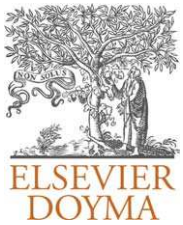
Apunts Med Esport. 2011;46(172):163–168



apunts
MEDICINA DE L'ESPORT
www.apunts/org

ORIGINAL ARTICLE

# Kinanthropometry of world champion junior male field hockey players

**Francis E. Holway**[a,*], **Mariano Seara**[b]

[a] *Departamento de Medicina Aplicada a los Deportes, Club Atlético River Plate, Buenos Aires, Argentina*
[b] *Universidad Abierta Interamericana, Buenos Aires, Argentina*

Received 22 November 2010; accepted 22 February 2011
Available online 8 April 2011

**KEYWORDS**
Somatotype;
Proportionality;
Anthropometry;
Birth-day effect

**Abstract**
*Introduction and purpose:* There is a lack of published data on the anthropometric and relative-age effect of elite youth field hockey players.
*Purposes:* (a) To establish the anthropometric characteristics of elite junior Argentine male field hockey players; (b) to look for differences in physique, years of playing and birth-date effect between the final players selected to make up the team and those who were not selected out of the original pre-selected sample; and (c) to establish whether there are any differences in proportional limb lengths between elite junior hockey players and a local reference sample.
*Methods:* Thirty five elite Argentine junior field hockey players pre-selected to form the base of the national junior team for the 2005 Junior World Cup (Age 19.0 ± 1.0 years; weight 70.7 ± 5.4 kg; height 176.4 ± 6.4 cm). A full anthropometric battery including lengths, heights, breadths, girths, and skinfolds, plus number of years playing and date of birth.
*Results:* No statistically significant differences were found in skeletal structural dimensions when compared to a reference sample, nor between finally selected and non-selected players in anthropometric dimensions, playing history ($P = .11$) and relative-age effect ($P = .11$).
*Conclusion:* Male field hockey is a sport with normal bone-structural requirements, and with a lack of birth-date effect in Argentina.


**PALABRAS CLAVE**
Somatotipo;
Proporcionalidad;
Antropometría;
Efecto fecha de nacimiento

**Cineantropometría de jugadores juveniles varones campeones mundiales de hockey sobre hierba**

**Resumen**
*Introducción y objetivos:* Existe un vacío de información sobre la antropometría y el efecto de fecha de nacimiento sobre jugadores de hockey de elite juvenil masculino.
*Objetivos: a*) Describir las características antropométricas de jugadores de hockey de elite juvenil masculino de Argentina; *b*) establecer diferencias en el físico, la edad deportiva y el

* Corresponding author.
*E-mail address:* fholway@hotmail.com (F.E. Holway).

1886-6581/$ – see front matter 
doi:10.1016/j.apunts.2011.02.009

efecto de la fecha de nacimiento entre los jugadores seleccionados para el mundial juvenil y quienes quedaron afuera, y *c*) establecer si existen diferencias en las longitudes de los miembros entre estos jugadores de elite y una muestra normal de referencia adulta local.
*Métodos:* Se evaluaron longitudes, alturas, diámetros, perímetros, pliegues y masa corporal en 35 jugadores de hockey juveniles que componían la base y la selección Argentina para el mundial de 2005 (edad 19,0 ± 1,0 años; peso 70,7 ± 5,4 kg; estatura 176,4 ± 6,4 cm). Paralelamente se encuestó sobre la edad deportiva y la fecha de nacimiento.
*Resultados:* No se encontraron diferencias estadísticamente significativas en las variables estructurales del esqueleto entre esta muestra y una referencia normativa local, ni entre la submuestra seleccionada y los no-seleccionados, ni en la edad deportiva (p = 0,11) ni en el efecto de fecha de nacimiento (p = 0,11).
*Conclusiones:* El hockey sobre hierba masculino es un deporte con requerimientos de estructura ósea normales, y sin efecto de la fecha de nacimiento, en Argentina.


