Patient reported outcomes are associated with lower-limb muscle strength and functional performance in Acl-patients – A cross-sectional study

Larsen, Anders Holsgaard; Jensen, Carsten; Aagaard, Per

Published in:
Osteoarthritis and Cartilage

DOI:
10.1016/j.joca.2014.02.222 showArticle Info

Publication date:
2014

Document version
Early version, also known as pre-print

Citation for published version (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain.
- You may freely distribute the URL identifying the publication in the public portal.

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
moment, knee adduction angular impulse) and varus degrees on the frontal plane of knee joints after operation (P < 0.05). Besides, significant changes were also found in spatiotemporal variables and VAS pain score (P < 0.05). But, there were no gait difference between cemented and cementless cases.

**Conclusions:** Our data suggested that both cemented and cementless TKA can help to improve walking ability of subjects but no significant differences were found between them. So further long term follow up comparison research are urgent needed and the results may help to further understand the advantages and disadvantages between them.

**Conclusions:** Longitudinal differences in symmetry and imbalance patterns between CBA and Str/ort mice indicate different gait modification during normal growth periods and OA development. Assuming treadmill task non-compliance is linked with OA, our data suggest that hind-limb asymmetry is more closely related to OA development, but that fore-limb asymmetry tempers these hind-limb OA effects. Vitality, capacity for swing: stance asymmetry and paw area gait moderation index to predict Str/ort mouse non-compliance in the treadmill task supports their use as early OA markers.

**Results:** All 20 CBA, but only 3/22 Str/ort mice completed treadmill tasks until 36wks of age; 9 Str/ort mice dropped-out between 16-28wks and a further 10 at 32 wks. Results were consistent for both SI and SR for all gait characteristics. Longitudinal pattern of SI differed in hind- and fore-limbs for swing: stance ratio, in hind-limb paw area (Figure 1) and stance time (p = 0.03) in CBA and Str/ort mice. Str/ort had lower fore-paw area SI than CBA mice. SI did not differ in CBA and Str/ort for stride length, frequency, swing, propel or brake time; the majority remained stable in hind- but not in fore-limbs. Longitudinal GMI patterns differed between strains (swing: stance, paw area (Figure 2); propel time p = 0.001) except stride length and frequency. SI for hind-limb swing:stance (HR = 1.72, 95% CI: 1.20-2.48, p = 0.004 for per 10 units increase) and GMI for paw area (HR = 0.52, 95% CI:0.27-1.04, p = 0.04, for per 0.1 units increase) were predictors of treadmill non-compliance in Str/ort mice.

**Conclusions:** Longitudinal differences in symmetry and imbalance indices as predictors of treadmill task non-compliance in Str/ort mouse OA development.

**Results:** Twenty-two male Str/ort and 20 CBA mice (non-OA prone) were monitored longitudinally and gait measurements (Digigait™ system) taken at 4wk intervals from age 8-36wks or until treadmill task non-compliance; a period encompassing pre-OA and overt, active OA phases in Str/ort mice. Spatiotemporal gait measurements including swing, brake, propel and stance times, stride length and frequency, and paw area were each used to calculate: symmetry index (SI = 100% × [R-L]/[0.5% × (R+L)]), and symmetry ratio (SR) = max(R,L) / min(R,L), where R and L were right and left contralateral hind- or fore-limbs. We also defined gait moderation index (GMI) as max[(RR-LF),(LR-RF)], where RR, LR, RF, LF referred to right-hind, left-hind, right-fore and left-fore limbs. Linear mixed effects models were employed to assess difference in gait symmetry between CBA and Str/ort mice. Models included the effects of strain, age and strain*age interaction, as well as random mouse effect. Time-dependent Cox regression models were used to assess effects of SI, SR and GMI on early treadmill task non-compliance in Str/ort aged 16-28wks. Hazard ratio (HR) and its 95% confidence interval (CI) are presented.

