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JUSTIFYING CHANGES TO WOMEN'S HANDBALL SIZE BASED ON SCIENTIFIC FINDINGS: THE "BALL COVERAGE INDEX" ANALYSIS

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Abstract

The anatomical and performance traits of 2000 handball players—1200 men and 800 women—across a range of age groups are investigated in this research. The average lengths between toes and the Ball Coverage Index are the two main measurements that the study focuses on, and it offers insights into how these characteristics vary by age and sex. The findings demonstrate that female players had lower C.I.B. scores in all age groups, with the largest difference shown in the under-16 group, while male players often have bigger foot dimensions, especially in the thumb-little finger and thumb-middle finger measures. Furthermore, performance indicators drop with age for both sexes, emphasizing the importance of skill development in addition to physical growth. These results highlight the necessity for specialized training plans and gear that take into account the anatomical variations between male and female players in order to improve performance and promote inclusion in the handball community.

Keywords: *Handball, anatomical characteristics, Ball Coverage Index, foot dimensions, gender differences, performance metrics, training programs*.

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1. INTRODUCTION

Women's handball has evolved over time, with notable improvements in ability and strategy as well as increased participation and competitiveness. The size of the handball used in women's events is one important component of the game that hasn't changed in line with these advancements. Handball sizes have historically been created using a one-size-fits-all methodology, often ignoring the anatomical variations between male and female players. This mistake may have an adverse influence on a player's ball handling and control skills, especially in high-pressure situations.

These inequities have been brought to light by recent scientific studies, especially via measurements like the Ball Coverage Index. A player's ability to control the ball in relation to their hand size, grip strength, and other physical characteristics is measured by the C.I.B., which offers an evidence-based method for determining the appropriateness of equipment. Research has repeatedly shown that when utilizing conventional ball sizes, female players struggle to achieve the same degree of ball control as their male counterparts because of their typically smaller hands. The need of changing the ball size in women's handball to better fit the physical attributes of female players has been brought up by these results and has prompted an important discussion.

This conversation seeks to guarantee that women are not only competing at their fullest capacity but are also provided with the resources they need to succeed by using scientific facts. Women's handball might benefit from improved performance, more inclusion, and general sport development if a smaller ball is used. The groundwork for a more thorough examination of the rationale for changing the size of the ball, its effects on play, and its possible advantages for women's handball is laid by this introduction.

2. LITERATURE REVIEW

García-Sánchez, C., et.al., (2022).demonstrated that all outer burden factors had bigger outright qualities for players with longer match playing time ($p < 0.001$; extremely tremendous impacts),

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except for HSR, where just wings had higher qualities in view of how much time played ($p < 0.001$; extremely huge impacts). