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## ORIGINAL

### **P.O.S. COVERAGE INDEX: MEASUREMENT PROCEDURE OF THE RELATIONSHIP BETWEEN BALL AND HAND**

### **INDICE COBERTURA P.O.S.: PROCEDIMIENTO DE MEDICIÓN DE LA RELACIÓN ENTRE BALÓN Y MANO**

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#### **ABSTRACT**

This paper designs a novel measurement procedure that relates the size of the hand and the size of the ball. This procedure was devised in order to determine the "Hand Coverage Index of Porras, Oliver, Sosa" (H.C.I.P.O.S.) on the ball.

Using three measurements obtained from the dominant hand of athletes with the hand on its maximum aperture taken on a flat plane, we calculated their coordinates in space, and their applications on the sphere of the ball. Subsequently, through a formula, and taking into account the central value of the measurement of the circumference of the ball and the corresponding sport category, we will be able to know the Hand Coverage Index of the athlete over the ball, or the surface of the ball that an athlete is able to cover with his fully open hand with respect to the the sphere of the ball of his sport category.

**KEY WORDS:** Sport, Handball, Kinanthropometry, Sporting talent detection.

## RESUMEN

Este trabajo diseña un novedoso procedimiento de medición que relaciona el tamaño de la mano y el tamaño del balón. Se detalla este procedimiento ideado para la determinación del “Índice de Cobertura de la Mano Porras, Oliver, Sosa” (I.C.M.P.O.S.) sobre el balón.

A partir de tres medidas obtenidas de la mano dominante de los deportistas con la mano en máxima apertura tomadas sobre un plano, calcularemos sus coordenadas en el espacio, y las aplicaremos sobre la esfera del balón. Posteriormente, a través de una fórmula, y teniendo en cuenta el valor central de la medida de la circunferencia del balón del deporte y de la categoría deportiva correspondiente, podremos conocer el Índice de Cobertura de la mano del deportista sobre el balón, o cantidad del balón que un deportista es capaz de abarcar con su mano completamente abierta respecto a la media esfera del balón de su categoría deportiva.

**PALABRAS CLAVE:** Deporte, Balonmano, Cineantropometría, Detección talentos.

## INTRODUCTION

There is clearly an important relationship between the size of the ball and the hand in sports where this round equipment item is controlled and played with hands (Bárcenas, 1976; Bárcenas and Román, 1991; Bayer, 1978; Czerwinski, 1984; Firan and Massano, 1973; Gladman, 1967; Oliver and Sosa, 1996).

The measurements of balls in sports using this type of mobile objects are specified in the regulations from the sports associations. These rules establish size and weigh differences depending essentially on the athlete's gender and age.

In most cases, the criteria used for determining the measurements of balls remain a mystery. This study does not intend to challenge these measurements by discussing whether they are correct or not. It, however, poses a relevant initial question that needs to be addressed: are the official measurements of a ball in a given sport proportionate to the size of the athlete's hand sport for each age group between men and women within that sport?

As a matter of fact, a procedure, allowing to establish the relationship between the measurements of the ball and the size of the athlete's hands, needs to be designed.

Subsequently, that procedure will help to determine whether there is a proportional relationship between the measurements of the ball and hands between women and men in the same sport category.

As a result of all the previous considerations, this study substantially aims to design a procedure, system or formula that will allow to transform three specific linear hand measurements taken in a “spherical” measurement on a plane expressed in percentage or the regulatory ball amount that the hand can cover while fully open according to the sport

discipline each athlete belongs to based on gender and age, which would be referred to here as "Hand Coverage Index Porras, Oliver, Sosa" (H.C.I.P.O.S.).

Therefore, this procedure, system and formula will allow for the specification of the official amount or circumference of the ball in a given sport category that can be covered by the hands of any athletes while fully open, which will then allow for an analysis and comparison in order to determine whether there is proportionality between the official size of a ball in a sport and the size of the athletes' hands in the corresponding sport in each age group between women and men.

