was performed for each condition with a 20 seconds rest interval between them. If the subject performed any kind of jump, or touched the floor/platform with the suspended limb the test was repeated. The dominance test was composed of kicking a ball in a target of one meter of width positioned at 10 meters away; climb a step with 20 cm of height; and recovery the balance after a hard push applied in the middle point between the shoulder blades in an anterior-posterior way, causing the subject to give a step forward to maintain balance.

TABLE 3 depicted the goniometry values.

FIGURE 1 - Equilibrium test with single-leg support.

After that, the passive ankle position sense test was performed. The test was performed in a dynamometer isokinetic Biodex System 4 Pro (Biodex®), with a sample frequency of 100 Hz. The data were collected using the Biodex Advantage...
software (Biodex®). Firstly, the researcher positioned the ankle of the subject passively, starting from a neutral position, with angular velocity of 1º/s, with 10º of inversion and held for 10 seconds. After that, the dynamometer was adjusted to perform the movement with an angular velocity of 1º/s. Then, the subject was instructed to reposition the segment at the same angle in which it was held for 10 seconds, stopping the dynamometer manually by pressing the stop button. The same procedure was repeated for the 20º of inversion position. The difference between the position establish by the protocol and the one assumed by the subject was considered as the proprioceptive deficit (absolute angular error - AAE, in degrees). The test was performed twice with the subject blindfolded to avoid any visual support (FIGURE 2). The subjects had up to two attempts to familiarize with the procedure. This procedure was performed for both lower limbs.

- Total displacement (TD): sum of the root mean square of the squares of the displacement in the anterior-posterior displacement and medium-lateral during the 20 seconds of test;
- Standard deviation anterior-posterior (SDap): standard deviation of the mean of the displacement in the anterior-posterior direction during the 20 seconds of test;
- Standard deviation medium-lateral (SDml): standard deviation of the mean of the displacement in the medium-lateral during the 20 seconds of test;
- Total mean velocity (TMV): mean of the velocity of the displacement in the anterior-posterior and medium-lateral direction during the 20 seconds of test;
- Anterior-posterior mean velocity (MVap): mean of the velocity of the displacement in the anterior-posterior direction during the 20 seconds of test;
- Medium-lateral mean velocity (MVml): mean of the velocity of the displacement in the medium-lateral direction during the 20 seconds of test;

The data regarding the passive joint reposition were obtained with the Biodex Advantage (Biodex®) software. The AAE values were acquired for the angle of 10º (AAE-10º) and 20º (AAE-20º).

Statistical analysis

Data were analyzed with the SPSS Statistic 18.0 (SPSS®) software. Firstly, all data were tested for normality, after that, the statistical test was used accordingly.

All data considered normal according to the Shapiro-Wilk test were analyzed with the Student t test. Only the variables TD and SDml did not met the criteria for normality, thus, they were analyzed with the Mann-Whitney test. Similarly, the relationship between variables for the normal data was performed with Pearson’ correlation; for the non-normal data the Spearman’s correlation was used. The significant level for all variables was set as $\alpha < 0.05$.

Results

TABLE 4 depicted the center of pressure displacement, TD, SDap, SDml, TMV, MVap, MVml, during the single-leg balance test with the eyes open (EO) and eyes closed (EC) in the SG and UG.
COP and joint position sense in the ankle instability

**TABLE 4 - Variables of the center of pressure during the single-leg balance test with the eyes open and eyes closed.**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Eyes open</th>
<th>Eyes closed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SG (n = 10)</td>
<td>UG (n = 10)</td>
</tr>
<tr>
<td>TD (mm)</td>
<td>310.22 ± 39.52</td>
<td>302.55 ± 6.07</td>
</tr>
<tr>
<td>SDap (mm)</td>
<td>0.0070 ± 0.0012</td>
<td>0.0069 ± 0.0015</td>
</tr>
<tr>
<td>SDml (mm)</td>
<td>0.0049 ± 0.0011</td>
<td>0.0051 ± 0.0015</td>
</tr>
<tr>
<td>TMV (m/s)</td>
<td>0.0792 ± 0.232</td>
<td>0.0743 ± 0.0156</td>
</tr>
<tr>
<td>MVap (m/s)</td>
<td>0.0680 ± 0.0201</td>
<td>0.0651 ± 0.0004</td>
</tr>
<tr>
<td>MVml (m/s)</td>
<td>0.0284 ± 0.0095</td>
<td>0.0246 ± 0.0035</td>
</tr>
</tbody>
</table>

