

Comparison of the Angular Compartment of Hip Flexion Before and After Training in 11 to 12-Year-old Soccer Players.

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Abstract

An anterior cruciate ligament (ACL) injury is an important cause of rest in athletes. In most cases, ACL injuries do not require external contact and they are associated with biomechanical risk factors that increase ACL tension. The increase of the hip flexion angle (HF) is included within these. The ACL requires cooperation of the periarticular musculature of the knee, muscle groups, hip stabilizers and CORE muscles; consequently, fatigue caused by exercise would alter the balance and put this ligament at risk.

The objective of the study is to determine the angular behavior for HF before and after a physical load (a standardized training) in children between 11 and 12 years old.

A non-randomized clinical study was carried out. The sample consisted of 50 soccer school students born between 11 and 12 years old. The angular behavior of HF was compared before and after performing a training session. The angular behavior was measured through the Drop Jump test (DJ), with data obtained by inertial sensors.

After the exercise, there was a significant increase in HF. It was concluded that the angular behavior of HF increases significantly in both extremities after training and that preventive measures must be applied for neuromuscular control of the hip.

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Keywords: angular compartment; hip flexion; anterior cruciate ligament.

Received: Jun 11, 2019

Accepted: Jun 27, 2019

Published: Jul 02, 2019

Editor: Liye Zou, Department of Physical Education and Sports Science, The Chinese University of Hong Kong.

Introduction

The anterior cruciate ligament injury (ACL) is an important cause of lost days for athletes and it is the most common reason for injuries that require more than eight weeks of recovery¹. This injury usually occur while practicing sports and it is more common during competition than during training². The predominant mechanism is a pivot shift type injury, which occurs without contact in the support leg. This mechanism is a combination of hip and knee flexion associated with internal rotation and initial valgus of the knee and, finally, an external rotation of the tibia^{1,3,4}.

Biomechanical risk factors have been proposed for ACL tear such as an increase in knee valgus moment, increased hip flexion and lesser knee flexion, also greater ground reaction force during the fall would increase ACL tension, bringing it closer to its moment of failure^{5,6,7,8,9,10,11}.

Bowerman et al demonstrated that fatigue is related to a decrease in motor balance, which in turn causes a decrease in neuromuscular response, thus increasing the risk of injury to the stabilizing structures¹². A study examined non-athletic and healthy adult subjects before and after a workout, and they observed that both in men and women, fatigue produced an increase in the anterior translation of the tibia¹³. However, these findings have not been systematically reproduced. Increased tibial translation after conducting strenuous training only on the left knee are also a finding in Skinner studies¹⁴, but this not happen when isokinetic exercises were executed¹⁵.

On the other hand, epidemiological studies have shown that the majority of ACL injuries occur during the last 15 minutes of the first half and the last 30 minutes of the second half of a game, so, once again, fatigue could be an important risk factor.

These contradictions in the findings can be explained by the type of training applied to the subjects under study and by the manner in which the deficit produced by fatigue was measured¹⁶. Nevertheless, there are no studies in the literature of the effects of everyday training on the biomechanics of hip flexion. This must be the initial approach for measuring the risk of suffering lower extremity injuries for each athlete. The objective

of this work is to analyze the effect of soccer training on the biomechanics of hip flexion and to relate these findings to the risk of ACL tear.

Subjects and Methods

Our Ethics Committee approved our Non-randomized, uncontrolled experimental study. The population under study are people between 11 and 12 years of age who belonged to children's soccer schools. Sampling was done for convenience, inviting 11 and 12 year old players from five Santiago soccer schools to participate voluntarily. All participants signed an informed consent prepared by our ethics committee prior to their participation. Children born in 2002-2003, who played soccer three to five hours per week, were included. Players with a history of recent lower limb injuries (3 months) or with surgical repair for a lower limb injury were excluded.

The angular peak corresponds to the maximum angle reached by a joint at a certain moment during any movement. For the study, the angular peak of hip flexion was measured for both legs¹⁷ using XSens inertial motion sensors. 6MTx sensors plus two Master Xbus sensors were used. The sensor modules (MTx) were placed on the feet, legs, pelvis as described by Roetenber et al^{17, 18} using as reference points the greater trochanter of the femur, the tuberosity of the tibia and the center of the tibioastragalina. The use of inertial sensors is supported in the literature¹⁹. Cuesta-Vargas, compared inertial sensors with bio-instruments, he concluded that inertial sensors can offer a reliable and accurate method for the study of human movement²⁰.