## Introduction

Field hockey is a team sport with heavy demands on the player's physiology[1,2]. As a consequence, elite players show a high degree of leanness[3]. Furthermore, team mean percentage body fat was found to bear a relation with finishing position in a sample of 12 teams playing the South African Senior Provincial tournament. On the contrary, in Australia, sub elite male field hockey players did not differ from Senior or Youth select sides in mass, height, nor body fat levels[4].

Elite level sport tends to self-select individuals with morphological characteristics which respond optimally to its physical demands[5]. Since field hockey requires players to spend time in a crouched position, having long arms may be an advantage in this activity. Data on 33 male field hockey players from the Montreal Olympic Games showed them to have proportionally longer arm and forearm lengths when compared to a reference Canadian university student sample[6]. Scott[3] did not find any correlation between functional arm length and playing ability in his large sample of players.

The birth-date effect is often found in under-age squads, where age categories are delimited by at least a one-year period, favoring those who are biologically more mature from being born earlier in the year[7]. This effect may carry on to senior select sides if early selection processes have discouraged late-year birth daters away from high-level competition[8]. Again, we have not found such information in male field hockey.

### Purpose

The aims of our study are: (a) to establish the anthropometric characteristics of elite junior Argentine male field hockey players who won the International Hockey Federation (IHF) Junior World Cup in 2005; (b) to look for differences in physique, years of playing and birth-date effect between the final players selected to make up the team and those who were not out of the original pre-selected sample; and (c) to establish whether there are any differences in proportional limb lengths between elite junior hockey players and a local reference sample. In this manner we wish to contribute to the anthropometric database on successful elite junior athletes and the characteristics that set them apart for the processes of talent identification.

## Methods

### Design

The study is observational, cross-sectional, and prospective. We measured the players on one occasion, in August 2004, after being selected to form the base from which the final select squad will emerge, to compete in the June 2005 IHF Rabo Hockey Junior World Cup held in Rotterdam, The Netherlands. The final chosen players make up the selection team that is compared to those who were left out.

### Subjects

Thirty five junior male field hockey players from all regions of Argentina (age 19.1 ± 1.0 years, weight 70.7 ± 5.4 kg, height 176.4 ± 6.4 cm), chosen by coaches to make up a preselection from which the final 17 players would compete in the IHF Junior World Cup of 2005. In the month preceding their evaluation battery at the national sports centre in Buenos Aires, players were sent an informed consent formulary via electronic mail detailing the scope and intent of the measurements, and were asked to sign it or have their parent or legal tutor do it if underage. Approval for the study was granted by the Ethics Committee at the Medical Department of Club Atlético River Plate. We excluded the four goalkeepers from this analysis, since they have different morphologic characteristics than the other playing positions which could affect the general average, such as higher skinfolds, perhaps because their activity profile is very different from field players; nevertheless their data is shown for descriptive purposes. The other two goalkeepers selected as part of the final team were unavailable for measurement at the time. Selection criteria were based on

