NEED AND PROPOSAL FOR CHANGE IN THE SIZE OF WOMEN'S HANDBALL BALL SUPPORTED BY A SCIENTIFIC STUDY: 'THE COVERAGE INDEX OF THE BALL'

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Summary
The present study collected and analyzed data from 1612 handball players (779 women and 833 men) from 13-14 up to more than 18 years old. We collected data of 3 linear measurements of players' s dominant hand, and using a new formula we obtained the "ball coverage index" which indicates the % of ball that a hand is able to cover. Finally, we propose, in a scientific way, the measure of ball that should have each age category in order to be proportional between men and women

Keywords:
Team handball, women handball, size of ball, hand's measurement, ball coverage index

Introduction

The intention of this study is to analyze and determine if the game official balls according to the article 3: the ball, of the Rules of the game (International Handball Federation, 2011), are proportionate, among men and women, depending on the measure of their hands, and more specifically, whether our findings on what we have called "ball coverage index, Porras, Oliver and Sosa"[1] of the dominant hand, is proportional between women and men in the same age category.

Different authors (Antón, 1990; Bárcenas, 1976; Bárcenas & Román, 1991; Enríquez & Falkowski, 1982; Oliver & Sosa, 1996; Torres, 1991) indicate the importance of adapting the ball properly to perform subsequent actions such as pass or shoot, with guarantees of success. Llorente and Díez (1996) remark that is very important to adapt correctly the ball in the introduction of handball at school. From the earliest references (Bayer, 1978, 1983; Czerwinski, 1977, 1984; Firan & Massano, 1973; Ghermanescu, 1979; Goluch, 1982; Marz, 1967; Müller & Baier, 1975; Singer, 1978; Taborsky, 1993; Vick, 1979) have been highlighted the importance of adapting the ball with safety. Furthermore, numerous studies exist, cited by Molina (2010), where are measured different segments of the body, including hands, with the aim of players detection (Antón, 1990; Ávila, 1997; Cercel, 1980, 1990; Czerwinski, Rouba, & Aguilá, 1993; Laguna y Torrescusa, 2000; Román, 1994; Trosse, 1984, 1993).

But despite the importance of this topic, were found only studies of the authors (Oliver, 2000; Oliver & Sosa, 2011a, 2011b) that deal the relation between the measures of handball players' hands with the measures of the balls of different age categories, men and women.

Objectives

The main objective of this study is to find the coverage index of the dominant hand of handball players, men and women, and to analyze the relationship or proportion of that coverage index among sports categories: infantile, cadet, junior and senior, according to sex.

[1] Ball coverage index, of Porras, Oliver and Sosa, is a new term, coined by the authors, in recognition of those who devised the procedure for calculating this index.

So, we can understand and analyze whether the official size of handball balls by age category, male and female, are proportionally well determined, and depending on the results, propose the official bodies responsible of drafting of the Rules Game of Handball, the size that should have the balls of the women to be equal and achieve proportional ball coverage indices than men of the same age category.

Methods

Participants

The study was conducted with a sample of 1612 Spanish handball players (although in the case of the senior also with some foreign players of both sexes). It comes to 779 women and 833 men, grouped by sex and age category. As regards senior category (over 18 years old) is concerned, participated in the study 98 athletes, 49 women and 49 men. The women belonged to the National Teams of Spain, Brazil and the Netherlands, while the men belonged to Spanish clubs of highest male Division, called "Asobal League"; namely the F.C. Barcelona, BM Granollers and Ciudad Real.

Table 1 *shows in detail the characteristics of the sample.*

Tabla 1. Characteristics of the sample.

		N (1612)	Sample %
Sport	Team Handball	1612	100
Sex	Women	779	48,32
	Men	833	51,67
Age category	Under 14	534	33,12
	Under 16	498	30,89
	Under 18	482	29,90
	Senior (+18)	98	6,07
Sex and age category	Women Under 14	266	16,50
	Men Under 14	268	16.62
	Women Under 16	245	15,19
	Men Under 16	253	15,69
	Women Under 18	219	13,58
	Men Under 18	263	16,31
	Women Senior (+18)	49	3, 03
	Men Senior (+18)	49	3,03

Measure instrument

As we had to measure a very high number of athletes, specifically 1612 hands of Handball players in a very short space of time (using different championships organized in a concentration system) and in full competition, was decided to use a method in which data collection were rapid, valid and effective. Thus, and having studies as reference in which the hand is drawn on paper (Fallahi & Jadidian, 2011; Jürimäe, Hurbo, & Jürimäe, 2009; Visnapuu & Jürimäe, 2007, 2008), we adapt this method and we used the forward by the authors in previous studies (Oliver, 2010, Oliver & Sosa, 2011a, Oliver & Sosa, 2011b).

