Incidence of Decreased Hip Range of Motion in Youth Soccer Players and Response to a Stretching Program: A Randomized Clinical Trial

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Context: After years of focusing on the management of anterior cruciate ligament (ACL) injuries, the most common soccer related injuries, the orthopedic community has concluded that soccer players have a wide range of variation in joint biomechanics and has thus started to focus research efforts on the morphological factors that might contribute to ACL trauma. One such factor is decreased hip-rotation range of motion (ROM), which may be due to compensatory musculoskeletal changes occurring in response to longstanding soccer practice since childhood. **Objective**: This study sought to assess decreased hip rotation and the influence of stretching exercises on the behavior of the hip joint in players of the youth soccer categories of a Brazilian soccer team. **Design**: Randomized clinical trial. Setting: University hospital. **Patients**: 262 male soccer players. **Interventions**: Subjects were randomly allocated into 2 groups—control or a stretching program. **Main Outcome Measures**: Subjects were reassessed after 12 wk. **Results**: The findings suggest that hip-rotation ROM decreases over the years in soccer players. In the study sample, adherence to a stretching program improved only external hip-rotation ROM in the nondominant limb. **Conclusion**: Playing soccer can restrict rotation ROM of the hip, and adherence to stretching exercises may decrease the harmful effects on the hip joints.
Keywords: hip-rotation range of motion, youth sports, constrained hip joints

Contexto: Depois de anos focados nas lesões do ligamento cruzado anterior (LCA), as lesões mais comuns relacionadas com futebol, a comunidade ortopédica concluiu que os jogadores de futebol têm uma ampla gama de variações biomecânicas e, assim, começou a concentrar esforços na pesquisa de fatores morfológicos que possam contribuir para a lesão do ACL. Um desses fatores é a restrição da amplitude de movimento (ADM), que pode ser devido a alterações músculo-esqueléticas compensatórias que ocorrem em resposta à prática do futebol de longo prazo, desde a infância. **Objetivo**: Este estudo avaliou a restrição de rotação do quadril e a influência dos exercícios de alongamento sobre o comportamento da articulação do quadril em atletas das categorias de base de um time de futebol brasileiro. **Delineamento:** ensaio clínico randomizado. **Pacientes**: 262 jogadores de futebol do sexo masculino. **Intervenções**: Os pacientes foram distribuídos aleatoriamente em dois grupos de controle ou de um programa de alongamento, e reavaliados após 12 semanas. **Resultados**: Os achados sugerem que a ADM de rotação do quadril diminui ao longo dos anos em jogadores de futebol. Na amostra estudada, a adesão a um programa de alongamento melhorou apenas na ADM de rotação externa do quadril no membro não dominante. **Conclusão**: Jogar futebol pode restringir a ADM de rotação do quadril, e a adesão a exercícios de alongamento podem diminuir os efeitos nocivos sobre as articulações do quadril.
Palavras-chave: ADM de rotação de quadril, jovens atletas, futebol, restrição do quadril.

After years of focusing on the management of[1] anterior cruciate ligament (ACL) injuries in soccer players[1–4], the orthopedic community began to take into account that, despite similar athletic training, soccer players have individually distinct body types and constitutions[5–10]. Studies then started to focus on the morphological factors[6,8,11–13] that might contribute to ACL trauma. Recent research has found a strong association between soccer and decreased hip-rotation range of motion (ROM), which has often been considered a significant risk factor[6,14–16] . However, no actions have been proposed for the management of these consequences or prevention of their effects.

Constrained hip joints tend to increase torsional strain on the knee[15,17,18]. Two possibilities may account for this: First, after a traumatic event that leads to ACL rupture, the athlete attempts to exert an additional force at the level of the knee that is capable of counteracting the excess rotational torque brought about by functional impairment of the hip joint[15,19] .The second possibility involves the development of a mechanism that is able to detect and, if possible, correct restrictions in hip-joint motion, thus preventing ACL tears[9,20,21].