**Table 1** Basic and skeletal characteristics of players and reference sample

| | Field players | Goalkeepers | Argoref sample |
|---|---|---|---|
| *Basic measurements* | | | |
| Sample size | 35 | 4 | 87 |
| Age (years) | 19.1 ± 1.0 | 18.4 ± 1.6 | 25.3 ± 2.8 |
| Weight (kg) | 70.7 ± 5.4 | 72.5 ± 3.2 | 74.7 ± 9.0 |
| Height (cm) | 176.4 ± 6.4 | 174.1 ± 3.4 | 175.4 ± 7.3 |
| Sitting height (cm) | 94.4 ± 3.3 | 93.1 ± 2.5 | 92.4 ± 4.2 |
| Arm span (cm) | 178.1 ± 6.3 | 176.0 ± 2.3 | 177.4 ± 7.3 |
| *Lengths and heights (cm)* | | | |
| Acromiale-radiale | 33.2 ± 1.3 | 32.2 ± 0.9 | 33.3 ± 1.7 |
| Radiale-styloid | 25.8 ± 1.4 | 24.6 ± 0.6 | 26.1 ± 1.5 |
| Midstyloid-dactylion | 19.7 ± 0.9 | 19.0 ± 0.2 | 19.9 ± 1.1 |
| Iliospinale height | 98.0 ± 4.7 | 96.1 ± 2.5 | 97.1 ± 5.4 |
| Trochanterion | 92.2 ± 4.1 | 91.1 ± 3.0 | 91.4 ± 5.5 |
| Trochanterion-tibiale laterale | 45.2 ± 2.0 | 44.8 ± 0.9 | 45.1 ± 2.7 |
| Tibiale laterale | 46.2 ± 2.1 | 45.4 ± 1.2 | 46.4 ± 2.8 |
| Tibiale med.-sphyrion tib. | 38.9 ± 2.3 | 38.3 ± 1.5 | 38.8 ± 2.7 |
| Foot length | 26.5 ± 1.2 | 25.8 ± 0.2 | 26.6 ± 1.2 |
| *Breadths (cm)* | | | |
| Biacromial | 39.9 ± 1.7 | 40.2 ± 0.8 | 40.3 ± 2.1 |
| Transverse chest | 29.1 ± 1.2 | 29.1 ± 1.3 | 29.6 ± 1.9 |
| Antero-posterior chest | 19.1 ± 1.3 | 18.2 ± 1.0 | 20.0 ± 1.4 |
| Biiliocristal | 27.3 ± 1.6 | 26.8 ± 0.7 | 27.9 ± 1.6 |
| Humerus | 7.0 ± 0.3 | 6.8 ± 0.3 | 7.1 ± 0.3 |
| Femur | 9.7 ± 0.5 | 9.8 ± 0.2 | 9.9 ± 0.5 |
| Wrist | 5.8 ± 0.3 | 5.6 ± 0.2 | |
| Ankle | 7.6 ± 0.4 | 7.4 ± 0.3 | |
| Hand | 8.1 ± 0.4 | 8.0 ± 0.2 | |

coaches's subjective observation of playing skills, and the final select squad went on to win the tournament.

### Measures

Level 2 and Level 3 International Society for the Advancement of Kinanthropometry (ISAK)-certified anthropometrists undertook a full anthropometric profile including height and weight, skinfolds, girths, and structural dimensions (breadths, segment lengths and heights) following procedures outlined by ISAK[9], as well as information on playing position and history of training. Lastly, we used the roster of the final select team from the Confederación Argentina de Hockey web page[10].

### Anthropometry

A Level 3 anthropometrist landmarked all subjects prior to being measured. We weighted the players using a mechanical scale (Model p1001, CAM, Buenos Aires, Argentina), and measured height, arm span, and sitting height with wall-mounted stadiometers and a 50 cm wooden box. We then used a segmometer (Rosscraft, Buenos Aires, Argentina) for segment lengths and heights; large and small bone calipers (Campbell 20 and Campbell 10, Rosscraft, Buenos Aires, Argentina) for large and small bone breadths; a flexible, non-stretching steel tape (W606PM, Lufkin, USA) for girths; and a Harpenden skinfold caliper (Body Care, Baty International, Harpenden, England) for skinfolds. We took all skinfolds and most girths in duplicate, which are the variables that normally have the largest technical error of measurement. A third measure was taken if a large discrepancy between the first two was found. We measured the players in the afternoon before training, barefooted and in minimal clothing. We included the sum of six skinfolds, a popular indicator of body fatness[6], and somatotype[11] as derived variables.

### Statistical analyses

We entered data into Microsoft Excel spreadsheets (MSN, Cupertino, USA), and later transferred them to Epi Info 6.0 statistical package (CDC, USA) for analysis, including means, standard deviations, frequencies, Bartlett's test for homogeneity of variance, analysis of variance, Kruskall-Wallis, and Chi square. Statistical significance was set at $p < 0.05$.

