Concurrent Criterion-related Validity, Reliability, and Responsiveness to Treatment of the Figure-of-Four Position for Measurement of Anterior Hip Joint Structures Tightness

Tomás Coloma Martínez, PT,[a] Enrique Lluch, PT, PhD,[b] Rafael Torres-Cueco, PT,[b] Daniel Pecos-Martín, PT, PhD,[c] and Jenny McConnell, PT, PhD[d]

Abstract

Objective: The objective of this study was to examine the intra- and intertester reliability, concurrent criterion-related validity, and responsiveness to treatment of the "figure-of-four" position.

Methods: A total of 52 asymptomatic male soccer players participated in this study. The intraclass correlation coefficient (2, 1) was used to determine intra- and intertester reliability of the figure-of-four position. Pearson product moment correlation coefficients examining the association between the figure-of-four position and goniometric measurements of hip extension and external rotation were used to establish concurrent validity. To evaluate responsiveness to treatment, the figure-of-four position was assessed by a blinded examiner before and immediately after the application of a stretching technique or control intervention.

Results: Excellent reliability (intraclass correlation coefficient > 0.75) was obtained for both intra- and intertester reliability of the figure-of-four position. Overall, the figure-of-four position and goniometric measurements of both hip extension and external rotation were significantly correlated. However, no significant treatment effects were observed for the figure-of-four position.

Conclusion: The results of this study demonstrated that the figure-of-four position is a reliable and valid way to obtain information on tightness of anterior hip joint structures in male soccer players. However, responsiveness to treatment of the figure-of-four position should be questioned. (J Manipulative Physiol Ther 2018;41:780-788)

Key Indexing Terms: *Hip Joint; Range of Motion, Articular; Reproducibility of Results; Muscle Stretching Exercises*

Introduction

Identification of abnormal movement impairments and alignment of the lower extremities is considered important for the management of lower limb and spinal musculoskeletal conditions.[1-3] Alteration in hip alignment and kinematics in the form of increased internal rotation has been recognized as a contributing factor to some pain conditions affecting the lower limb, such as patellofemoral pain,[4,5] medial tibial stress syndrome,[6] or piriformis syndrome.[7] Increased internal rotation of the hip during weight bearing may be due to poor dynamic control from the gluteal musculature or may be due to adaptively shortened anterior hip structures. Adaptively shortened anterior hip structures will not allow the hip to extend and externally rotate sufficiently, thus maintaining the hip in flexion and internal rotation. If the hip is maintained in a more flexed and

[a] Levante U.D., Valencia, Spain.
[b] Department of Physical Therapy, University of Valencia, Valencia, Spain.
[c] Department of Physical Therapy, Universidad de Alcalá, Alcalá de Henares, Spain.
[d] Centre for Sports Medicine, University of Melbourne, Melbourne, Victoria, Australia.
Corresponding author: Enrique Lluch, PT, PhD, Department of Physical Therapy, University of Valencia, Gascó Oliag 5, 46010, Valencia, Spain. Tel.: +34 963983853.
(e-mail: *enrique.lluch@uv.es*).
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internally rotated position, the gluteal muscles will elongate and will test weaker when placed in a shortened position,[8] contributing to the dynamic valgus collapse of the knee seen in many patellofemoral pain patients.[9,10] Increased internal femoral rotation or poor dynamic external rotation control reduces the patellofemoral contact area and increases patellofemoral joint stress,[11] predisposing to knee pain.[12-14]

Besides patellofemoral pain, excessive hip internal rotation has been claimed as a contributing factor to chronic low back and leg pain.[1] During trunk forward bending, the hips must flex and internally rotate. If hips are already at the end of range of internal rotation they cannot rotate further during the forward bending so movement will have to increase elsewhere, usually in the lumbar spine, resulting in an increase in relative lumbar spine flexibility.[1] In addition, the reduction of hip extension and external rotation secondary to the excessive hip internal rotation can provoke an increase in lumbo-pelvic rotation during walking,[1] potentially contributing to damaged fibers of the annulus fibrosis.[15,16] Moreover, there is also some evidence that a limitation on hip extension is a potential contributor to nonspecific chronic low back pain.[17]