**Discussion**

The present study compared the displacement of the center of pressure and the joint position sense of university students that practiced soccer with and without FAI. The variables related to COP did not present significant differences between the SG and UG in the present study. Ross et al. observed that individuals with FAI exhibited higher values for TD, SDml, MVap and MVml. However, these authors demonstrated that the most sensible variables to distinguish between individuals with and without FAI were the standard-deviation of the median-lateral ground reaction force (GRF-SDml) and the anterior-posterior stabilization time (STap), though, neither were analyzed in the present study. Hertel and OLMSTED-KRAMER showed that traditional measures of the COP, may not be sensible enough to detect differences between individuals with and without FAI, given that MVap was the only variable (among other eight) that exhibit significant differences between the SG and UG.

**TABLE 5 - Between-groups comparison for absolute angular error (AAE) in the passive joint reposition test.**

<table>
<thead>
<tr>
<th>Angle</th>
<th>SG (n = 10)</th>
<th>UG (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAE-10° (º)</td>
<td>1.29 ± 0.90</td>
<td>2.82 ± 1.70*</td>
</tr>
<tr>
<td>AAE-20° (º)</td>
<td>1.89 ± 1.33</td>
<td>1.73 ± 1.17</td>
</tr>
</tbody>
</table>

SG: stable group, UG: unstable group. * Significant different to SG (p<0.05.)

**TABLE 6 - Correlation coefficient between the absolute angular error and the center of pressure variables.**

<table>
<thead>
<tr>
<th>AAE x</th>
<th>10°</th>
<th>20°</th>
<th>EO</th>
<th>EC</th>
<th>EO</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD</td>
<td>0.700*</td>
<td>-0.595</td>
<td>0.632</td>
<td>-0.321</td>
<td>0.872</td>
<td>0.590</td>
</tr>
<tr>
<td>SDap</td>
<td>0.099</td>
<td>-0.551</td>
<td>0.248</td>
<td>-0.517</td>
<td>0.996</td>
<td>-0.002</td>
</tr>
<tr>
<td>SDml</td>
<td>0.585*</td>
<td>-0.198</td>
<td>0.126</td>
<td>-0.201</td>
<td>0.875</td>
<td>0.057</td>
</tr>
<tr>
<td>TMV</td>
<td>0.362</td>
<td>-0.302</td>
<td>0.001**</td>
<td>-0.867</td>
<td>0.995</td>
<td>0.002</td>
</tr>
<tr>
<td>MVap</td>
<td>0.399</td>
<td>-0.301</td>
<td>0.002**</td>
<td>-0.854</td>
<td>0.963</td>
<td>0.017</td>
</tr>
<tr>
<td>MVml</td>
<td>0.32</td>
<td>-0.351</td>
<td>0.009**</td>
<td>-0.771</td>
<td>0.825</td>
<td>-0.081</td>
</tr>
</tbody>
</table>

SG: stable group; UG: unstable group; TD: total displacement; SDap: anterior-posterior standard deviation; SDml: medium-lateral standard deviation; TMV: mean total velocity; MVap: anterior-posterior mean velocity; MVml: medium-lateral mean velocity.
Análise do COP e sentido de posição em jogadores universitários de futebol com e sem instabilidade de tornozelo

O objetivo do estudo foi comparar o comportamento do COP e do sentido de posição articular passivo em indivíduos com e sem instabilidade de tornozelo, e correlacionar as variáveis de COP e sentido de posição articular passivo. Participaram 20 indivíduos, divididos em dois grupos: grupo estável (GE) e grupo instável (GI). A avaliação do COP foi feita com o teste de apoio unipodal, com olhos abertos e fechados sobre uma plataforma de força. O teste de reposicionamento articular passivo foi realizado com os olhos vendados. O tornozelo foi posicionado em um ângulo alvo (10° e 20°) e o dinamômetro movia passivamente o tornozelo, então os participantes eram instruídos a apertar o botão para parar o movimento quando sentissem que o tornozelo estava no ângulo alvo, obtendo assim o erro angular absoluto (EAA). Foram obtidas as variáveis: deslocamento total (DT); desvio padrão ântero-posterior (DPap) e médio-lateral (DPml); velocidade média total (VMT); velocidade média ântero-posterior (VMap) e médio-lateral (VMml). A comparação entre dados
COP and joint position sense in the ankle instability

References