## Results

### Limitations

It is important to state that measurements were taken almost one year before the Junior World Cup, and that the anthropometric data of the squad that made up the final selection may be different from measurements had they

**Table 2** Girths, skinfolds and somatotype of players and reference sample

| | Field players | Goalkeepers | Argoref sample |
|---|---|---|---|
| *Girths (cm)* | | | |
| Head | 56.2 ± 1.3 | 56.0 ± 1.0 | 57.0 ± 1.5 |
| Neck | 35.5 ± 1.4 | 35.5 ± 1.1 | 37.4 ± 1.8 |
| Arm (relaxed) | 28.4 ± 1.4 | 30.5 ± 2.0 | 31.1 ± 2.6 |
| Arm (flexed and tensed) | 30.7 ± 1.4 | 32.4 ± 1.9 | 33.3 ± 2.7 |
| Forearm (maximum) | 26.6 ± 1.1 | 26.9 ± 0.8 | 27.7 ± 1.6 |
| Wrist (distal styloids) | 16.6 ± 0.6 | 16.4 ± 0.3 | 16.8 ± 0.8 |
| Chest (mesosternale) | 92.0 ± 3.9 | 93.1 ± 3.6 | 97.5 ± 5.8 |
| Waist (minimun) | 76.0 ± 2.7 | 76.7 ± 2.9 | 80.8 ± 5.6 |
| Abdominal (omphalion) | 78.5 ± 3.1 | 80.5 ± 4.9 | |
| Gluteal (hips) | 96.6 ± 3.1 | 100.0 ± 4.6 | 96.8 ± 4.9 |
| Thigh (1 cm below gluteal) | 57.0 ± 3.0 | 59.3 ± 3.1 | 57.5 ± 3.2 |
| Thigh (mid) | 52.7 ± 2.9 | 53.8 ± 3.3 | 53.2 ± 2.9 |
| Calf (maximum) | 36.1 ± 1.8 | 36.8 ± 0.5 | 37.4 ± 2.2 |
| Ankle (minimum) | 22.2 ± 0.9 | 22.6 ± 0.6 | 22.6 ± 1.2 |
| *Skinfolds (mm)* | | | |
| Triceps | 8.4 ± 2.4 | 11.6 ± 3.1 | 9.1 ± 3.8 |
| Subscapular | 7.7 ± 1.2 | 9.9 ± 2.9 | 10.6 ± 3.2 |
| Biceps | 3.6 ± 0.7 | 5.7 ± 3.0 | 4.2 ± 1.8 |
| Iliac crest | 10.3 ± 3.9 | 16.0 ± 6.8 | 15.2 ± 6.6 |
| Supraspinale | 5.3 ± 1.6 | 7.6 ± 2.4 | 8.9 ± 4.2 |
| Abdominal | 10.9 ± 4.6 | 17.6 ± 8.3 | 18.5 ± 9.1 |
| Front thigh | 10.1 ± 3.3 | 16.2 ± 4.5 | 12.7 ± 4.8 |
| Calf | 6.5 ± 1.9 | 9.1 ± 2.7 | 7.8 ± 3.5 |
| Sum 6 skinfolds[a] | 48.7 ± 13.1 | 71.8 ± 20.4 | 67.5 ± 24.5 |
| *Somatotype components* | | | |
| Endomorphy | 2.0 ± 0.5 | 2.8 ± 0.8 | 2.8 ± 1.0 |
| Mesomorphy | 4.5 ± 0.9 | 5.0 ± 0.6 | 5.6 ± 0.9 |
| Ectomorphy | 2.7 ± 0.9 | 2.0 ± 0.6 | 2.0 ± 0.9 |

[a] Sum of triceps, subscapular, supraspinale, abdominal, front thigh, and calf skinfolds.

been taken at the tournament. It is not uncommon for athletes this age to undergo morphological changes within a year. Hence care must be used when interpreting the data of the tournament winners.

