

## Research Article

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## Youth Female Field Hockey Players Physical Condition

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### ABSTRACT

**Introduction:** lower limb injuries and low back pain are common injuries in field hockey that have different risk factors. The aim of this study was to characterize youth field hockey players' physical condition to determine their possible injury risk factors.

**Methods:** youth field hockey players of the Club Deportivo Universidad Católica of Chile were assessed during April and May of the 2022 season. The test used were: Ely's, Thomas, Ober and AKE for flexibility, Biering Sorensen, Plank Test, Sport Specific Endurance Plank Test, Single Leg Bridge Test, Lunge Test, Hop Test (single, triple and croo-over) and Y Balance Test. Statistical analyses were performed using R Statistical Software (2023.09.0+463; R Core Team 2023).

**Results:** 87 youth field hockey players from the under 14, 16 and 19 were assess (age  $15.1 \pm 1.5$ ). Poor core and back extensor endurance was found, along with poor hamstring strength and unipodal balance. Significant difference was found between categories in the plank test and sport specific endurance plank test ( $p < 0.001$ ).

**Conclusion:** several impairments were found in chilean youth field hockey players that could pose a risk of injury, however, further research is needed in order to determine if these impairments really are risk factors in this sport and population.

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### Introduction

In the last few decades, there has been an increase in sport activity in children and adolescents that has led to a consecutive increase in skeletal lesions attributed to physical activity [1]. It is estimated that each year, more than 3.5 million children require medical treatment for sport-related injuries in the United States [2]. Despite the popularity and benefits of athletic participation, there is a trending concern about specialized training at earlier ages, because it is associated with high-volume training that can result in psychological stress and overuse injuries [3]. Considering the increasing prevalence of overuse injuries in youth population, some authors have stated that it is critical to evaluate the risk of injury based on an individual's functional motor competence within the context of their sport and address potential limitations prior to participation to alleviate injury prevalence [4-7].

Field hockey is an Olympic sport played by men and women at both recreational and professional level worldwide, and because common practice in field hockey requires athletes to adopt a semi-crouched posture and the use of the stick on the right side most of the time, players have a greater risk of musculoskeletal

disorders related to the asymmetry they may present [8-10]. In this sport, lower limb overuse injuries [ankle and knee] and low back pain are some of the injuries that cause more concern due to its chronic development [8, 11]. Some risk factors that may be associated with injuries in field hockey players have been determined in the literature, among which is a poor dorsiflexor torque, lower proprioceptive ability in the lower limb, higher spinal loading due to semi-crouched position, decreased range of motion (ROM) and more rigid, less flexible pelvis-trunk coordination patterns, along with a rotational asymmetry in the thoracic spine [12-17, 9]. Since most of these risk factors were identified in adult population, the aim of this study is to characterize youth field hockey players' physical condition to determine whether they have the same risk factors or there are different risk factors according to the player's age.

### Material and Methods

#### Participants

All hockey players of Club Deportivo Universidad Católica of Chile of the 2022 season were invited to participate in the study during their training hours. The inclusion criteria for this project were female field hockey players that were part of Club Deportivo Universidad Católica of Chile of the 2022 season and that were between 12 and 19 years old. The exclusion criteria were male

players, female players over 19 years old, players that were not able to attend to the assessments and those players that due to a musculoskeletal impairment were not able to do the evaluations.

On the 2022 season, 120 youth female hockey players were actively training in the club, so 92 players should have been evaluated with a confidence level of 95% and margin of error of 5%.

Before running the project, each one of the participants under 18 were asked to sign an assent form, and parents and players over 18 were asked to sign an informed consent form that was sent through email. This project was approved by the scientific ethic committee of the Pontificia Universidad Católica of Chile and by the AECC ethic committee.

### Assessments

Flexibility was assessed with Thomas test, Ely's test, Active Knee Extension (AKE) test and Ober test [18-21]. Also, the lunge test were assessed to determine if the athlete had ankle dorsiflexion limitation [22, 23].

The resistance of the trunk musculature and core was assessed with the Biering-Sorensen test and the plank test and Sports Specific Endurance Plank Test respectively [24-26]. Moreover, the strength of the hamstring musculature was assessed with the single leg bridge (SLBT) [27].

The Hop test was applied in its three modalities (single, triple and crossover), and finally, the Y balance test was applied to assess unipodal balance [28, 29].

For the abovementioned assessments, six physiotherapist and two last year physiotherapy students of the Pontificia Universidad Católica of Chile, all previously trained in the evaluations, carried out the assessment in the order shown in figure 1. This order was selected to ensure that flexibility tests were carried out with the athlete at rest and that the fatigue tests (SLBT, Biering Sorensen and Sports Specific Endurance Plank Test) were made far apart and after the hop test, so that they don't affect the result of it. Each evaluator carried out the same assessment every day for more reliability.

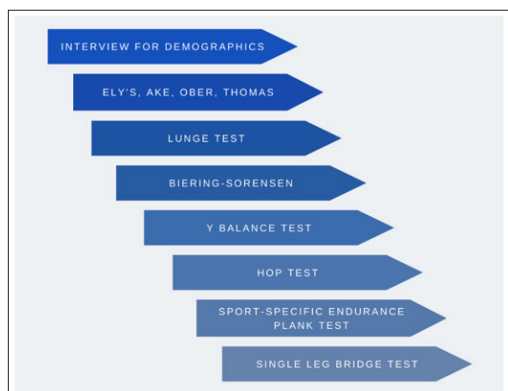


Figure 1: Assessments in Order of Application

The assessments were conducted during the players' training hours in the months of April and May 2022. To achieve efficient organization, an Excel document was sent to the players, allowing them to sign up for a specific evaluation time slot, which were distributed every 5 minutes within the established training schedules. On evaluation days, it was the players' responsibility to arrive at their designated time slots to undergo their assessments.

### Data Collection

Along with the physical assessments, basic information (name, gender and age) and their sport related background (player position, the time they've been practicing hockey and if they are part of the national team) were collected in an excel sheet right before the assessments were carried out. Chronic diseases, surgical interventions, commonly used medications, and their injury history were collected through an online survey that were sent through email.

All the physical assessments results were collected in one online excel sheet that all the evaluators had access to during the assessment period. Once all the information was collected, the survey information was added in the assessments excel sheet and the access to the document was removed from all the evaluators who were not authors of this article.

### Data Analysis

After organizing the data, the players were coded with a single identification number so no personal identification were used in the statistical analysis.

In the analysis of the assessment, the results were not only analyzed in terms of their distribution, but also categorized as altered/poor performance based on prior literature. This approach allowed us to gain a comprehensive understanding of the data, considering both the statistical distribution and the qualitative assessment of individuals' performance, aligning our evaluation process with established scholarly frameworks.

Based on prior literature, a lunge test is considered altered when the person being evaluated is not able to touch the wall with the knee at 10 cm or less from the wall [23, 30]. According to the study conducted by Johnson et.al. [31], which assessed 625 adolescents aged 11 to 19 years old, the Biering-Sorensen test results are categorized, for females, as poor endurance when the duration of the test is less than 67 seconds, medium endurance between 67 seconds and 170 seconds and good endurance over 170 seconds.

The plank test for the under-14 and under-16 categories was considered altered when they maintained the position for under 77 seconds [32]. Conversely, the plank test for athletes in the under 19 category was considered altered when they lasted less than 180 seconds and a second analysis was made considering low performance when they lasted less than 120 seconds, right before the most demanding part of the test (elevating arm and leg at the same time) [26]. In the context of the single-leg bridge test, it is considered as poor when individuals cannot complete more than 20 repetitions, average when they achieve between 21 and 30 repetitions, and good when they can perform more than 30 repetitions [33]. Regarding the hop test and Y balance test, they are considered altered and represent a greater risk of injury when there is a difference greater than 10% in jumping performance between limbs and a composite distance less than 94% in dynamic balance [34-36].

Statistical analyses were performed using R Statistical Software (2023.09.0+463; R Core Team 2023).

### Results

88 players were assessed but only 87 were included in the analysis since one player couldn't do all the assessments. The demographic data of the players can be found in table 1.

**Table 1: Demographics**

	<b>Under 14 (N=18)</b>	<b>Under 16 (N=43)</b>	<b>Under 19 (N=26)</b>	<b>P value</b>
<b>Gender</b>				
Female	18 (100%)	43 (100%)	26 (100%)	-
<b>Age</b>				
Mean (SD)	13.2 (0.707)	14.7 (0.549)	17.0 (0.599)	0.000
Median [Min, Max]	13.0 [12.0, 14.0]	15.0 [14.0, 16.0]	17.0 [16.0, 18.0]	
<b>National team</b>				
No	4 (22.2%)	32 (74.4%)	19 (73.1%)	0.001
Si	13 (72.2%)	11 (25.6%)	7 (26.9%)	
<b>Years of practice</b>				
Mean (SD)	7.12 (1.62)	6.65 (3.17)	8.96 (2.88)	0.006
Median [Min, Max]	8.00 [5.00, 10.0]	7.00 [0.400, 12.0]	9.50 [1.00, 13.0]	
<b>Position</b>				
Goalkeeper	1 (5.6%)	1 (2.3%)	1 (3.8%)	0.730
Defenser	5 (27.8%)	10 (23.3%)	6 (23.1%)	
Fordward	6 (33.3%)	12 (27.9%)	10 (38.5%)	
Midfilder	6 (33.3%)	16 (37.2%)	9 (34.6%)	
Not reported	0 (0%)	4 (9.3%)	0 (0%)	
<b>Body mass (kg)</b>				
Mean (SD)	50.2 (7.65)	58.5 (5.81)	60.5 (8.07)	0.000
Median [Min, Max]	50.5 [39.5, 68.0]	59.6 [45.9, 68.5]	60.8 [41.3, 71.4]	
Missing	6 (33.3%)	18 (41.9%)	10 (38.5%)	
<b>Height (m)</b>				
Mean (SD)	1.18 (0.702)	1.64 (0.0540)	1.63 (0.0562)	0.000
Median [Min, Max]	1.57 [0, 1.63]	1.64 [1.53, 1.72]	1.62 [1.52, 1.74]	
Missing	2 (11.1%)	18 (41.9%)	10 (38.5%)	
<b>BMI</b>				
Mean (SD)	20.4 (2.44)	21.9 (2.12)	22.7 (2.37)	0.030
Median [Min, Max]	20.1 [18.0, 26.8]	22.1 [18.4, 25.2]	22.3 [18.0, 26.6]	
Missing	6 (33.3%)	18 (41.9%)	10 (38.5%)	
<b>Previous injury</b>				
Not reported	4 (22.2%)	8 (18.6%)	7 (26.9%)	0.323
No	3 (16.7%)	6 (14.0%)	0 (0%)	
Yes	11 (61.1%)	29 (67.4%)	19 (73.1%)	

**BMI:** Body Mass Index

Data is presented as mean, standard deviation, percentiles and range for continuous variables and percentages and frequencies for categorical variables. A one-way ANOVA analysis was used to compare continuous variables by category. A two-sample t-test was used to analyze continuous variables by national team. Chi-square test was used to detect relationship between categorical variables. Statistical significance was set at  $P \leq 0.05$ .

The results of the continuous variables are showed in table 2 and the distribution of the categorical variables are shown in table 3. The only test that had statistically significant differences between categories regarding the proportion of altered results was the plank test for poor core endurance ( $p < 0.001$ ) between the under 19 and the under 16 and 14 categories.

**Table 2: Distribution of Continuous Variables**

	<b>Under 14 (N=18)</b>	<b>Under 16 (N=43)</b>	<b>Under 19 (N=26)</b>	<b>P value</b>
<b>Lunge test R° (cm)</b>				
Mean (SD)	12.2 (2.49)	11.2 (3.14)	12.0 (2.79)	0.313
Median [Min, Max]	12.0 [7.00, 18.0]	11.0 [5.00, 17.0]	13.0 [6.00, 17.0]	
<b>Lunge test L° (cm)</b>				
Mean (SD)	11.9 (2.71)	11.4 (3.50)	12.2 (2.65)	0.544
Median [Min, Max]	12.0 [7.00, 18.0]	12.0 [3.00, 19.0]	13.0 [7.00, 16.0]	
<b>Y Balance CD R° (%)</b>				
Mean (SD)	95.6 (7.71)	93.5 (6.16)	95.9 (7.92)	0.342
Median [Min, Max]	95.6 [77.3, 109]	93.7 [78.6, 102]	94.5 [82.7, 116]	
<b>Y Balance CD L° (%)</b>				
Mean (SD)	98.2 (8.10)	94.2 (6.49)	98.0 (7.98)	0.005*
Median [Min, Max]	100 [78.6, 109]	94.1 [79.4, 110]	95.0 [87.5, 116]	
<b>SLBT R° (rep)</b>				
Mean (SD)	16.9 (6.94)	23.3 (9.40)	20.0 (8.16)	0.028*
Median [Min, Max]	15.0 [8.00, 29.0]	23.0 [8.00, 46.0]	18.0 [8.00, 45.0]	
Missing	0 (0%)	1 (2.3%)	2 (7.7%)	
<b>SLBT L° (rep)</b>				
Mean (SD)	16.7 (7.14)	22.6 (8.15)	21.0 (7.69)	0.032*
Median [Min, Max]	14.0 [9.00, 32.0]	23.0 [9.00, 45.0]	20.0 [10.0, 42.0]	
Missing	0 (0%)	1 (2.3%)	2 (7.7%)	
<b>Plank test (s)</b>				
Mean (SD)	116 (39.5)	88.3 (41.2)	80.0 (21.0)	0.006*
Median [Min, Max]	103 [60.0, 180]	82.0 [11.0, 180]	73.0 [54.0, 124]	
Missing	0 (0%)	0 (0%)	1 (3.8%)	
<b>B. Sorensen (s)</b>				
Mean (SD)	89.8 (22.0)	117 (47.1)	127 (46.9)	0.019*
Median [Min, Max]	86.0 [58.0, 141]	117 [43.0, 200]	137 [32.0, 216]	
Missing	0 (0%)	1 (2.3%)	0 (0%)	
<b>HOP Single R° (cm)</b>				
Mean (SD)	143 (13.7)	128 (25.5)	144 (16.4)	0.003*
Median [Min, Max]	144 [119, 166]	133 [0, 162]	147 [106, 172]	
<b>HOP Single L° (cm)</b>				
Mean (SD)	140 (12.7)	127 (25.7)	142 (16.0)	0.008*
Median [Min, Max]	136 [122, 162]	132 [0, 157]	143 [106, 172]	
<b>HOP Triple R° (cm)</b>				
Mean (SD)	425 (36.4)	372 (49.8)	419 (44.9)	0.000*
Median [Min, Max]	426 [330, 480]	370 [253, 470]	429 [305, 495]	
<b>HOP Triple L° (cm)</b>				
Mean (SD)	411 (45.6)	364 (43.2)	412 (42.6)	0.000*
Median [Min, Max]	409 [303, 497]	367 [247, 441]	417 [316, 491]	
<b>HOP CO R° (cm)</b>				
Mean (SD)	380 (45.5)	330 (49.5)	369 (48.6)	0.000*
Median [Min, Max]	389 [244, 457]	326 [190, 439]	363 [297, 491]	
<b>HOP CO L° (cm)</b>				
Mean (SD)	385 (59.0)	324 (69.0)	366 (54.9)	0.001*
Median [Min, Max]	393 [234, 484]	330 [34.0, 418]	363 [278, 464]	

CD: Composite Distance; SLBT: Single Leg Bridge Test; LSI: Limb Symmetry Index; CO: Cross Over.