As data collection instrument we used graph paper notebooks of 100g/m2, A4 size, Guarro's brand, with millimeter grid, both horizontally and vertically. Ballpoints pens, BIC's brand, were also used (fine point: 0.8mm, line width 0.4mm), as well as millimetered rules for the measurement accuracy and to be as accurate as possible. Always was used a table where the

graph paper was placed on it, as well as the dominant hand of each athlete, with the palm of the hand on graph paper and completely open.

Procedure
We proceeded to take the following measures:
First measure: from the outside of the distal phalanx of the thumb to the outside of the distal phalanx of the little finger. Second measure: from the outside of the distal phalanx of the thumb to the outside of the distal phalanx of the middle finger. Third measure: from the outside of the distal phalanx of the middle finger to the outside of the distal phalanx of the little finger. These measures were taken with the palm completely open. With these three measures we proceeded to determine the mean of each, and based on these, calculate the coverage index of each athlete's hand, and the mean of each Age category, with the aim of analyzing the results and draw conclusions according to sex and age category.

The procedure followed to discover and calculate the "ball coverage index", explained in summary form, was as follows:
The three measures of the athlete's hand triangulate in the plane, to later transpose them to the situation in space. As shown graphically in **Figure 1**, we place the point O (distal phalanx of the thumb), the point A (distal phalanx of the middle finger) and the point B (distal phalanx of the little finger). We take these points because they are what we are going to define the claw of athlete when adapting the ball.

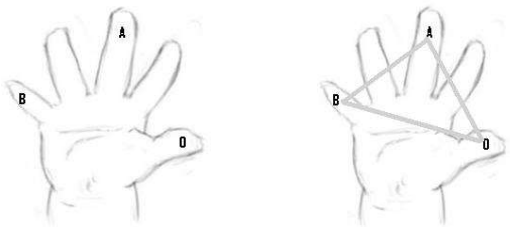


Figure 1. *Points to determine athlete's claw (distal phalanges of the 3 fingers).*

With these three measures (OA, OB and AB), and calculating their coordinates in the Cartesian axis and its perpendicular bisectors we determine an interior point that we call C that corresponds to the circumcenter of the triangle OAB.

As shown in **Figure 2**, the point C, the circumcenter, is the place where they intersect the three bisectors of a triangle and is the center of the circumcircle that will determine the grip area of the ball.

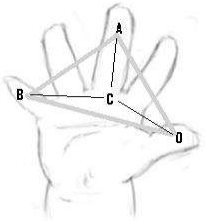


Figure 2. *Circumcenter (C), place that intersect the three bisectors of a triangle. Is the center of the circumcircle that will determine the ball's grip area.*

We take the circumcenter to the distances CA, CB and CO are equal, and so, to proceed to grip the ball, will be at the pole of the ball, and the points O, A and B will determine a not maximum circumference and parallel to the ball Ecuador, as illustrated in **Figures 3 and 4.**

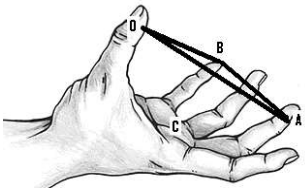
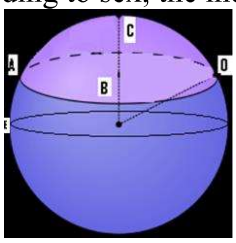


Figure 3. *The circumcenter (C) is located at the pole of the ball, and the points O, A and B determine a not maximum circumference and parallel to the ball Ecuador.*

The distance CA with respect to distance CE (quadrant of the circumference of the ball) is the one that determines the coverage percentage of player's hand over the ball with respect to the official ball of his sex and aged category.

Therefore, in order to determine whether there are differences in the percentage of coverage of the ball for each age category according to sex, the index *I,* is calculated, being:

$$I = \frac{CA}{CE} \bullet 100$$



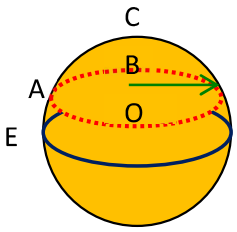


Figure 4. *The circumcenter (C) is located at the pole of the ball, and the points O, A and B determine a not maximum circumference and parallel to the ball Ecuador (dashed line in the illustrations).*

For example, the initial triangle vertices (O, A, B) are the grip points of the ball, and will be situated on the circumference of dotted line, and the circumcenter (C), on top of the ball (**Figure 4).**

The radius of this circumcircle of the triangle will have the same length as the fraction of quadrant covered by the player's hand from (C) to the cutting point with the circumference points.