Tight anterior hip structures contribute to increasing the internal rotation of the hip, usually in association with an underlying femoral anteversion. These structures include the anterior hip joint capsule, iliofemoral and pubofemoral ligaments, tensor fascia latae, rectus femoris, and psoas and adductor muscles.[18] Impaired strength of the hip extensors, abductors, and external rotators is another contributing factor maintaining the hip in internal rotation.[19-24] The flexibility of the anterior hip structures can be examined with the patient in a "figure-of-four" position placing the assessed leg bent under the non-assessed straight leg, with the malleolus contacting at the level of the tibial tubercle.[1,25] This position tests the available hip extension and external rotation, which often is limited because of chronic adaptive shortening of the hip anterior structures. The distance of the anterior superior iliac spine (ASIS) from the plinth is measured, providing the clinician an objective measure of change.[25] Ideally, the pelvis should be flat on the table. If external femoral rotation is restricted, anterior hip joint flexibility also can be improved by doing a prone figure-of-four stretch.[25]

Despite that the figure-of-four test has been used purportedly for measuring tightness of the anterior hip joint structures[1,18,25] and several randomized trials[26,27] and case reports[28] have included the figure-of-four position for stretching anterior hip structures, the clinometric properties of this test have not been previously investigated.

The primary aim of this study was therefore to examine the intertester and intratester reliability of the figure-of-four test in a population of healthy professional soccer players. As secondary aims, concurrent criterion-related validity and responsiveness of the figure-of-four test to treatment were evaluated. Goniometry was used as the criterion measure to establish concurrent validity.

Methods

Participants

Fifty-two healthy male soccer players (mean ± standard deviation [SD] age, 19.90 ± 2.56 years; height, 180.08 ± 5.26 cm; weight 74.72 ± 5.49 kg) participated in this study. Study participants were recruited from a Spanish First Division soccer team (Levante U.D.). The study was conducted at the sport campus of the Levante U.D. soccer team in Buñol (Valencia, Spain) from January to October 2014. All participants took part in the reliability, validation, and responsiveness to treatment portions of the investigation. Before participation, all participants were informed of the nature of the study and informed consent was obtained. The study was approved by the Research Ethics Committee of the University of Valencia (Spain) and was conducted following the principles of the Declaration of Helsinki. Participants in either portion of this study were excluded if they had any pain or surgery in the lower extremities.

Raters Training

The 2 examiners of this study were physiotherapists with 5 years of clinical experience in outpatient orthopedic practice. Both worked fulltime in the Spanish First Division soccer team (Levante U.D.) and held a master's degree in manual therapy. They routinely performed this test as part of their clinical practice. Before the study, both raters underwent a training session that lasted approximately 2 hours. The examiners practiced on 2 healthy volunteers who were not included in the current study and compared their measurements and discussed with each other ways to standardize procedures.

Procedure

Participants were initially examined by an independent researcher, who assessed fulfillment of the inclusion criteria and recorded demographic and anthropometric data of each participant. Those who met the study requirements underwent 2 separated sessions. The first session involved goniometric measurement of hip extension and external rotation as the criterion standard by the 2 examiners. After that, the figure-of-four position was performed independently by those same examiners to establish intertester reliability. To determine the criterion-related validity of the figure-of-four position, the results of this test were compared with those obtained with hip range of motion (ROM) goniometric assessment. Examiners were not allowed to access their hip ROM data sheets once completed, to avoid possible bias when performing the figure-of-four position.