## Technical error of measurement

Technical errors of measurement (TEMs) for girths on the 37 players fall under the 1.0% cut-off value considered to be the acceptable upper limit of error for these measures, and under the 5.0% cut-off for skinfolds[12], indicating good reliability in measurement. We established the validity of the anthropometrists' technique beforehand during four-month long certification courses, when inter-subject TEMs were calculated against Criterion Level 3 and Level 4 anthropometrists.

The descriptive characteristics of the players and goalkeepers are shown in Tables 1 and 2. Data from a local 20 to 30 year-old fitness sample, Argoref[13], are also shown to compare heights and segment lengths. This sample, although older, was deemed adequate for comparison of bone structural characteristics, considering that by age nineteen the

**Table 3** Anthropometric differences between playing positions

| Variable | Goalkeepers (n = 4) | Defenders (n = 10) | Halves (n = 11) | Forwards (n = 14) |
|---|---|---|---|---|
| Weight (kg) | 72.5 ± 3.2 | 72.4 ± 4.7 | 68.0 ± 5.7 | 71.6 ± 5.1 |
| Height (cm) | 174.1 ± 3.4 | 179.0 ± 5.1 | 174.0 ± 6.4 | 176.5 ± 7.0 |
| Σ 6 skfinfolds (mm)[a] | 71.7 ± 20.4 | 42.5 ± 8.7 | 52.7 ± 16.5 | 50.1 ± 11.9 |
| Endomorphy[b] | 2.84 ± 0.82 | 1.71 ± 0.38 | 2.11 ± 0.58 | 2.08 ± 0.58 |
| Mesomorphy | 5.03 ± 0.60 | 4.50 ± 1.08 | 4.48 ± 0.81 | 4.56 ± 0.92 |
| Ectomorphy | 2.00 ± 0.58 | 2.88 ± 0.90 | 2.65 ± 0.75 | 2.57 ± 1.08 |

[a] ($p = 0.009$).
[b] ($p = 0.017$).

players have reached or are very close to final bone length growth. In this comparison, there were no differences in height or any of the segment lengths, with the exception of sitting height (p = 0,03), where the hockey players had, on average, a larger value for trunk height (Table 1).

Within the group of players (Table 3), there were no statistically significant differences between player positions in age, weight, and height, although the Σ 6 skinfolds (p = 0.009) and endomorphy (p = 0.017) were larger in the goalkeepers. There is the possibility of a Type II error here since the sample sizes for each group are small. We must point out that, although statistically not significant, defenders were, on average, taller (p = 0.27) and halves lighter (p = 0.17) than all the other players. Defenders also had lower values for Σ 6 skinfolds and endomorphy.

After goalkeepers were separated from the sample, no statistically significant differences were found between the selected and non-selected players in any of the anthropometric variables nor somatotype, with the exception of humerus breadth which was 0.2 cm smaller in the selected sample (p = 0.01). This difference in breadth is meaningless in practical terms.

## Discussion

The lack of skeletal differences between the selected players and the normal reference sample refutes the hypothesis that field hockey players may have longer upper limb lengths, as found by Ross et al[6], but further confirms the finding of these authors that «this sport has minimal structural limitations, and qualities and factors other than physique enter into the development of the field hockey player.» One such quality is lower back strength, where field hockey players have superior values than a normal poplulation sample[17]. The difference in sitting height maybe explained by the fact that the hockey players were on average taller than the Argoref sample, but since trochanterion height, which represents leg length, was also greater, we conclude that there might be a slight difference in measurement technique (errors in sitting height measurement are not uncommon, according to Carr et al[14]) or positioning of the wall-mounted sitting height stadiometer, or accurate assessment of seat height. The older Argoref sample had more weight, endomorphy and mesomorphy than the young field hockey players.