## **INSTRUMENTS & METHODOLOGY**

A data collection method in compliance with the speed and easiness requirements in the application and recording processes needs to be designed. The collection of data will usually be carried out during tournaments where the athletes are focused on the game and have obviously no time to go to faraway places for their hand measurements to be taken.

In an effort to avoid interfering with the athletes' training and to safely store the collected data, a simple procedure or method design is suggested where data can be collected wherever the athletes happen to be (a sport venue, their accommodation site, using a means of transport, etc.) for later analysis.

In that sense, there is no method or procedure in the analysed scientific literature for determining the relationship between the size of the ball and hand that is mainly used for adaptation and to play.

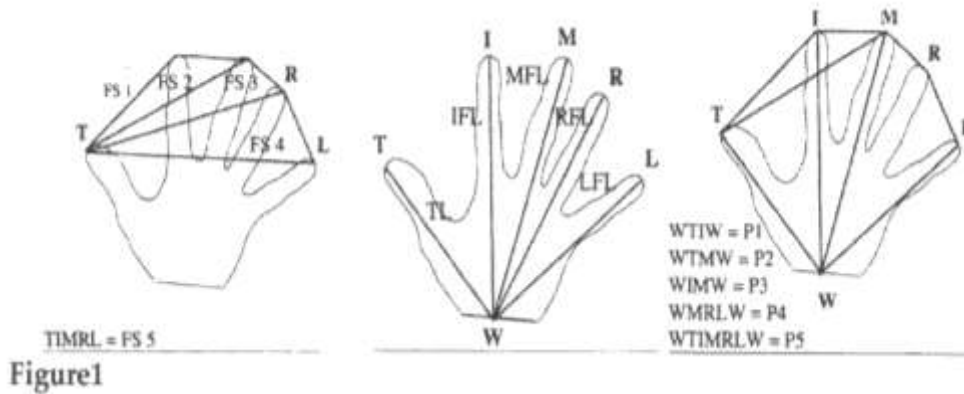
These premises lead to the use of paper as a tool for the collection and storage of accurate measurements that are produced.

Many previous studies already resorted to drawing the dominant hand on a sheet of paper.

Likewise, Visnapuu and Jürimäe (2007), analysed the relationship between the grip power and the hand dimensions in young Estonian handball and basketball players. Their method consisted in drawing the perimeter of the chosen hand in its maximum aperture and fingers separation on paper.

The same measurement method was also used in more studies attempting to determine the relationship between the size of the hand and pressure power (Fallahi and Jadidian, 2011; Jürimäe, Hurbo and Jurimäe, 2009; Visnapuu and Jürimäe, 2008).

Figure 1 shows this measurement method designed and used for the first time by Visnapuu and Jürimäe (2007).



Outlines of anthropometric parameters and dimensions of hand: finger spans (FS1, FS2, FS3, FS4 and FS5), finger lengths (TL, IFL, MFL, RFL, LFL), and 5 perimeters (P1, P2, P3, P4, P5) (Visnapuu and Jürimäe, 2007)

**Figure 1**; Error! No hay texto con el estilo especificado en el documento.. Measurement method designed and initially used by Visnapuu and Jürimäe (2007). Figure obtained from Fallahi and Jadidian (2011, p. 153).

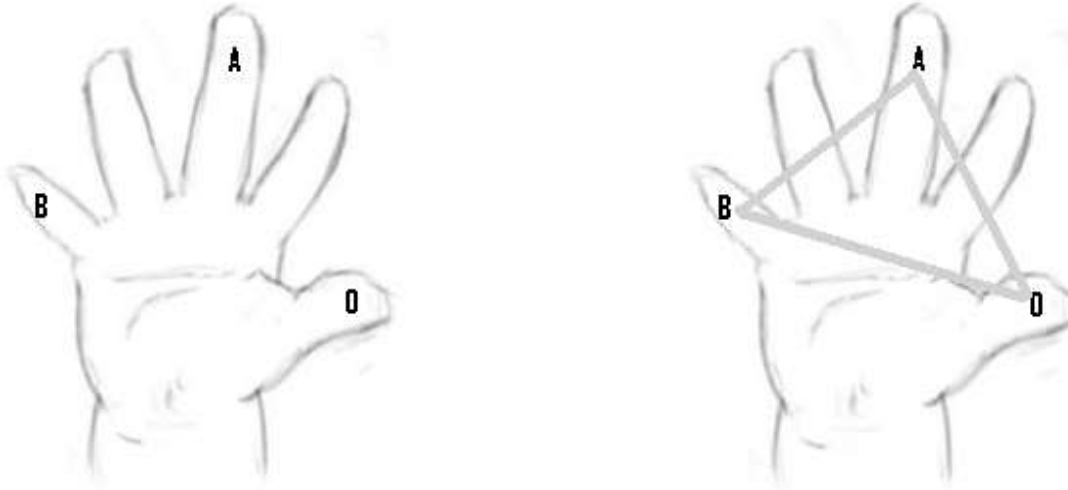
Other studies dealing with hand measurements were also found. Thus, there is, for instance, a study which measured the hands of women in India ( $n= 95$ ) in order to provide data for the design of appropriate tools in the textile industry (Nag, Nag and Desai, 2003). Likewise, there are many other research projects worldwide on anthropometric measurements of hands for the design of tool and staff safety in the industry (Imrhan, Sarder and Mandahawi, 2009; Mandahawi, Imrhan, Al-Shobaki and Sander, 2008; Okunribido, 2000; Saengchaiya and Bunterngchi, 2004).

Anatomical features as well as the dimensions of the hand and the object to be handled such as the size and shape together with the texture of the object to be handled also have an impact on the grip style and power (Firrell and Crain, 1996; Fraser, Vallow, Preston and Cooper, 1999; Nag et al., 2003).

Based on the aforementioned studies where the subject's hands were outlined on paper (Fallahi and Jadidian, 2011; Jürimäe et al., 2009; Visnapuu and Jürimäe, 2007; 2008), this method was adapted for the current study, as detailed below, like in previous studies carried out by one of the authors (Oliver, 2000; 2010) or various of them (Oliver and Sosa, 2011a; 2011b; 2013).

Consequently, the procedure designed and used to determine the "Coverage Index Porrás, Oliver, Sosa" of the hand on the ball is explained below. It makes use of three specific measurements obtained from the athletes' dominant hand producing a triangular shape of the hand on a sheet of paper, which are later transferred to the situation in space and applied to the ball circumference.

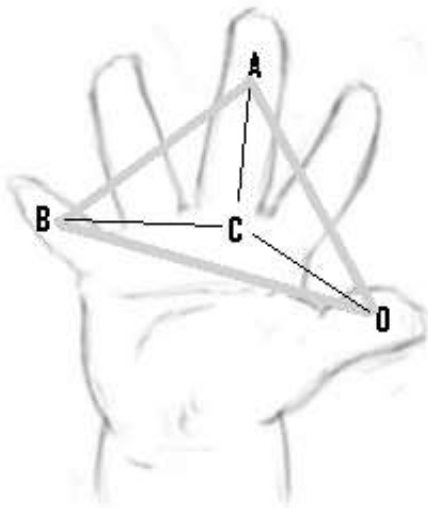
The graphic hand shapes in Figure 2 show the points O (tip of the thumb), A (tip of the middle finger) and B (tip of the little finger). These points are chosen because they will determine the athlete's grip when catching the ball with a hand.



**Figure 2.** Points determining the athlete's grip (distal phalanx of the three fingers).

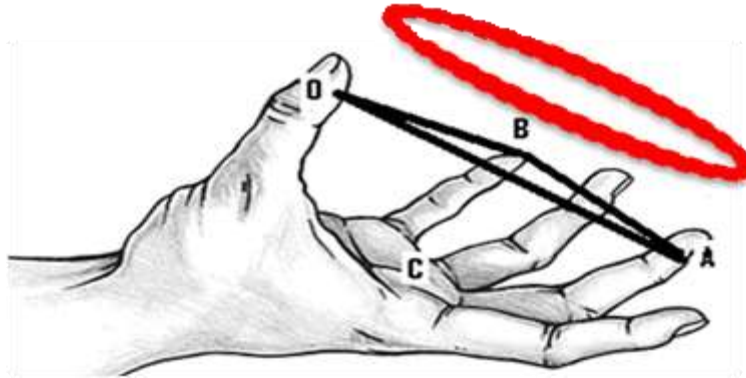
An internal point called C corresponding to the triangle circumcenter OAB was established using these three measurements (OA, OB and AB) and the calculation of their coordinates on the cartesian axis and its mediatrices.

Figure 3 shows that point C is where the three triangle mediatrices are intersected and it is the center of the circumscribed circumference which will determine the ball grip area of the hand.



**Figure 3.** Establishing the circumcenter.

The circumcenter is taken so that the distances CA, CB and CO are equal and will, therefore, be located at the pole of the ball while gripping it. The points O, A and B determine a non-maximal circumference parallel to the equator of the ball as illustrated in Figure 4.



**Figure 4.** Representation of the circumcenter (C) where the ball will rest at its pole and calculation of the non-maximal circumference parallel to the equator of the ball.

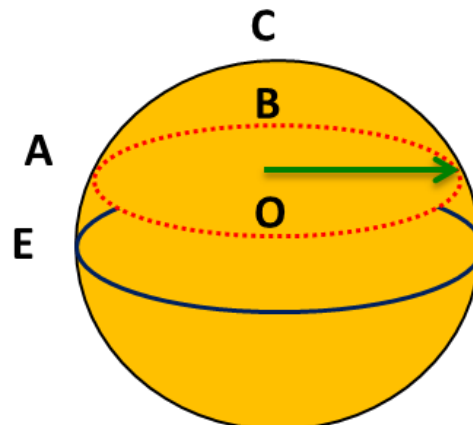
Once the circumcenter is found, the radius of the circumscribed circumference, which is the main target, is calculated using the distance between the circumcenter and one of the vertices.

Therefore, in order to know whether there are differences regarding the ball grip percentage for different categories according to gender, the index I is calculated, which is referred to as the Ball Coverage Index where:

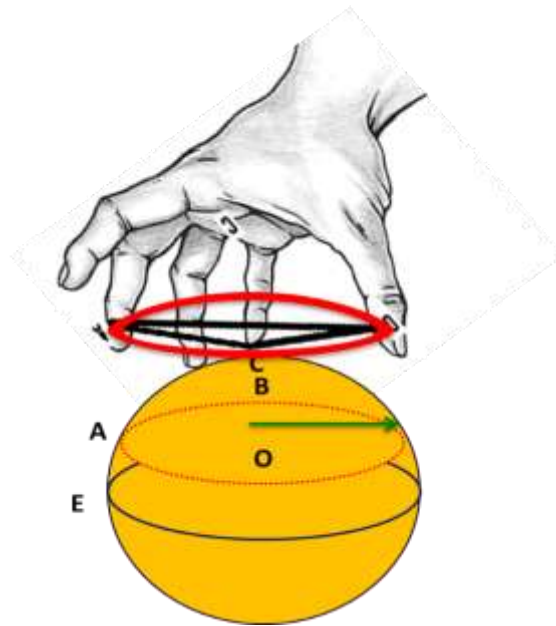
Distance CA in relation to distance CE (ball circumference quadrant) determines the percentage of the athlete's hand coverage with respect to the official ball size within the corresponding sport category. Subsequently, the Ball Coverage Index should more accurately be described as the percentage of the ball's half sphere being covered by the athlete's hand when it is caught.

Thus, whenever the coverage index is later assigned a value of 0.8097, for example, this simply means that the athlete covers 80.97% of half the sphere of the ball.

Figures 5 and 6 reveal that the circumcenter (C) is located at the pole of the ball and the points O, A and B determine a non-maximal circumference parallel to the equator of the ball (E), which is represented by the dotted red line.



**Figure 5.** Location of the circumcenter (C) at the pole of the ball and the non-maximal circumference parallel to the equator (E) of the ball determined by the points O, A and B.



**Figure 6.** Correlation between the athlete's hand and the ball for the calculation of the coverage index.

Actually, the vertexes (O,A,B) of the first triangle are the gripping points of the ball and they are located on the dotted circumference line and the circumcenter (C) is on the upper part of the ball when it is grabbed as illustrated in Figure 6.

The radius of the circumference circumscribed to the triangle will have the same length as the fraction of the quadrant covered by the athlete's hand from (C) to the intersection with the dotted circumference line as illustrated in Figure 6.

Finally, the coverage index will be the correlation between that fraction of the quadrant (CA) and the total quadrant of the ball (CE).

Hence, the coverage index of the athlete's hand on the ball is established as the meridian quadrant length of the sphere covered by the hand in relation to the total.

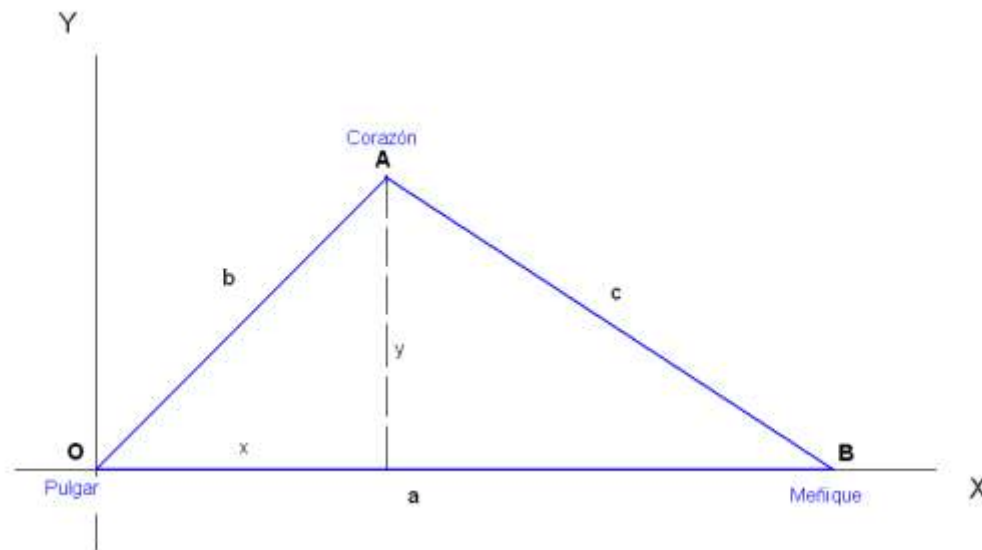
As a consequence, the index *I* called "*Hand Coverage Index Porras, Oliver, Sosa*" will be calculated, in order to determine the ball grip percentage in the different sport categories based on age and gender, using the following formula in Figure 7.

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

**Figure 7.** Formula determining the Coverage Index Porras, Oliver, Sosa of the dominant hand holding the ball.

In order to produce the desired indicator, the coordinates of the points O, A and B

corresponding to the thumb, middle and little fingers are calculated first on the cartesian axis as revealed in Figure 8.



**Figure 8.** Calculation on the cartesian axis of the coordinates of points O, A and B corresponding to the thumb, middle and little fingers.