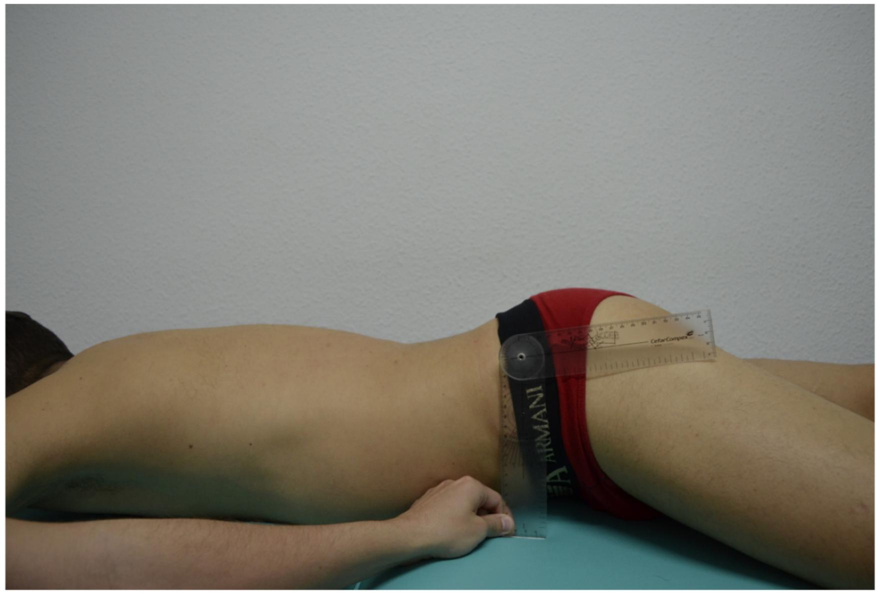

Fig 1. *The figure-of-four position assessment.*

The second session was performed 2 weeks later and involved assessment of the figure-of-four position to establish intratester reliability. Participants were told to continue with normal activity during the 15-day interval between the 2 measurement points. In addition, all participants received a random application of a prone figure-of-four stretch or control intervention, followed by an immediate reassessment with the figure-of-four position, to determine the responsiveness to treatment of this test. For all testing sessions, evaluation and treatment were performed bilaterally.

Measurement of Hip Extension and External Rotation. A universal goniometer (ROHO, Inc, Belleville, Illinois) was used to measure hip ROM. Hip extension was measured in the modified Thomas test position.[29,30] Participants were instructed to sit as close to the edge of the plinth as possible and use their hands to bring their knees to their chest, rolling back on the plinth with the assistance of the examiner. While maintaining this position, they were told to release the lower limb being measured, allowing the limb to hang unsupported off the plinth. The examiner assured visually and with palpation that the lumbar spine remained in contact with the plinth. Thigh position also was monitored to prevent abduction of the thigh during hip extension.[30] When the final test position was achieved, the examiner placed the goniometer. The fulcrum was placed over the lateral aspect of the greater trochanter, with the proximal arm aligned with the lateral midline of the pelvis and the distal arm aligned with the lateral midline of the femur using the lateral epicondyle for reference.[31] If the thigh of the limb being tested was horizontal the hip angle was recorded as 0°, and the hip angle was recorded as negative or positive if the thigh was above or below the horizontal, respectively.

Hip external rotation was measured in supine, with the examined leg in 90° of hip and knee flexion.[32,33] One examiner passively applied hip external rotation until resistance was felt. This examiner assured that the initial position was maintained and only hip rotation movement occurred without compensations. Another examiner placed the center of the goniometer at the tip of the patella. The stationary arm was aligned parallel to the transverse line across the anterior superior iliac spines of the pelvis, and the distal arm was aligned with the tibia shaft following its movement for measurement.

Both hip extension and external rotation were measured 3× and the mean was used for further analysis.[34] Goniometry is a valid and reliable method to measure hip ROM both in healthy participants and people with hip pain.[31-33]

Assessment of Tightness of Anterior Hip Joint Structures. The figure-of-four position was performed as previously described.[1,25] First, participants were positioned prone on a plinth with the leg to be examined bent under the contralateral straight leg, placing the malleolus at the level of the tibial tubercle. They were told to remain as relaxed as possible while in that position to obtain an objective measure of the available range of hip extension and external rotation. The distance from the ASIS to the plinth was then measured 3× using the ruler of the goniometer, and the average was used for analysis (Fig 1).

Responsiveness of the Figure-of-Four Position to Treatment. After being included in the study, participants were randomly assigned to either a passive stretching group or a control group, using a computer-generated random number list

Fig 2. *Prone figure-of-four passive stretch.*

(Epidat, version 3.1). One of the 2 examiners was responsible of this part of the study. The stretching group received a passive stretch to the anterior hip joint structures while in the figure-of-four position. The examiner attempted to flatten the abducted and rotated hip by pushing along the length of the thigh and holding the stretch for 30 seconds (Fig 2). Each stretch repeated 5×, with a 5-second rest period between repetitions. In the control group, the examiner simulated the same hands position as for the stretching group, but no force was applied. The number and duration of repetitions was the same as in the stretching group.

Immediately after treatment, the other examiner, who was blinded to patient group assignment, reassessed the figure-of-four position. Results obtained after assigned intervention were compared with first measurements taken by this same examiner in the second session (as part of the intratester reliability investigation), to determine responsiveness to treatment of this clinical test.

Statistical Analysis

Descriptive statistics were used to define demographic characteristics of the sample, and *t* tests were conducted to determine if both intervention groups (stretching, control) were comparable at baseline.

To assess the intra- and intertester reliability of the figure-of-four position, the intraclass correlation coefficient (ICC [2, 1]) with 95% confidence intervals was calculated. Intertester reliability was calculated using values obtained during the first testing session and intratester reliability with values obtained during the first and second testing sessions for each tester. Intraclass correlation coefficient values above 0.75 reflect excellent, between 0.40 and 0.75 fair to good, and below 0.40 poor reliability.[35]

The Pearson product moment correlation coefficient (r) was used to examine the associations between figure-of-four test results obtained by each examiner and goniometric measurements of hip extension and external rotation as an indicator of concurrent criterion-related validity. Q plots to study the normality of the variables were used, and the lack of normality was not severe enough to threaten the use of zero-order correlations This analysis was performed using values obtained in the first clinical session and was repeated for each examiner.

To determine responsiveness to treatment of the figure-of-four position, 2-way repeated-measures analysis of variance was conducted to evaluate differences in distance from the ASIS to the plinth with the interventions group (stretching, control) and time (pre, post) as factors. Partial eta-squares were calculated as effect size measures.

Data were analyzed using SPSS Statistics version 22.0 (IBM Corp, Armonk, New York), and statistical significance was set at $P < .05$.

Results

The participants' demographic characteristics are presented in Table 1. No significant differences were observed between groups (stretching, control) for age, weight, height, or hip ROM (all $P > .05$). The mean (± SD) distance from the ASIS to the plinth for all the sample measured at the first session was 7.2 ± 1.9 cm (right leg) and 7.4 ± 2 cm (left leg) for examiner 1 and 7.4 ± 1.9 cm (right leg) and 7.3 ± 1.7 cm (left leg) for

Table 1. *Participant Demographics*

Baseline Measurements	Stretching Group (N = 25)	Control Group (N = 27)	*P* Value
Age (y)	19.5 ± 2.6	20.3 ± 2.5	*P* > .05
Weight (kg)	75.1 ± 6.2	74.4 ± 4.8	*P* > .05
Height (cm)	180.4 ± 5.3	179.7 ± 5.3	*P* > .05
Hip extension angle right (°)	6.4 ± 3.7	8.3 ± 5.2	*P* > .05
Hip external rotation angle right (°)	40.5 ± 5.1	42.4 ± 5.3	*P* > .05
Hip extension angle left (°)	9.2 ± 3.7	9.3 ± 5.8	*P* > .05
Hip external rotation angle left (°)	41.9 ± 4.8	44.1 ± 4.6	*P* > .05

Data are mean ± standard deviation (95% confidence interval).

examiner 2. Mean values obtained with the figure-of-four position for each group, examiner and measurement times are represented in Table 2. The mean values (± SD) of hip ROM were 7.4 ± 4.6° (right hip extension), 41.5 ± 5.3° (right hip external rotation), 9.3 ± 4.9° (left hip extension), and 43.1 ± 4.8° (left hip external rotation).

Concurrent Criterion-Related Validity

Overall, a significant correlation between the figure-of-four position and hip ROM measurements was obtained, except between the figure-of-four position and right hip extension (measured by examiner 2) and left hip external rotation (measured by both examiners; Table 3).

Reliability

The ICC values representing intertester reliability of the figure-of-four position were 0.86 (right leg) and 0.87 (left leg). The ICC values representing intratester reliability were 0.92 (right leg) and 0.94 (left leg) for examiner 1 and 0.94 (right leg) and 0.95 (left leg) for examiner 2.

Responsiveness to Treatment

The time × group interaction was not statistically significant in the right [F(1,49) = 2.817; p = .1; χ^2 = .054] nor in the left leg [F(1,49) = 3.161; p = .082; χ^2 = .061].