This sample of elite youth field hockey players is similar in height and weight to the Spanish B and Junior sides[15], shorter than Dutch 18-19 year old elite players[19] and lighter than senior samples like the South African players surveyed by Scott[3] and the Argentine Olympic team measured in Montreal 1976 by Carter[16], as would be expected when comparing this players with older samples.

**Table 4** Anthropometric differences between selected and non-selected players[a]

| Variable | Selected (n = 15) | Non-selected (n = 20) |
|---|---|---|
| Weight (kg) | 72.1 ± 6.4 | 69.6 ± 4.3 |
| Height (cm) | 177.8 ± 7.0 | 175.4 ± 6.0 |
| Σ 6 skfinfolds (mm) | 48.7 ± 7.7 | 48.7 ± 16.2 |
| Endomorphy | 1.95 ± 0.25 | 2.02 ± 0.70 |
| Mesomorphy | 4.28 ± 0.76 | 4.70 ± 1.00 |
| Ectomorphy | 2.71 ± 0.84 | 2.67 ± 1.00 |

[a] Goalkeepers excluded.

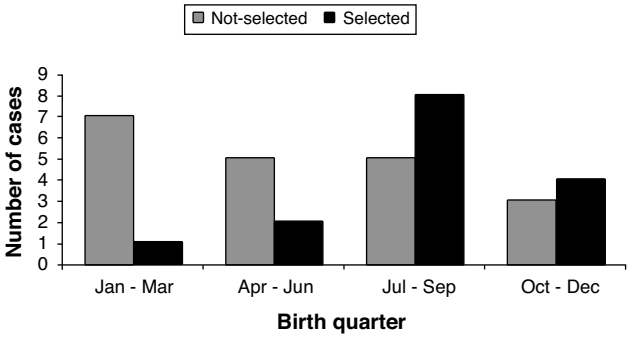



**Figure 1** Birth-quarter in selected and non-selected players.

The lack of differences in physique between the selected and non-selected players might stem from the fact that the whole group was already an elite different from the rest of the country's players, where again, factors other than physique determine the outcome of the selection process at this level. As before, the possibility of a Type II error is real, with the selected players being slightly taller (p = 0.30), heavier (p = 0.18), and less mesomorphic (p = 0.19), as shown in Table 4.

The final selection of players had birth dates that were skewed towards the second half of the year, with eight out of the 17 players being born in the third quarter of the year (Figure 1). Nevertheless, considering the low number of cases in each birth-quarter strata, there were no statistically significant differences between birth-quarter of the selected versus the non-selected players (p = 0.11) nor is there an asymmetry in birth dates for the whole sample (p = 0.80). This is in contrast to what usually is reported in other sports such as youth soccer across Europe[8], where there is an over-representation of those born in the first quarter of the selection year, and in professional basketball in Spain[18]. The reason why no relative age effect was found in this elite youth field hockey sample is not clear, and merits further research. We can think of a few answers: (a) perhaps the smaller numbers of players of this sport make selection processes not as competitive as in soccer; or (b) that those who did not succeed in soccer turned to other sports like field hockey; or (c) that the nature and competitive schedule of this sport does not place a very high emphasis on the physical and psychological advantages of early maturers. Whatever the reason, this fact is a welcome occurrence for the fairness in competition in youth field hockey.

These players had been playing field hockey an average of 11.2 ± 2.6 years, and there were no differences between the selected and non-selected groups (p = 0.11). In these players, who on average had been playing for more than ten years, sporting age or experience was not an important factor in being selected to make the final team. This time period is surely ample enough to attenuate any advantages from extra time practicing the sport.

## Conclusion

We have described the anthropometric profile of the champion junior field hockey players, who are very similar in structural characteristics to a normal reference adult sample, albeit leaner. Within the pre-selected group, those who were selected to make up the final team did not differ anthropometrically nor in playing history from those who were not selected. It was interesting to find the absence of a relative-age effect in this group, and we do not fully understand the reasons for this, an area which merits further research.