Systematic involvement in the sport of soccer is associated with musculoskeletal changes that, despite their slow onset and gradual development, can decrease performance or even prematurely end a promising athletic career[6,22–25]. It is often assumed that playing soccer tends to have a negative impact on flexibility[22–24]. Although there is no consensus on the matter, comparative studies have suggested that continuous practice of this sport is associated with development of below-average joint mobility compared with that of nonathletic persons[6,22,24].

The current study was prompted by our belief that a progressive decline in flexibility occurs with continuous involvement in the sport of soccer. We sought to assess decreased ROM in soccer players and determine the stage of body development at which this decrease begins or starts to pose a risk to the athlete[6,7,14,23]. We then propose specific stretching exercises for the hip-rotator groups, designed to aid in maintenance or restoration of hip ROM[26–28].

Methods

Design

This work was based on a previous article by the same authors published in 2008[6], which demonstrated an association between decreased hip-rotation ROM and the incidence of ACL ruptures in soccer players. The study was carried out in 2 stages. Stage 1 consisted of a cross-sectional study of 216 athletes with the objective of assessing internal and external hip-rotation ROM in youth soccer players age 10 to 18 years. Stage 2 consisted of an unblinded, randomized clinical trial designed to assess the effect of a specific program of stretching exercises on hip-rotation ROM over a 12-week period. The study was originally designed as a blind trial. However, although attempts were made to blind the investigator for the assessments, the study involved a population of children and adolescents, who often questioned why some of them were doing and others were not doing the stretching exercises and ended up disclosing their groups, which resulted in significant unblinding. Thus, we found it prudent to consider the investigator not blinded to group.

Participants

The study sample comprises the youth soccer system of a professional soccer team from Porto Alegre, State of Rio Grande do Sul, Brazil, which is subdivided into 8 age-specific youth categories: under-10 (n = 34), under-11 (n = 29), under-12 (n = 23), under-13 (n = 30), under-14 (n = 30), under-15 (n = 27), under-17 (juvenile) (n = 39), and under-18 (junior) (n = 23), for a total N = 235. The study design was approved by the local institutional review board, and all athletes (or their parents, as appropriate) provided written informed consent. The inclusion criterion was being part of one of the previously mentioned youth categories. The sole criterion for exclusion was a history of pelvic, hip, pubic, or knee injury. All eligible athletes were then assessed for hip ROM according to a previously published protocol.6

Procedures

For anthropometric assessment of the hip, subjects were placed supine with the hip and knee flexed at 90°,29,30 and the external and internal rotation of both lower extremities were measured with a conventional goniometer by 2 examiners, who acted alternately as the examiner or assistant (helping the athlete position himself on the table). Participants were then randomized into 2 groups, intervention and control, using the PEPI (Computer Programs for Epidemiologists) version 4.0 software package. Players in the intervention group took part in specific stretching exercises 3 times/wk, 1 session at a time, as part of their regular training program (3 sets of 30s each stretch). Subjects were instructed to force as far as they were able to go without pain. Stretches were performed sequentially, without pause.

Active stretching exercises were designed with an emphasis on improving flexibility in the muscles involved in internal and external rotation of the hip (Figures 1–4). The exercise program was implemented by the athletic trainers of each youth category, all of whom have bachelor's degrees in physical education. All trainers first underwent specific theoretical and practical training and were then given a DVD of the proposed exercise program and a printout with step-by-step photographs of each stretching exercise.23 Even though a dominant leg was determined in each athlete as the leg used to kick the ball, the same exercise protocol was employed for both legs.