**Results:** Twenty-two male Str/ort and 20 CBA mice (non-OA prone) were monitored longitudinally and gait measurements (Digigait™ system) taken at 4wk intervals from age 8-36wks or until treadmill task non-compliance; a period encompassing pre-OA and overt, active OA phases in Str/ort mice. Spatiotemporal gait measurements including swing, brake, propel and stance times, stride length and frequency, and paw area were each used to calculate: symmetry index (SI = 100% × [R-L]/[0.5% × (R+L)]), and symmetry ratio (SR) = max(R,L) / min(R,L), where R and L were right and left contralateral hind- or fore-limbs. We also defined gait moderation index (GMI) as max[(RR-LF),(LR-RF)], where RR, LR, RF, LF referred to right-hind, left-hind, right-fore and left-fore limbs. Linear mixed effects models were employed to assess difference in gait symmetry between CBA and Str/ort mice. Models included the effects of strain, age and strain*age interaction, as well as random mouse effect. Time-dependent Cox regression models were used to assess effects of SI, SR and GMI on early treadmill task non-compliance in Str/ort aged 16-28wks. Hazard ratio (HR) and its 95% confidence interval (CI) are presented.

**Results:** All 20 CBA, but only 3/22 Str/ort mice completed treadmill tasks until 36wks of age; 9 Str/ort mice dropped-out between 16-28wks and a further 10 at 32 wks. Results were consistent for both SI and SR for all gait characteristics. Longitudinal pattern of SI differed in hind- and fore-limbs for swing: stance ratio, in hind-limb paw area (Figure 1) and stance time (p = 0.03) in CBA and Str/ort mice. Str/ort had lower fore-paw area SI than CBA mice. SI did not differ in CBA and Str/ort for stride length, frequency, swing, propel or brake time; the majority remained stable in hind- but not in fore-limbs. Longitudinal GMI patterns differed between strains (swing: stance, paw area (Figure 2); propel time p = 0.001) except stride length and frequency. SI for hind-limb swing:stance (HR = 1.72, 95% CI: 1.20-2.48, p = 0.004 for per 10 units increase) and GMI for paw area (HR = 0.52, 95% CI:0.27-1.04, p = 0.04, for per 0.1 units increase) were predictors of treadmill non-compliance in Str/ort mice.

**Conclusions:** Longitudinal differences in symmetry and imbalance patterns between CBA and Str/ort mice indicate different gait modification during normal growth periods and OA development. Assuming treadmill task non-compliance is linked with OA, our data suggest that hind-limb asymmetry is more closely related to OA development, but that fore-limb asymmetry tempers these hind-limb OA effects. Vitality, capacity for swing: stance asymmetry and paw area gait moderation index to predict Str/ort mouse non-compliance in the treadmill task supports their use as early OA markers.
we used self-reported questionnaires and a set of performance-based objective tests to investigate associations between the two constructs, in ACL-reconstructed patients, a population known to be at high risk of developing osteoarthritis.

**Aim:** To investigate the extent to which an objective test-battery of 4 separate tests of functional and/or muscle performance are associated with Knee osteoarthritis outcome score (KOOS) subscale scores Sport/Recreation (Sport/Rec) and Quality of life (QOL)) in ACL-reconstructed patients, with the perspective of specifying future areas of intervention, that potentially may facilitate rehabilitation in this patient population.

**Methods:** This cross sectional study was performed in 23 ACL-reconstructed men (mean age: 27.2 ± 7.5 years and BMI: 25.4 ± 3.2) 18-30 month post-surgery. KOOS-questionnaires were completed and subsequently, all patients performed a test-battery composed of: (i) one-leg maximal jump for distance (OLJD), isometric maximal voluntary contraction (MVC) strength for (ii) knee extensors and (iii) knee flexors, and (iv) unilateral maximal counter movement jump (CMJ). Sagittal kinematic data was synchronously recorded during CMJ using a 6-camera Vicon MX system. KOOS Sport/Rec and QOL were a priori defined as the depended variables. Furthermore, we defined 4 models of non-depended variables to be tested using outcomes from the 4 separate tests (Table 1). Multilevel regression analysis was used to determine coefficient of determinations for the 4 defined models.