Where the coordinates of points O, A and B are as follows:

1. Coordinates of O (Ox, Oy)
2. Coordinates of A (Ax, Ay)
3. Coordinates of B (Bx, By)

Given the measurements OA, OB and OC, the coordinates of point O will always coincide with point (0,0); then the coordinates of B, resulting from the measurement (a,0) where “a” is the measurement obtained between the thumb and the little finger, are calculated. Finally, the coordinates of point A are determined by resolving the following system of equations:

$$\begin{cases} b^2 = x^2 + y^2 \\ c^2 = (a - x)^2 + y^2 \end{cases}$$

$$\text{Where } x = \frac{a^2 + b^2 - c^2}{2a} \quad \text{and} \quad y = \frac{\sqrt{(a+b+c)(a+b-c)(a-b+c)(-a+b+c)}}{2a}$$

Point A has coordinates (Ax, Ay) based on these measurements.

The coordinates of the circumcenter are calculated once those of points O, A and B are revealed.



There is a problem to solve before calculating the index  $I$  since the coordinates of the circumcenter need to be determined using the coordinates of the points of the triangle, which can be done using different methods. One of these is mentioned above and consists in finding the mediatrices of each one of the sides and solve the set of equations allowing to calculate the intersection points of two of them since these lines are joined at a point called circumcenter, which is the intersection point of the three perpendiculars of the mediatrices.

As an example of applicability, the hand coverage index of a ball used by a female youth handball player (age 8 to 14) is calculated below:

The three measurements of that player's fully open hand are as follows:

1. Distance from the tip of the thumb to the little finger: 20.63 cm
2. Distance from the tip of the thumb to the middle finger: 17.33 cm
3. Distance from the tip of the middle finger to the little finger: 10.62 cm

The central value of the ball size in her women's youth handball category (age 8 to 14) is 51 cm since the ball must have a size of between 50 and 52 cm according to the International Handball Federation (2016).

First of all, the coordinates of the points are calculated:

Coordinates

Thumb (O) (0,0)

Middle finger (A) (x, y)

Little finger (B) (20,63; 0)

A. If the first calculation method is used:

1. Calculation of the coordinates of vertex A (x,y):

$$\begin{array}{rcl}
 b^2 = x^2 + y^2 & \begin{array}{l} - \\ b^2 = x^2 + y^2 \end{array} & \text{Subtracting:} \\
 c^2 = (a - x)^2 + y^2 & \begin{array}{l} - \\ c^2 = a^2 + x^2 - 2ax + y^2 \end{array} & b^2 - c^2 = -a^2 + 2ax
 \end{array}$$

Then:  $x = (a^2 + b^2 - c^2) / 2a$

In our case:  $x = (20,63^2 + 17,33^2 - 10,62^2) / (2 * 20,63) = 14,86$

$$y = \sqrt{b^2 - x^2} = \sqrt{17,33^2 - 14,86^2} = 8.92$$

Subsequently, the coordinates of vertex A are (14.86; 8.92)

2. Figure 9 shows the calculation of circumcenter C (x,y), intersection point of the mediatrices (perpendicular lines on each side at the intermediate point of each side).