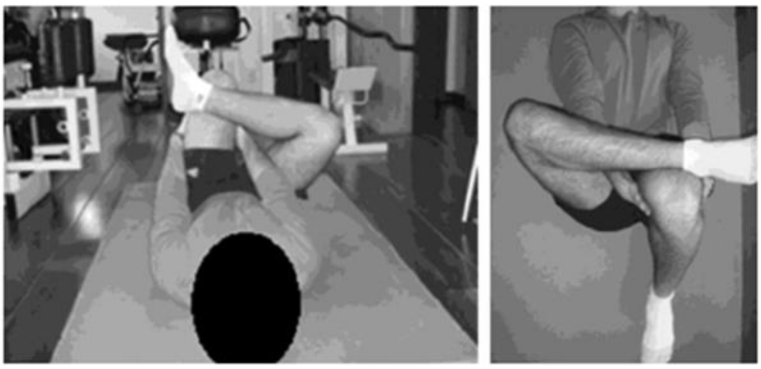

Figure 1 — Stretching exercise 1

Figure 2 — Stretching exercise 2.

Figure 3 — Stretching exercise 3.

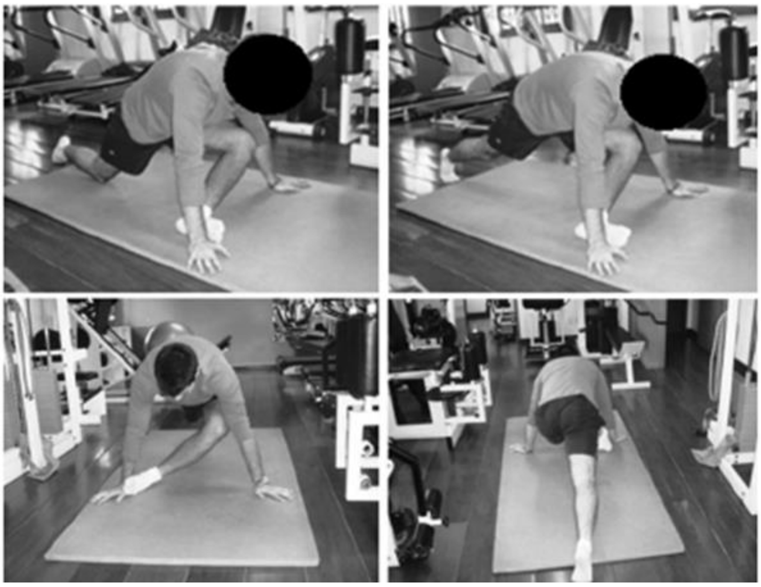

Figure 4 — Stretching exercise 4.

After 12 weeks of the stretching-exercise program, which coincided with the end of the regular season, the athletes in both groups once again underwent measurement of hip rotation to determine whether any differences in hip mobility had occurred from baseline.

Statistical Analyses

Quantitative variables were expressed as mean and SD, and categorical variables, as relative frequencies. One-way and 2-way analysis of variance (ANOVA) for repeated measures and Student t test were used for analysis of within- and between-groups differences. In both groups, the magnitude of effect was evaluated using effect sizes, which were calculated with the following formula:

(M1 – M2)/

where M1 and M2 represent the mean values before and after intervention, respectively, and 12 corresponds to the pooled SD. The significance level was set at P < .05.

Results

The study sample comprised 262 athletes of the youth categories of a professional soccer team. Of these, 27 joined the team after the start of the assessment period; hence, 235 were left in the sample. Nineteen players were automatically excluded due to hip or knee injury. Therefore, the final sample included 216 athletes for comparison of hip-rotation ROM across the several youth categories.

Mean age was 13.3 ± 2.7 years (range 9–19 y). Mean length of time participating in sport was 6.6 ± 3.3 years. Mean length of time playing soccer in the club where the study was carried out was 3.2 ± 2.1 years. The distribution of athletes across categories was similar, with each category accounting for approximately 12% of the sample. Comparison of ROM among categories yielded significant differences in all parameters assessed (P < .001). Mean internal rotation of the hip was 20.9° ± 5.7°, lowest in the under-17 (14.4° ± 3.4°), under-18 (18.9° ± 7.1°), and under-14 (19.5° ± 2.1°) categories. Mean external rotation was 36.5° ± 6.9°, lowest in the under-18 (30.9° ± 6.7°), under-17 (33.3° ± 6.5°), and under-14 (33.6° ± 5.9°) categories.