Discussion

In the current study, reliability, concurrent criterion-related validity, and responsiveness to treatment of a clinical test, namely the figure-of-four position, was investigated. The test was found to exhibit excellent intra- and intertester reliability and overall good correlation with goniometric measurements of hip extension and external rotation. However, the figure-of-four test was not responsive to change after 1 session of 5 x 30-second stretches of the anterior hip joint structures.

The figure-of-four position has been used purportedly for measuring tightness of several structures located in the anterior hip joint.[18] Although the reliability part of this study is not comparable with similar data because reproducibility of the figure-of-four position was not explored before, previous studies reported good reliability values for measuring tightness of some of those structures separately, such as the rectus femoris,[36] tensor fascia latae/ iliotibial band,[37,38] or iliopsoas muscles.[39] Thus, for reliability, our results agree with previous research regarding hip tightness assessment. However, whereas the figure-of-four position evaluates combined motion of hip extension and external rotation, most studies have used single-plane hip movements to determine tightness of hip joint structures (ie, hip extension for iliopsoas muscle).[39]

Excessive tightness of tissues surrounding the hip joint is claimed to modify hip alignment and kinematics, produce movement dysfunction, and predispose to injury development, in particular in the lower limb.[40] However, the exact relevance of hip capsular tightness in patients with musculoskeletal pain disorders is unknown. Contrarily, capsular tightness is a recognized and well-defined clinical entity in other body regions such as the shoulder, where it can lead to altered kinematics[41-43] and increase the risk for development of shoulder injuries.[44,45] Although the figure-of-four position is a clinical test postulated for quantifying tightness of the hip anterior capsule, the ability of this test to truly reflect the flexibility of the anterior capsule has not been evaluated. Future studies should quantify the amount of strain on the anterior hip tissues during simulated hip clinical tests such as the figure-of-four position using, for instance, cadaver specimens.[46,47] In addition, it would be worthwhile to determine the contribution of hip capsular tightness, as measured through the figure-of-four position, to lower limb and spinal musculoskeletal injuries using prospective designs.

Table 2. *Mean ± Standard Deviation Values (95% CI) Obtained With the Figure-of-Four Position for Each Group, Examiner, and Measurement Times (Day 1 and Day 15, Both Before and After Intervention)*

Assessment Characteristics	Stretching Group (N = 25)	Control Group (N = 27)
Examiner 1 Day 1 Right leg	7.3 ± 1.5	7.1 ± 2.3
Examiner 1 Day 1 Left leg	7.4 ± 1.6	7.4 ± 2.3
Examiner 2 Day 1 Right leg	7.5 ± 1.4	7.4 ± 2.3
Examiner 2 Day 1 Left leg	7.3 ± 1.4	7.4 ± 2.1
Examiner 1 Day 15 before intervention Right leg	7.3 ± 1.7	7.2 ± 2.6
Examiner 1 Day 15 before intervention Left leg	7.1 ± 1.7	7.1 ± 2.4
Examiner 2 Day 15 before intervention Right leg	7.5 ± 1.6	7.4 ± 2.4
Examiner 2 Day 15 before intervention Left leg	7.3 ± 1.4	7.5 ± 2.1
Examiner 2 Day 15 after intervention Right leg	6.5 ± 1.8	6.9 ± 2.5
Examiner 2 Day 15 after intervention Left leg	6.5 ± 1.7	7 ± 2.4

Data are expressed in cm.

Lack of responsiveness to treatment of the figure-of-four position may be due to several reasons. On one hand, the stretching group only received 1 session of treatment comprising 5 repetitions of 30-second stretches (2 ½ minutes). Passive stretching for 2 minutes resulted in significant decreases in musculotendinous stiffness that returned to baseline only within 10 minutes.[48] On the other hand, a low-force and sustained end-range stretch was applied in the current study to produce a permanent plastic deformation of the restricting hip periarticular structures and thus increase ROM.[49,50] However, the increase in length (if any) achieved in some of the structures stretched may have been transient and only secondary to an increase in stretch tolerance,[51,52] not enough to be detected by the figure-of-four position. In addition, the passive structures around the hip such as noncontractile tissue may take much longer to stretch out than contractile tissue (ie, muscles), so perhaps 1 session of stretching was too short to effect a change. A long-term stretching (ie, >3 weeks) program might be necessary to attain biomechanical effects and thus detect a true measurable change with the figure-of-four position.[51,53]