**Table 3: Data is Presented as Frequencies and Percentages**

	Under 14 (N=18)		Under 16 (N=43)		Under 19 (N=26)	
	Right	Left	Right	Left	Right	Left
<b>Muscle shortening</b>						
Rectus femoris	11 (61.1)	12 (66.7)	20 (46.5)	25 (58.14)	15 (57.7)	17 (65.4)
Hamstrings	9 (50.0)	6 (33.3)	26 (60.0)	25 (58.1)	10 (38.5)	11 (42.3)
Iliotibial band	4 (22.2)	3 (16.7)	15 (34.8)	14 (32.6)	3 (11.5)	8 (30.8)
Hip flexors	10 (55.6)	7 (38.9)	10 (23.3)	10 (23.3)	9 (34.6)	6 (23.1)
<b>Lunge test</b>						
< 10 cm	1 (5.6)	2 (11.2)	13 (30.2)	14 (32.6)	5 (19.2)	6 (23.1)
<b>Y Balance</b>						
CD < 94%	8 (44.4)	5 (27.8)	22 (51.2)	21 (48.8)	13 (50.0)	10 (38.5)
<b>SLBT</b>						
Poor (<20 rep)	11 (61.1)	13 (72.2)	17 (39.5)	17 (39.5)	15 (57.7)	13 (50.0)
Average (20-30 rep)	7 (38.9)	4 (22.2)	14 (32.6)	19 (44.2)	8 (30.8)	10 (38.5)
Good (>30 rep)	0 (0.0)	1 (5.6)	11 (25.6)	6 (13.9)	3 (11.5)	3 (11.5)
<b>Plank Test</b>						
<77s (a) / 120s (b)	2 (4.4) (a)		20 (44.4) (a)		23 (51.1) (b)	
<b>Biering Sorensen</b>						
Poor (<67s)	3 (16.7)		8 (18.6)		3 (11.5)	
Medium (67-170s)	15 (83.3)		27 (62.8)		18 (69.2)	
Good (>170s)	0 (0.0)		8 (18.6)		5 (19.2)	
<b>Hop test</b>						
Single (LSI > 10%)	2 (12.5)		8 (18.2)		3 (11.5)	
Triple (LSI > 10%)	2 (12.5)		7 (16.3)		3 (11.5)	
CO (LSI > 10%)	1 (5.5)		7 (16.3)		4 (15.4)	

CD: Composite Distance; SLBT: Single Leg Bridge Test; LSI: Limb Symmetry Index; CO: Cross Over.

### Discussion

Over the past years, there has been an increase in the available literature regarding physical and physiological characteristics of field hockey, allowing professionals to better understand the athletes' requirements and have a more effective planning of physical loads during training and competitive periods [37, 38]. Since an injury may cause an alteration in this planning, it is essential to know about them and to prevent them in order to optimize the athlete's performance. However, there is still a gap in the literature regarding the risk factors for injuries in this sport, and it is even more limited when considering female athletes in youth categories.

The high incidence of lower back and lower limb injuries in this sport underscores the need for studies that assess the overall physical condition of the structures involved in these injuries [39]. This is essential for determining whether the athletes' physical condition allows them to withstand the current demands of the sport, and to evaluate the necessity of timely interventions to mitigate the risk of injuries in adulthood.

In this study, the physical characteristics of 87 youth female field hockey players were assessed through various tests, revealing different anomalies that may pose an injury risk for the sport. In this sport, lower limb overuse injuries [ankle and knee] and low back pain are some of the injuries that cause more concern due to its chronic development [8, 11]. Regarding the lower

extremities, insufficient joint range of motion can increase the likelihood of future injuries. Ankle dorsiflexion range is crucial in daily activities, sports performance, and may represent a risk for sustaining an injury in this joint or other body segments [40, 41]. Limitations in this range may require compensatory movement strategies that may lead to different sports injuries such as ankle sprains, anterior cruciate ligament injuries, patellar tendinopathy, plantar fasciitis, and others [42-45]. Furthermore, dorsiflexion has been linked to increased muscle activation in the transverse abdominal, pelvic floor, and quadriceps, potentially influencing the development of lower back pain and injuries in other joints [46, 47]. While our results indicate an adequate ankle dorsiflexion range of youth players, it would be interesting to determine whether this sufficient ankle range is a result of the sport demands, or it is influenced by the greater joint laxity that players may have at younger ages compared to adult categories. The authors suggest including ankle dorsiflexion assessment in preseason and return-to-sport examinations since this range is associated with the activation of the brain area responsible for movement preparation, the cortex of sensory integration, motor planning, and execution, along with visuomotor coordination [40, 48, 49].

The posterior chain of field hockey players requires adequate flexibility, strength, and muscular endurance to withstand the physical demands of maintaining a semi-crouched posture during various instances of play. Our results showed that more than 60% of the players in all categories had medium endurance of the back

extensors, reaching up to over 80% in the under 14 category (figure 2). Understanding the values of the Biering Sorensen test in this sport and among the female youth population can be highly relevant for injury prevention since it has been seen that women experience a higher incidence of lower back pain in the young population (between 6 and 19 years), and decreased isometric back extensors endurance is associated with the presence of low back pain in adolescents [50-52].

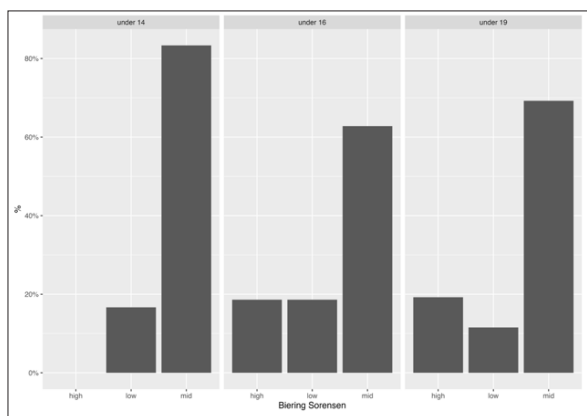


Figure 2: Biering Sorensen Results

Along with poor endurance of back extensors, it was observed that under 16 and under 19 categories had poor endurance of the core musculature when performing the plank test and sports specific endurance plank tests (figure 3), deficit that has also been associated with low back pain, nevertheless, future studies should be made to gain further insights into the execution times of these assessments and their relationship with the risk of experiencing lower back pain in this sport [53].

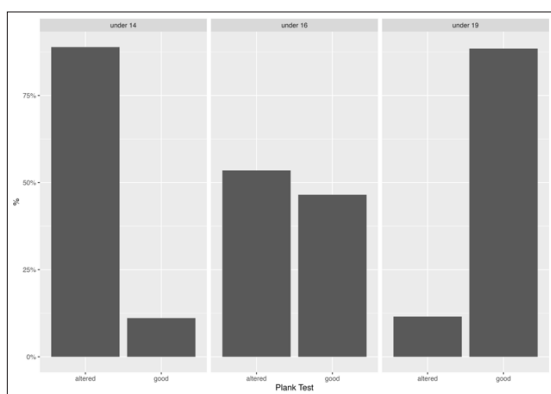


Figure 3: Plank Test and Sports Specific Endurance Plank Test Results

When analyzing the number of players with deficient performance in the core endurance tests, none of the under 19 category reached 180 seconds and even when analyzing the results with a cut-off point of 120 seconds, they had significantly worse results when compared with the other categories ( $p < 0.01$ ), difference that could be attributed to the fact that the tests that were used have different levels of difficulty. The sports specific endurance plank test (SSEPT) is a complex test that requires control in all three movement planes, unlike the plank test, where the primary focus lies on evaluating sagittal plane stability [25, 26]. Since field hockey is a sport that requires control in the sagittal, frontal and transverse plane of movement, the SSEPT is a relevant assessment that should be carried out in all players to evaluate the CORE control that aligns more with the demands of the sport. Unfortunately, there are no normative data, and the test is not yet

validated for youth athletes (under 18 years old) so it was not suitable to perform it in our younger players. We recommend that future studies focus on developing and/or validating tests that assess core control in all three planes of motion for youth athletes. It is important to note that the results of the under 14 category should be interpreted with caution as over 70% of the players were part of the national team and in this specific test, there was an almost significant difference ( $p = 0.058$ ) observed between those who are part of the national team and those who were not, so the category results are influenced by the high proportion of national team players.

In soccer, it has been identified that increased tension in the hamstring and quadriceps muscles, along with poor hamstring muscle strength and endurance may lead to a higher risk of muscle injury in the posterior region [27, 54]. The significant number of athletes with hamstring tightness and inadequate performance on the single leg bridge test (figure 4) are noteworthy since they suggest that these athletes may be at a heightened risk of hamstring muscle injury. Although the incidence of muscle injuries in sport is lower at younger ages, it is essential to prevent injuries in this muscle group during the athlete's development since it has been observed that age and the number of previous hamstring injuries can be significant factors in the risk of experiencing a new hamstring injury [55, 56]. In the case of field hockey, there are still no high-quality studies that mention whether there is a relationship between muscle tightness and a higher risk of injury [57]. Therefore, it would be interesting to determine in future studies whether this observed tightness indeed signifies a risk for injuries in this sport or if it's merely a predictable physical condition due to the semi-flexed position of the trunk and lower limbs adopted by the players, which may be causing hamstring tightness.