On comparative assessment of decreased hip-rotation ROM in the right and left lower limbs, the mean sum of hip rotation on the right was 58.9° ± 11.7°. The lowest means were found in the under-17 (49.7° ± 9.7°), under-18 (50.9° ± 12.5°), and under-14 (53.5° ± 8.5°) categories. The mean sum of hip rotation on the left side was 55.9° ± 11.7°, also lowest in the under-17 (45.8° ± 9.4°), under-18 (48.8° ± 14.5°), and under-14 (52.7° ± 9.6°) categories.

Mean total rotation (internal and external in both lower extremities) was 57.4 ± 11.1° and again was lowest in the under-17 (47.8° ± 9.1°), under-18 (49.9° ± 13.3°), and under-14 (53.1° ± 8.2°) categories.

For the next stage of the study, the 216 athletes were randomly allocated into 2 groups (intervention and control), for 108 athletes in each group. However, during this stage of the study, 54 athletes were cut from the team and consequently excluded from the study (45 from the intervention group and 9 from the control group), for a final sample of 162 athletes. Thus, the stretching and control groups comprised 63 and 99 players, respectively. Cutting players from teams is a common practice in soccer clubs. The greater sample loss observed in the intervention group was probably random, and the number of analyses remained relatively large and did not invalidate the results.

Within and between-groups differences were analyzed. Within-group comparisons showed statistically significant differences in all hip-ROM parameters in the intervention group. The effect sizes of intervention were weak (mean internal rotation) to moderate (all other parameters; Table 1). Statistically significant differences in all hip-ROM parameters were also found in the control group. Effect sizes were weak (mean internal rotation and sum of rotation on the right side) to moderate (all other parameters; Table 1).

Table 1 Between-Groups Comparison of Range of Motion (°), Baseline Versus Postintervention, Mean ± SD

Variable	Baseline	12-week follow-up	*P*	SES
Stretching group (n = 63)				
mean internal rotation	21.8 ± 6.1	23.4 ± 5.4	.015	0.28
mean external rotation	36.1 ± 6.5	42.7 ± 6.8	<.001	0.99
sum right lower extremity	59.6 ± 11.6	66.2 ± 10.9	<.001	0.62
sum left lower extremity	56.4 ± 12.2	65.9 ± 10.2	<.001	0.85
total	58.0 ± 11.4	66.1 ± 10.4	<.001	0.74
Control group (n = 99)				
mean internal rotation	20.2 ± 5.9	21.8 ± 5.1	.002	0.29
mean external rotation	36.3 ± 7.5	41.4 ± 6.8	<.001	0.71
sum right lower extremity	58.4 ± 12.5	63.7 ± 11.2	<.001	0.45
sum left lower extremity	54.6 ± 12.4	62.6 ± 10.7	<.001	0.69
total	56.5 ± 11.9	63.2 ± 10.7	<.001	0.59
Stretching vs control[a]				
Mean internal rotation			.948	
Mean external rotation			.226	
Sum right lower extremity			.473	
Sum left lower extremity			.395	
Total			.396	

Abbreviations: SES indicates standardized effect size (<0.6, weak; 0.6–1.2, moderate; >1.2, strong).

[a]*P* = group × time interaction.

On between-groups comparison, the intervention group was found to have larger effect sizes for practically all parameters except mean internal rotation. Nevertheless, no between-groups differences were statistically significant.

Further analysis of the study groups (stretching exercises vs control) taking into account limb dominance for comparison between baseline and post intervention findings revealed differences on between-groups and within-group comparison. Within-group comparison showed statistically significant differences in practically all hip-ROM measurements, except internal rotation on the nondominant side, in the intervention group. The effect sizes of intervention on variables for which a significant difference was detected ranged from weak (internal rotation on the dominant side, external rotation on the nondominant side, sum of hip rotation on the nondominant side, and total rotation) to moderate (external rotation on the dominant side and sum of hip rotation on the dominant side). The largest effect size (moderate effect) was seen on the dominant side (Table 2).