It is often difficult for individuals who are too tight to be stretched because of pain. Although complaint of pain during the stretch was not recorded, pain itself may have prevented participants to remain as relaxed as possible for the stretch, thus not allowing to obtain a treatment effect. To allow a painless figure-of-four position stretch, lifting the adductors up with the underneath hand during the stretch is recommended to take the tension off the tight structures.[18,25]

Table 3. *Pearson's r Assessing the Level of Agreement Between the Figure-of-Four Position, as Measured by Each Examiner, and Bilateral Hip Extension and External Rotation Angles*

	Examiner 1	Examiner 2	Hip Extension Angle	Hip External Rotation Angle
	Figure-of-four right	Figure-of-four right	Right	Right
Examiner 1 figure-of-four right	1	0.864 [a]	-0.354 [a]	-0.484 [a]
Examiner 2 figure-of-four right	0.864 [a]	1	-0.258	-0.457 [a]
Hip extension angle right	-0.354 [a]	-0.258	1	0.242
Hip external rotation angle right	-0.484 [a]	-0.457 [a]	0.242	1
	Figure-of-four left	Figure-of-four left	Left	Left
Examiner 1 figure-of-four left	1	0.878 [a]	-0.314 [b]	-0.089
Examiner 2 figure-of-four left	0.878 [a]	1	-0.435 [a]	-0.203
Hip extension angle left	-0.314 [b]	-0.435 [a]	1	0.390 [a]
Hip external rotation angle left	-0.089	-0.203	0.390 [a]	1

[a] Pearson's r significance $P < .01$.
[b] Pearson's r significance $P < .05$.

Limitations

Participants from the current study may have been stratified into "tight" (ie, further off the table with the figure-of-four position) versus "not so tight," to determine if the stretching technique was more effective on the tight versus less tight participants. However, stratification was not possible owing to lack of a validated cutoff value for the figure-of-four position, which may assist in deciding who has more or less tightness of the anterior hip joint structures. The effects of stretching are possibly greater in muscles with limited extensibility,[54] so maybe our sample did not really need stretching and that was the reason stretching techniques did not achieve effects. Alternatively, the restrictions may have been osseous in nature, so that a stretching strategy would not obtain a significant change.

Results from this study cannot be extrapolated to the general population because data were acquired from a sample of healthy male soccer players. Future research should expand the study of the figure-of-four position to other populations, in particular to those known to be affected by hip alignment and kinematics alterations in the form of excessive internal rotation (ie, patellofemoral pain). Comparison of the current results with data extracted from symptomatic populations would elucidate the discriminative validity of this clinical test. The concurrent criterion-related validity of the figure-of-four position was demonstrated against selected goniometric measurements, which were considered the gold standard for hip ROM. Results may have differed if hip ROM has been measured in other positions or if the figure-of-four position had been validated against other measures, such as hip joint passive stiffness.[40]

Conclusion

In healthy male soccer players, the figure-of-four position exhibited excellent intra- and intertester reliability and overall good agreement when compared with criterion-related goniometric measurements of hip extension and external rotation. However, the utility of this clinical test to detect changes after implementation of a short-term stretching treatment should be called into question.

Funding Sources and Conflicts of Interest

No funding sources or conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): E.L.L., R.T.-C.
Design (planned the methods to generate the results): T.C.M., E.L.L., R.T.-C., D.P.-M., J.M.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): E.L.L., R.T.-C., D.P.-M., J.M.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): T.C.M.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): E.L.L., R.T.-C., D.P.-M., J.M.

Literature search (performed the literature search): E.L.L., R.T.-C., D.P.-M., J.M.
Writing (responsible for writing a substantive part of the manuscript): T.C.M., E.L.L., R.T.-C., D.P.-M., J.M.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): E.L.L., R.T.-C., D.P.-M., J.M.

Practical Applications

- This study concluded that the intra- and intertester reliability of the figure-of-four position is excellent.
- The figure-of-four position and goniometric measurements of both hip extension and external rotation were significantly correlated.
- No significant treatment effects were observed for the figure-of-four position.

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