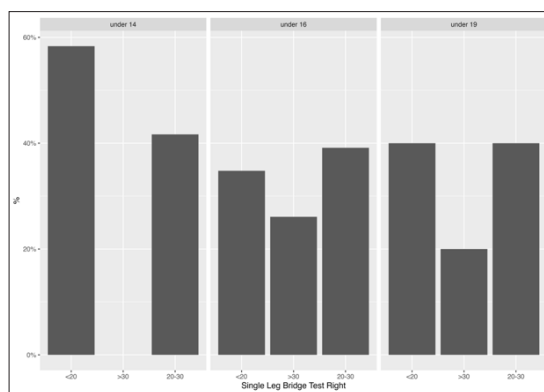


Figure 4A: Single Leg Bridge Test Results (Right Leg)

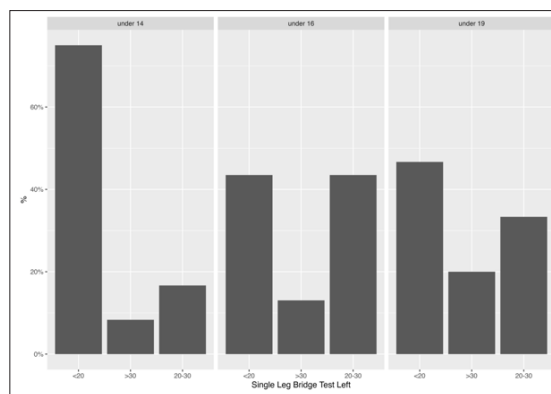


Figure 4B: Single Leg Bridge Test Results (Left Leg)

Single leg jump tests are used for the prevention or post-surgical clearance after anterior cruciate ligament reconstruction because they are functional assessments that evaluates dynamic stability of the lower extremity [58]. Although no significant asymmetries between extremities were found in our study, the results obtained in the single hop test, triple hop test and cross over hop test may provide a certain reference value for this specific population. For future studies we recommend analyzing the kinematics during the jump as it can offer valuable insights into the quality of movement.

The Y balance test is a dynamic neuromuscular control assessment, which in some populations is used as a reliable evaluation method that can be helpful in identifying athletes susceptible to lower extremity injuries like and ankle sprain [59, 60]. In this study, we found that over 20% of the players had a deficient composite distance, reaching up to 50% in the right leg of the under 16 and 19 categories. These results suggest that it would be appropriate to carry out interventions like incorporating balance exercises into the players training routines since it has been seen that they help to prevent acute ankle injuries [61].

Among the limitations of this study is that, despite categorizing the athletes into different age groups, within each category there is a varying number of women who are national team members. Since these individuals supplement their club training with national team practices, they may have a better physical condition in certain aspects and therefore, the results may be affected by it. Along with this, the cut-off points used to assess if the athlete had an alteration or not were not in all tests specific for our population age, which could have an impact in the interpretation of the results.

In conclusion, to enhance both individual and collective team performance, increasing our understanding of the physical characteristics of specific populations can facilitate more effective training load planning while simultaneously preventing injuries. Although certain deficits were identified in this study population, we recommend that future studies evaluates if these impairments indeed constitute a risk factor for this specific population and sport.

#### Acknowledgments

We would like to acknowledge the collaboration of the staff and members of the Club Deportivo Universidad Católica' field hockey team, Diego Amoroso, Pablo Yañez and all the players for letting us do the assessments during their training hours and actively participate. Along with this, we would like to acknowledge the collaboration of the sports development managers, Marcelo Venegas and Marta Miró, for supporting the project. And finally, we would like to acknowledge the collaboration of our colleagues and physiotherapy last year students for helping us do the assessments.

#### Conflicts of Interest

Authors have no conflict of interest to declare.

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