Table 2 Between-Groups Comparison of Range of Motion (°), Baseline Versus Postintervention, Subanalysis of Dominance, Mean ± SD

Variable	Baseline	12-week follow-up	*P*	SES
Stretching group (n = 63)				
internal rotation, dominant limb	21.7 ± 6.1	23.7 ± 5.5	.003	0.34
external rotation, dominant limb	36.0 ± 7.7	42.3 ± 7.3	<.001	0.84
internal rotation, nondominant limb	22.8 ± 5.6	23.2 ± 5.6	.521	0.07
external rotation, nondominant limb	40.8 ± 6.9	43.0 ± 6.9	.005	0.32
sum of rotation, dominant limb	57.8 ± 12.1	66.0 ± 10.5	<.001	0.73
sum of rotation, nondominant limb	63.6 ± 10.4	66.1 ± 10.6	.022	0.24
total	60.7 ± 10.3	66.1 ± 10.4	<.001	0.52
Control group (n = 99)				
internal rotation, dominant limb	19.8 ± 6.3	21.7 ± 5.2	.001	0.33
external rotation, dominant limb	37.3 ± 8.3	42.0 ± 7.2	<.001	0.61
internal rotation, nondominant limb	21.5 ± 5.5	21.8 ± 5.5	.241	0.05
external rotation, nondominant limb	40.1 ± 7.6	40.8 ± 7.0	.107	0.10
sum of rotation, dominant limb	57.1 ± 12.6	63.8 ± 11.0	<.001	0.57
sum of rotation, nondominant limb	61.7 ± 11.3	62.6 ± 10.9	.082	0.08
total	59.4 ± 10.9	63.2 ± 10.7	<.001	0.35
Stretching vs control[a]				
internal rotation, dominant limb			.989	
external rotation, dominant limb			.259	
internal rotation, nondominant limb			.883	
external rotation, nondominant limb			.050	
sum of rotation, dominant limb			.383	
sum of rotation, nondominant limb			.136	
total			.199	

Abbreviations: SES indicates standardized effect size (<0.6, weak; 0.6–1.2, moderate; > 1.2, strong).

[a]*P* = group × time interaction.

In the control group, statistically significant differences from baseline also occurred on the dominant side (internal rotation, external rotation, and sum of hip rotation) and in overall rotation measurements. Effects were weak (internal rotation on the dominant side, sum of rotation on the dominant side, total sum of hip rotation) to moderate (external rotation on the dominant side). Therefore, the effect sizes of changes detected in the control group were also larger for the dominant limb (Table 2).

Between-groups analysis taking limb dominance into account showed stronger effects in the stretching group for all parameters of rotation ROM. Nevertheless, the between-groups difference was only statistically significant for external rotation of the dominant limb. In other words, hip ROM increased significantly on the nondominant side in athletes allocated to the intervention group, whereas no such increase occurred in the control group (Table 2).

Comparison of the collected data showed a weak to moderate positive effect on hip ROM between the first and second assessments. All measurements were obtained after training, before players could cool off.

Discussion

At the start of this study, we had no clear understanding of the etiology of decreased hip ROM in this population of athletes. Whether this condition was the result of preexisting morphological abnormalities or partially or wholly due to longstanding soccer practice (since childhood) remained to be seen[6,22,24,31].

Prior studies have shown that, as time goes by, restrictive changes in the hip joint may worsen, with minor musculoskeletal abnormalities progressing to potential hip dysfunction, slowly aggravating joint restriction and limiting mobility[6,21–25,31]. This gradual, progressive restriction thus jeopardizes athletic performance and may keep young soccer players from elite competition[26,31].