The information provided by each sensor was processed in a computer, and a skeleton was reconstructed and used for the measurements that were made^{21,22,23}. After placing the sensors, the subjects under study were instructed to perform a drop jump test (DJ), which consisted in falling off from a box at a height of 0.3 m with both feet at the same time onto a ring located 0.5 m away on a horizontal level. This fall had to be performed by putting one foot forward and leaving the rest to the gravitational effect so as to not alter the height of the fall²⁴. After landing each subject was ask to perform a vertical jump as soon as they finish the fall. Each subject performed three (3) DJ pre physical load

and three (3) DJ post physical load. However, for the purposes of the study, only one angular peak was taken, which the highest value was reached in any of the three executions. Concerning the action of the arms in this study, this was not taken into account because the phase to be evaluated was the damping phase, a phase in which the action of the arms is negligible²⁴. The DJ and measurement of the three variables were made before and after carrying out standardized training. This training consisted of a soccer practice session in four stages: pre-competition, technical physical training, soccer drills and recovery.

These Stages are Detailed as Follows

Pre Competition

Development of low intensity training, mixing jogging with joint mobility for upper and lower limbs; jogging pace intensity is increased; at the sound of a whistle, actions such as jumps, dribbling and changes of direction are requested. Next, three series of four repetitions of 35 meters ascensions are made. Finally, the subjects are made to stand in rows and at a visual, auditory or tactile signal; they perform 15 meter sprints (three sets of five repetitions).

Duration of Stage: 25 Minutes Approximately.

Technical physical training: consists of three different drills with duration of 12 minutes each. The first exercise corresponds to a moving and controlling a ball, 20 meter passes to and from a specific position. The second exercise consists of coordination work in addition to technical sequences and vertical jumps that end with a 30 meter sprint (three series). The third exercise consists of a 4 on 4 soccer game.

Duration of Stage: 20 Minutes Approximately.

Soccer Drills

soccer is played in dimensions appropriate for the age group (50 x 30 meters). This stage lasts 20 minutes per time, with a break of five minutes.

Duration of Stage: 2 Times of 20 Minutes + 5 Minutes

Recovery

it starts with a 15-minute jog, followed by active-passive stretching exercises for all the muscle groups that are used the most during soccer practice, such as hip and knee flexors and extensors, abductors

and surae triceps in three 20 second series per muscle group.

Duration of Stage: 5 Minutes Approximately.

Statistical analysis

An exploratory data analysis was carried out. The mean was used as a summary measurement for the anthropometric variables and peak angular variables. In the statistical inference, the pre - and post-training differences of the peak angular variables for each subject were analyzed. The Shapiro Wilk test was carried out to determine if it was possible to assume normal distribution, $p > 0.15$ was accepted. In case of normality, a T- test was employed. On the other hand, the nonparametric test of paired samples for median difference was used (Wilcoxon test). A significance of 0.05 was used and the data analysis was performed using the Statgraphics Centurion XVI.I.

Results

Fifty male individuals were included. The demographic data of the participants is summarized in Table 1. Hip flexion increased after bilateral exercise. The angular peak mean in right HF was $24.80^\circ \pm 10.28^\circ$ prior to training and $29.82^\circ \pm 12.81^\circ$ after training. For left HF, the mean was $27.24^\circ \pm 10.19^\circ$ prior to training and $32.26^\circ \pm 12.76^\circ$ after training. The post-exercise increase of the hip flexion, both for the right and left lower limbs, was significant, obtaining a probability of 0.01 and 0.02, respectively (Figures 1 to 3).

Discussion

In the present study, 11 to 12 year old male subjects belonging to four children's soccer schools in the city of Santiago were evaluated. Within the strengths of the research, we identified the use of inertial sensors, which are highly reliable for measuring the biomechanical variables under study^{19,20}. Standardized training is similar to the training that the subjects perform week by week; therefore, its use is valid for establishing the degree of fatigue that they reach and identifying the risk that they are exposed to. In addition, they wore the usual clothing (shoes) and trained on the same type of surface they normally train on. Finally, the use of DJ allows measurement of the biomechanical variables, a common gesture in the sports practice of soccer. The results show that the load