Finally, the ball coverage index is the ratio of the fraction of quadrant (CA) and total quadrant ball (CE).

So, **the coverage index of the player's hand over the ball** is set as the length of the meridian quadrant of the area covered by the hand with respect to the total.

Results

The mean of the distances, or free space between the fingers, is shown in **Table 2.**

Table 2. Averages of each of the measures of the distances between the toes by sex and Age category

N=1612	Women (N=779)				Men (N=833)			
Age category		Thumb-Litle finger	Thumb-Middle finger	Middle-Little finger		Thumb-Litle finger	Thumb-Middle finger	Middle- Little finger
	N	Mean (cm)			N	Mean (cm)		
Under 14	266	19,84	16,31	10,01	268	20,93	16,95	10,20
Under 16	245	20,06	16,52	10,06	253	21,63	17,86	10,29
Under 18	219	19,69	16,28	9,71	263	21,88	17,93	10,41
Senior (+18)	49	19,57	15,49	9,83	49	21,94	17,56	10,47

Applying the ball coverage index formula (explained above) to the data of **Table 2** gives us the results presented in **Table 3.**

Table 3. Ball coverage index calculated by sex and age category.

Age category	Ball's size used to calculate the C.I.B. (cm)		Ball coverage index (%)	
	Women	Men	Women	Men
Under 14	51 cm	55 cm	78,30	77,05
Under 16	55 cm	55 cm	73,40	79,43
Under 18	55 cm	59 cm	72,16	75,03
Senior (+18)	55 cm	59 cm	72,11	75,60

Discussion

Analyzing the results presented in **Table 3**, we see that women have a lower ball coverage index in all age categories compared with the coverage index of men of the same age category, except in the Under 14 category. Since we want ball coverage indices are proportional between the sexes, we do the calculations, with reference, first, ball coverage indices achieved by men, and secondly, those obtained by women in each age group, to see what should be the size of the ball, in each age category, to be proportionally equalized both sexes.

- If we consider the men's ball size and their coverage index, in **Table 4** are reflected the balls' s sizes with which women should have to play to be proportional with men.

Table 4. Proposal for ball size for women, taking as reference the ball and coverage index of men, in each age category.

Age category	Current size of men´s balls (cm)	Current size of women´s balls (cm)	Women should have to play with these ball size (cm)	Proposal: Sizes of ball for women (cm)
Under 14	54/56 (55)	50/52 (51)	51,83	50/52 (51) Equal
Under 16	54/56 (55)	54/56 (55)	50,85	50/52 (51) Smaller
Under 18	58/60 (59)	54/56 (55)	52,88	52/54 (53) Smaller
Senior + 18	58/60 (59)	54/56 (55)	52,45	52/54 (53) Smaller

- If we consider the women's ball size and their coverage index, in **Table 5** are reflected the balls' s sizes with which men should have to play to be proportional with women.

Table 5. Proposal for ball size for men, taking as reference the ball and coverage index of women, in each age category.

Age category	Current size of men´s balls (cm)	Current size of women´s balls (cm)	Men should have to play with this size (cm)	Proposal: Sizes of ball for men (cm)
Under 14	54/56 (55)	50/52 (51)	54,12	54/56 (55) Equal
Under 16	54/56 (55)	54/56 (55)	59,60	58/60 (59) Bigger
Under 18	58/60 (59)	54/56 (55)	61,36	60/62 (61) Bigger
Senior + 18	58/60 (59)	54/56 (55)	61,87	60/62 (61) Bigger

Conclusions and proposal for changing women' s ball size

Women have a lower ball coverage index than men in all age categories except in Under 14. Thus, given the two proposals presented in Tables 4 and 5, and highlighting that our objective is not increase the men's ball sizes, **we defend the proposal of Table 4**. This is, maintain the sizes of men's balls, and **change the sizes of women's balls**, supported by the results of this study, which are line with the results already obtained by the authors in previous studies (Oliver, 2000, Oliver & Sosa, 2011a, 2011b).

Age category	Current size of women´s ball (cm)	Proposal: Sizes of ball for women (cm)
Under 14	50/52 (51)	50/52 (51) Equal. Current size 1
Under 16	54/56 (55)	50/52 (51) Smaller! Current sixe 1
Under 18	54/56 (55)	52/54 (53) Smaller! New size 1,5
Senior + 18	54/56 (55)	52/54 (53) Smaller! New size 1,5

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