Although hip-rotation ROM is not used as an objective parameter for transition from youth to older categories, our findings suggest that a natural selection process occurs when athletes with a more constrained hip do not perform as well as their peers without this characteristic. This ―natural selection‖ was most evident in the transition or promotion of players from the under-17 to the under-18 category, when a high number of unsatisfactorily performing athletes from the main team were dismissed and replaced with a selected, smaller group from different clubs. This rearrangement pushes up the average hip ROM to a level higher than the average of the previous group, as is easily verified by the fact that the worst mean hip-ROM measurements were obtained in the previous level. On the other hand, in this new group, new athletes from the under-18 category (the highest-age- based tier in the youth soccer pyramid before the professional category) had mean hip-ROM measurements similar to those found in the categories meant for younger athletes.

This finding corroborates our theory that there is a natural exclusion factor in the selection of athletes believed to be promising soccer talents, as the only change in the teams was their being joined by new players—there were no changes in training. This suggests that decreases in rotation ROM of the hip may act as a factor that keeps athletes from making it into the professional leagues[6,21,23].

In this randomized clinical trial, participants in the intervention group followed a program of stretching exercises meant to improve flexibility of the external and internal hip rotators as a means of facilitating acquisition or maintenance of arthrokinematics and osteokinematics. The current literature is inconclusive as to the end effects of stretching. Some authors maintain that stretching increases articular ROM. According to this hypothesis, the greater the flexibility of the athlete, the lower the incidence of injury. Nevertheless, other dogmas dispute the alleged effects usually ascribed to stretching exercises. Those studies have shown that, contrary to popular belief and practice, stretching is followed by a decline rather than an improvement in muscle performance. This somewhat paradoxical scenario gives rise to the main research question of this study: whether stretching exercises for these specific muscle groups are of any benefit to this population of athletes[23,26–28,30].

However, this seems to be the only option, as landing-posture training may be beneficial in some modalities of sport[29] but is certainly of very limited applicability to soccer because shifting and rotating the upper body are common elements of feints or fakes in the game. Even though stretching exercises were done in a non-weight-bearing manner, they could result in more flexible muscle fibers and, consequently, in less leverage force from the knee to the pelvis in a weight-bearing rotatory maneuver. This is a purely theoretical approach, as no dynamic laboratory studies have been able to provide definitive answers yet.

During the intervention period (stage 2 of the study), sample loss, because some individuals were cut from the team, may have affected representativeness, characterizing selection bias. However, this is an uncontrollable factor, because cutting players from teams is a common practice in soccer clubs. Furthermore, the greater sample loss observed in the intervention group was probably random, and the number of analyses remained relatively large and did not invalidate the results.

Another relevant finding was a slight increase in hip-rotation ROM in the intervention group compared with the control group. Only moderate gains in rotational mobility were observed on the nondominant side. Although statistically significant, these differences in hip-ROM parameters between groups were not clinically significant. We believe that continuing the stretching- exercise program trialed in this study for longer than 12 weeks may lead to greater gains in hip-rotation ROM of real clinical significance.

According to our findings, hip ROM decreases gradually with each year of soccer playing. The greatest movement restriction was measured in the under-17 category. However, this trend did not hold for the highest tier of youth soccer before promotion to the professional leagues (the under-18 category); this finding is justified by club-selection practices.

Conclusion

From the cross-sectional portion of this study, we conclude that the greatest degree of hip-rotation ROM restriction is found among the longest-tenured athletes. From the randomized clinical trial stage, we conclude that adherence to a program of specific stretching exercises may be able to prevent muscle restrictions in the hip that decrease hip-joint ROM. In this sample, our specifically designed stretching program had a weak to moderate statistical effect, despite the brief study period. Again, we believe that longer exposure to the proposed exercise program could have produced more relevant effects. Further studies should be conducted to test this hypothesis.

Acknowledgments

The authors would like to thank Sport Club Internacional de Porto Alegre, Porto Alegre, Brazil, for placing their squad and locker rooms at our disposal for the purposes of this study.

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