Table 1. Demographic data

Variable	Variable Mean ± Standard Deviation
Age	11,34 ± 0,51 years
Weight	46,51 ± 8,71 Kg
Size	152,04 ± 8,68 cm
Width	150,2 ± 8,65 cm
Foot size	25,8 ± 1,38 cm

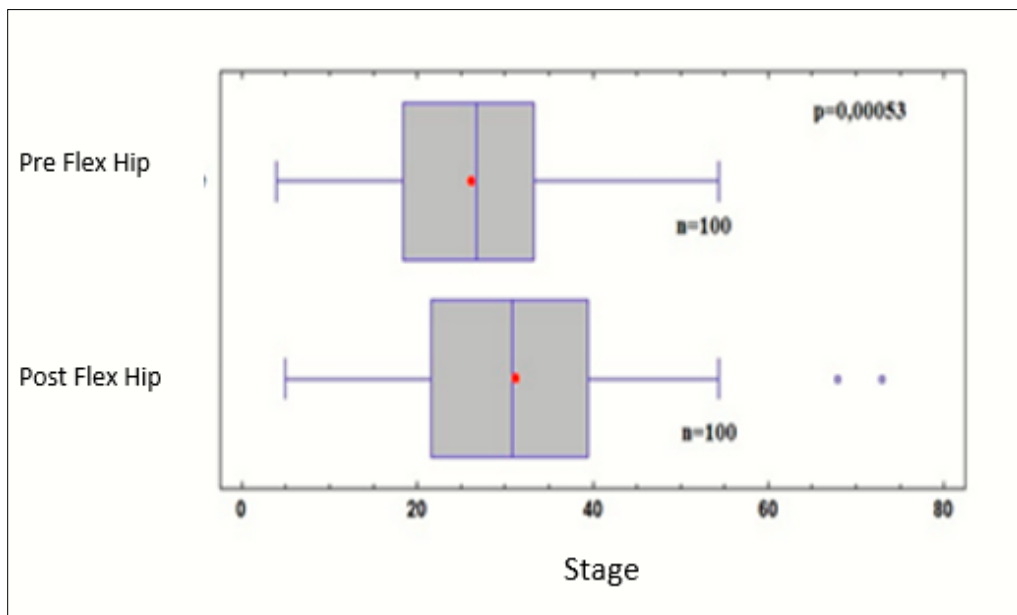


Figure 1. Comparison of HF pre physical load with HF post physical load.

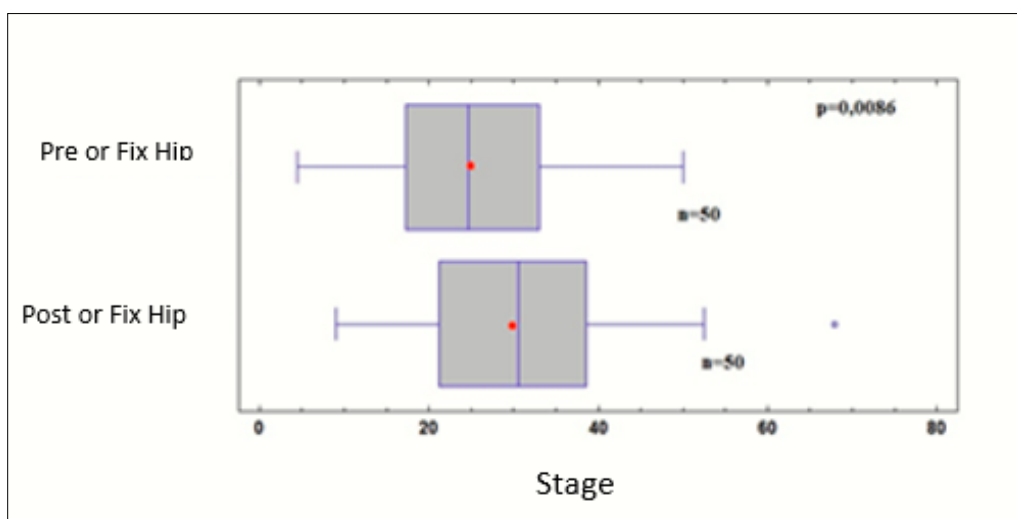


Figure 2. Comparison of HF right pre physical load with right HF post physical load