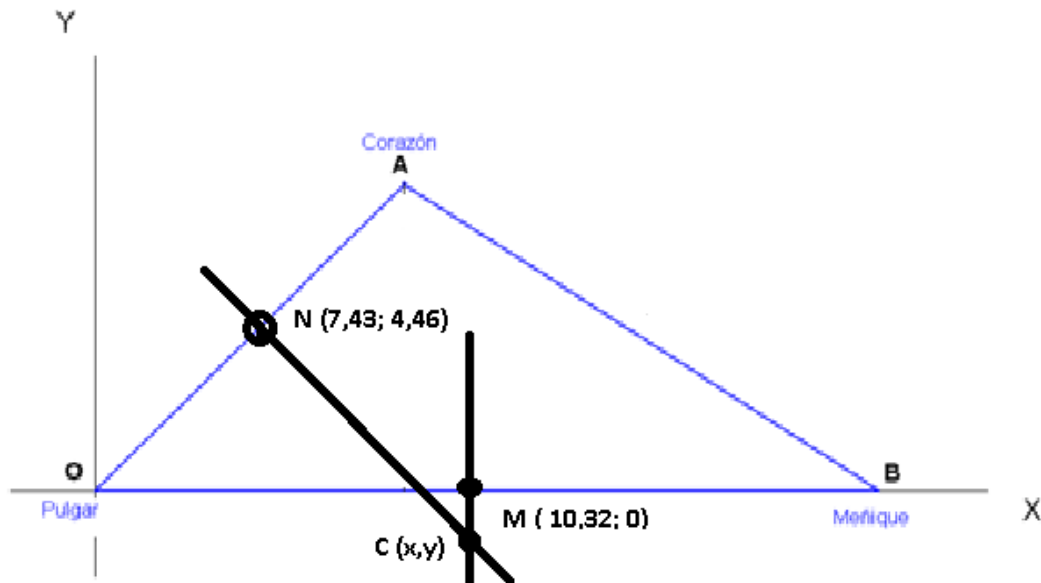


Figure 9. Calculation method for the circumcenter using the mediatrices.

2.1 Equation for line MC:  $x = 10.32$

Equation for line NC:  $(x,y) = (7,43; 4,46) + k (8,92; - 14,86)$ :

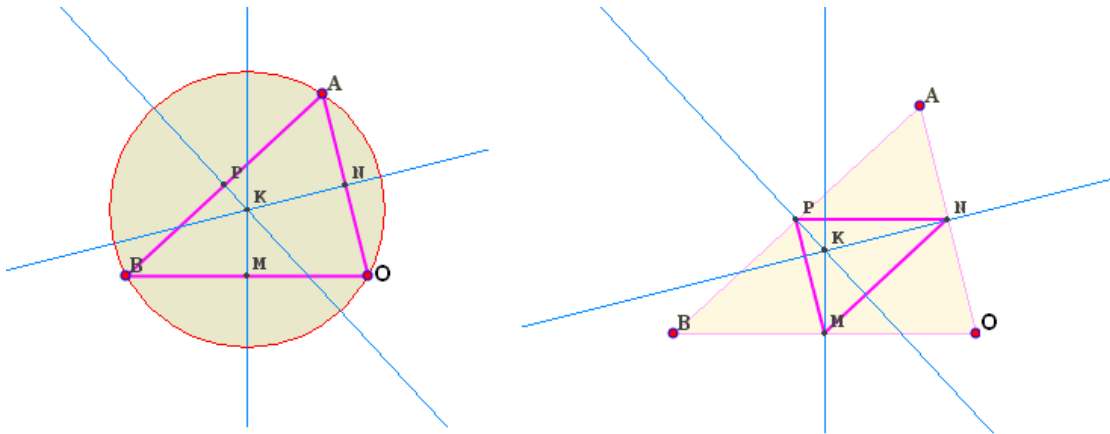
leading to  $x = 7,43 + 8,92 k$  } since x must have the value 10.32  $\rightarrow k = 0,32$   
 $y = 4,46 - 14,86 k$  }  $y = 4,46 - 14,86 * 0,32 = -0,32$

Subsequently, the coordinates of circumcenter C are (10.32; - 0.32)

3. Radius of the circumscribed circumference, which is the distance between points C (10.32; - 0.32) and O (0.0).

$$R = CA = \sqrt{(10,32 - 0)^2 + (-0,32 - 0)^2} = 10.3243$$

An alternative method, which is followed in this study, consists in calculating the intermediate points of the sides of the triangle drawn using the measurements of the hand and later finding the orthocenter (k) of the inner triangle resulting from these points as revealed by Figure 10.