**Results:** Moderate associations between OLJD and Sport/Rec (r = 0.26, p < 0.01) and QOL (r = 0.26, p < 0.01) were observed (Model 1; Table 1). Adding either knee extensor or flexor MVC to the analysis (Model 2a,b) increased the strength of the associations (up to r = 0.53, p < 0.01, and r = 0.31, p = 0.02 for Sport/Rec and QOL, respectively). Adding both knee extensor and knee flexor MVC strength to the analysis (Model 3) did not improve the regression model. Minor increases in regression strength were observed when including kinematic data from the motion analysis of CMJ (Model 4a,b,c) (up to r = 0.55, p < 0.001, and r = 0.40, p = 0.04 for Sport/Rec and QOL respectively).

**Conclusions:** A large proportion (31–53%) of the variation in KOOS (Sport/Rec and QOL) was explained by OLJD and knee extensor-flexor strength. Adding CMJ kinematics to the model had only minor additional impact. Thus, the present findings suggest that ACL-patients should be evaluated using both functional performance (OLJD) and lower limb muscle strength testing. This may add to our understanding on how to effectively design future rehabilitation interventions for this patient population, at high risk of osteoarthritis. To examine if patients’ self-perceived function and quality of life can be improved by enhancing physical function and muscle strength, more research should be directed towards understanding the association between objective measures and self-reported outcomes.

**Table 1** Associations between KOOS and objective outcomes organized in 4 models

<table>
<thead>
<tr>
<th>Sport/Rec</th>
<th>QOL</th>
<th>R²</th>
<th>P</th>
<th>R²</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td></td>
<td>0.256</td>
<td>0.012</td>
<td>0.259</td>
<td>0.011</td>
</tr>
<tr>
<td>Model 2a</td>
<td></td>
<td>0.516</td>
<td>0.001</td>
<td>0.311</td>
<td>0.020</td>
</tr>
<tr>
<td>Model 2b</td>
<td></td>
<td>0.366</td>
<td>0.008</td>
<td>0.311</td>
<td>0.020</td>
</tr>
<tr>
<td>Model 3</td>
<td></td>
<td>0.527</td>
<td>0.002</td>
<td>0.310</td>
<td>0.042</td>
</tr>
<tr>
<td>Model 4a</td>
<td></td>
<td>0.550</td>
<td>0.003</td>
<td>0.371</td>
<td>0.056</td>
</tr>
<tr>
<td>Model 4b</td>
<td></td>
<td>0.529</td>
<td>0.005</td>
<td>0.403</td>
<td>0.036</td>
</tr>
<tr>
<td>Model 4c</td>
<td></td>
<td>0.538</td>
<td>0.004</td>
<td>0.332</td>
<td>0.090</td>
</tr>
</tbody>
</table>

Model 1: One Leg Jump for distance (OLJD) vs. Knee Osteoarthritis Outcome Score (KOOS)

Model 2a: OLJD + extensor isometric maximal voluntary contraction (MVC) vs. KOOS

Model 2b: OLJD + flexor MVC vs. KOOS

Model 3: OLJD + extensor MVC + flexor MVC vs. KOOS

Model 4a: OLJD + extensor MVC + flexor MVC + Counter movement jump (CMJ) vs. KOOS

Model 4b: OLJD + extensor MVC + flexor MVC + CMJ knee range of motion vs. KOOS

Model 4c: OLJD + extensor MVC + flexor MVC + CMJ deepest knee angle vs. KOOS

**Discussion & Conclusions:** Although this cohort includes more severe OA knees than past studies [Baluinas2002, Hurwitz 2002, Hunt 2006], our results agree with those studies that KAM closely correlates with FTA and frontal plane lever arm. This fact suggests that static and dynamic limb alignment on the coronal plane is primary factor to determine KAM during gait, and explains validity to correct coronal plane limb alignment by surgeries such as high tibial osteotomy or total knee arthroplasty. Both medial and vertical GRF were increased in OA knees, however only medial GRF correlated with KAM (Figures 1-3 and Table 2). Also, toe-out angles in OA group did not show any correlation with KAM or other gait parameters (data not shown). Thus, increased medial GRF is thought to be a secondary factor to increase KAM. The results indicate that modification of gait pattern to reduce medial GRF by non-surgical interventions (insoles, gait training, etc) may be effective to reduce KAM and medial compartment loads, but effect of changing toe-out angle remains unclear.