## Conflict of interests

Authors declare that they don't have any conflict of interests.

## Acknowledgements

Federación Argentina de Hockey.
Coach Jorge Lombi.
Dr. Lindsay Carter.

## References

1. Reilly T, Borrie A. Physiology applied to field hockey. Sports Med. 1992;14:10–26.
2. Spencer M, Lawrence S, Rechichi C, Bishop D, Dawson B, Goodman C. Time-motion analysis of elite field hockey, with special reference to repeated-sprint activity. J Sports Sci. 2004;22:843–50.
3. Scott PA. Morphological characteristics of elite male field hockey players. J Sports Med Phys Fitness. 1991;31:57–61.
4. Lawrence S, Polglaze T. Protocols for the physiological assessment of male and female field hockey players. In: Gore CJ, editor. Physiological tests for elite athletes.. Champaign, Illinois: Human Kinetics; 2000.
5. Norton K, Olds T, Olive S, Craig N. Anthropometry and sports performance. In: Norton K, Olds T, editors. Anthropometrica.. Sydney, Australia: University of New South Wales Press; 1996.
6. Ross WD, Ward R, Leahy RM, Day JAP. Proportionality of Montreal athletes. In: Carter JEL, editor. The physical structure of athletes. Part I: The Montreal Olympic Games Anthropological Project. Basel, Switzerland: Karger; 1982. p. 81–106.
7. Musch J, Grondin S. Unequal competition as an impediment to personal development: a review of the relative age effect in sport. Developmental Review. 2001;21:147–67.
8. Helsen WF, van Winckel J, Williams AM. The relative age effect in youth soccer across Europe. J Sports Sci. 2005;23:629–36.
9. International Society for the Advancement of Kinanthropometry. International standards for anthropometric assessment; 2001.
10. Confederación Argentina de Hockey. 2005. Available in: http://cahockey.org.ar/seleccionado.php?id_seleccionados_tipos=4.
11. Carter JEL, Honeyman-Heath B. Somatotype: theory and applications. Cambridge, UK: Cambridge Press; 1990.
12. Ross WD, Kerr DA, Carter JEL, Ackland TR, Bach TM. Anthropometric techniques: precision and accuracy. In: Carter JEl, Ackland TR, editors. Kinanthropometry in aquatic sports.. Champaign, Illinois: Human Kinetics; 1994. p. 158–69.
13. Holway F. Tablas de referencia antropométrica para el trabajo en ciencias de la salud: las Argoref. 2005. Available in: http://www.nutrinfo.com.ar/pagina/info/argoref.pdf.
14. Carr RV, Rempel RD, Ross WD. Sitting height: an analysis of five measurement techniques. Am J Phys Anthropol. 1989;79:339–44.
15. Drobnic F, Galiles PA, Pons V, Riera J, Rodriguez FA. The breath frequency as a limiting factor for the ventilation of maximal effort in different sports. In: Proceedings First IOC Congress on Sports Science, Colorado Springs; 1989; p. 122-123. Cited in: Reilly T, Borrie A. Physiology applied to field hockey. Sports Med. 1992;14:10-26.
16. Carter JEL, editor. The physical structure of athletes. Part I: The Montreal Olympic Games Anthropological Project. Basel, Switzerland: Karger; 1982.
17. Til Pérez L, Barceló Peiró O, Pomés Díes T, Martínez Navas R, Galilea Ballarini P, Bellver Vives M. Fuerza lumbar en jugadores de hockey hierba. Apunts: Educación Física y Deportes. 2007;42:138–44.
18. Esteva S, Drobnic F, Puigdellivol J, Serratosa L, Chamorro M. Fecha de nacimiento y éxito en el baloncesto profesional. Apunts: Educación Física y Deportes. 2006;41:25–30.
19. Elferink-Gemser MT, et al. Development of the interval endurance capacity in elite and sub-elite youth field hockey players. Br J Sports Med. 2006;40:340–5.