**Figure 10.** Calculation method for the orthocenter (K) of the triangle drawn using the measurements of the hand.

Because both triangles OAB and MNP are similar, with a similarity reason of two, it is found that the distance from point M to the orthocenter K is half the distance between A and H, where H is the orthocenter of the first triangle OAB.

Therefore, the perpendicular vertex to AB ( $\perp AB$ ) alongside the cartesian results of  $BO \cdot OA$  and  $(\perp AB) \cdot OA$  are calculated:

$$\text{Coordinates} \quad \left\{ \begin{array}{l} BO (O_x - B_x, O_y - B_y) \\ OA (A_x - O_x, A_y - O_y) \\ AB (B_x - A_x, B_y - A_y) \end{array} \right.$$

Subsequently, the scalar product of  $CO \cdot OA$  and the perpendicular vertex of  $\perp AB$  are calculated:

$$CO \cdot OA = CO_x \cdot AB_x + CO_y \cdot AB_y$$

Coordinates of  $\perp AB (-AB_y, AB_x)$

This information help calculate the scalar product:

$$OA \cdot (\perp AB) = OA_x \cdot \perp AB_x + OA_y \cdot \perp AB_y$$

These vertexes allow to calculate the coordinates of the circumcenter:

$$C_x = 0.5 \cdot (A_x + B_x + ((CO \cdot OA \cdot \perp AB_x) / (OA \cdot \perp AB)))$$

$$C_y = 0.5 \cdot (A_y + B_y + ((CO \cdot OA \cdot \perp AB_y) / (OA \cdot \perp AB)))$$

After determining the coordinates of the circumcenter for the triangle OAB, the quadrant arc CA with the same measurement as CO and CB is calculated.

This quadrant arc CA will be the numerator of the desired index  $I$ .

The following operation is used to determine its value:

$$CA = \sqrt{(Cx - Ox)^2 + (Cy - Oy)^2}$$

B. Using the second calculation method:

The vertexes BO, OA and AB are established:

BO (-20.63; 0.00)  
 OA (14.86; 8.92)  
 AB (5.77; -8.92)

The vertex perpendicular to ( $\perp$  AB) and the cartesian products of BO•OA and  $\perp$  AB. OA are determined:

$\perp$  AB (8.92; 5.77)  
 BO•OA = -306.56  
 $\perp$  AB. OA = 6.18

Finally, the coordinates of the circumcenter will be (10.32; -0.32), which results in a quadrant CA of 10,3243.

The central value of the ball size within its women's youth category (age 8 to 14) is 51 cm resulting in a quadrant CE = 51/4=12.75.

Therefore, the desired hand coverage index expressed in percentage is:

$$I = \frac{CA}{CE} = \frac{10.3243}{12.75} * 100 = 80.97\%$$

This reveals a hand coverage index of 0.8097 for the female youth (age 8 to 14) handball player in the previous example.

This illustration is a proof that the formula is applicable to other cases in future research projects such as comparative studies based on age, gender and the category of athletes in different sports.

The required discussion stage was not developed due to a lack of literature about this research topic.

## CONCLUSIONS

This study achieved its main goal since it contributed to the design of a procedure as well as the production and application of an original and innovative formula which allows experts to determine the "Hand Coverage Index P.O.S.", in other words, the amount of regulated ball surface that any athlete within the corresponding sport category would be capable of covering with the dominant hand fully open when catching it. That measurement is expressed in percentage in relation to half the sphere of that ball and only required four pieces of data, three linked to the athlete's hand and one with the official size

of the ball, for it to be calculated.

In fact, this study a valuable contribution to the scientific community within the field of physical activity and sport. It paves the way for new projects allowing more research into sports where adaptation of the ball and its handling are crucial for sport performance and, above all, because it helps to adjust and balance possible differences in the proportion between women and men's ball sizes in the same sport category.

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