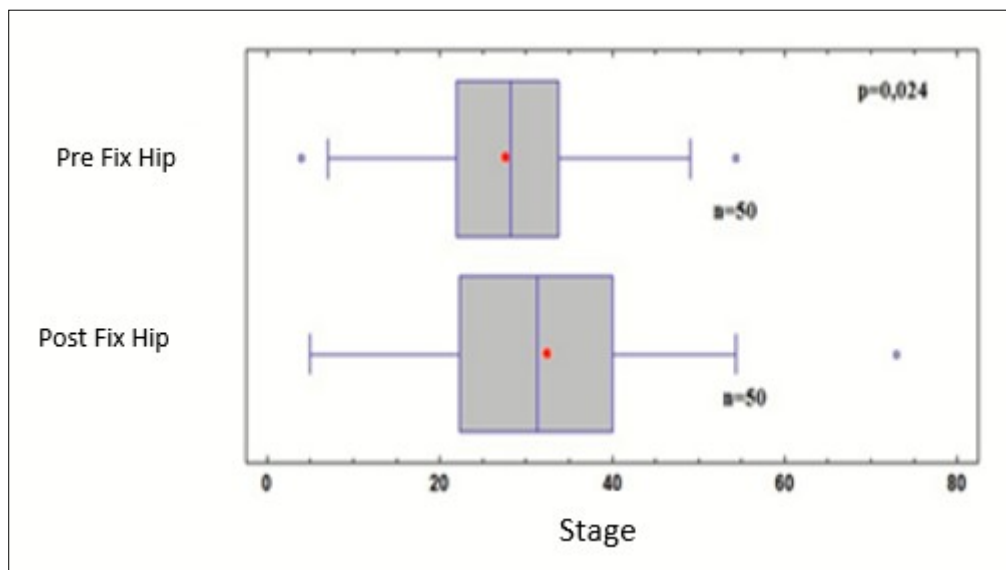


Figure 3. Comparison HF left pre physical load with left HF post physical load

subjected to during training causes significant changes in the angular peak of hip flexion. Boden and his colleagues studied the mechanism of ACL tear by video photogrammetry and found that the angular peak increased in those subjects who had an injury, compared to those who were not injured⁴. Given that the subjects of this work were subjected to an everyday and not maximum load, it may be considered that the increase of hip flexion peak is the first event in the sequence of alterations that fatigue produces in the biomechanical factors that predispose injuries. The cause of this increase in flexion can be attributed to a decrease in CORE muscle activation, which is consistent with what was posed by Hoshikawa et al. They reported significant improvements in unilateral hip muscle strength and jump performance in adolescent soccer players after working out for 6 months in order to strengthen CORE muscles and overall strength, in addition to regular soccer training, in comparison to those who only performed soccer training²⁵. Furthermore, on the neuromuscular level, significant but small-sized relationships were demonstrated between trunk activation levels and lower limb muscles during jumping tasks²⁶.

This work evidences the effect of regular hip flexion training in relation to knee injuries, specifically ACL in 11 to 12 year old children. We consider this

extremely important; given that the anthropometric and laxity changes that occur during puberty put athletes at risk of having knee injuries; to objectify that motor control reached at an early age with regular training helps prevent injuries. A recent meta-analysis of ACL injury prevention studies concluded that greater success in reducing knee injury in athletes was achieved through preventive neuromuscular training begun before the onset of neuromuscular deficits and the peak incidence of knee injuries in adolescences. This is ideally in the pre-pubertal stage^{27,28}.

The training tasked in a standard way to the students of the participating soccer schools is similar to the one that is commonly executed on practice days, both in terms of duration and type of work to be carried out. In addition, the place where the evaluation took place is where they usually carry out their soccer practice, which will positively influence several types of variables, such as the moderators (footwear and training surface), since the individuals used the same footwear they regularly train with. In addition, the surface used for the test was the same as the type used to carry out all their practices. The unknown variables (psychological state, stress and motivation) are also positively influenced by the fact that they were in a known environment, during their normal practice; this, added to the motivation received by their teachers and parents,

for which the psychological state and stress were favored with the control of these variables.

Conclusion

Sports training in our study group showed that hip flexion is modified by the fatigue achieved after normal training. Hip flexion could be the biomechanical factor that is first altered by fatigue, which should be handled by the technical team in order to prevent ligament injuries.

Funding

This study was supported by the Universidad Metropolitana de Ciencias de la Educación (UMCE).

Conflict of Interest

The authors declare that no personal relationship exists that could have influenced this manuscript. We declare no conflicts of interest.

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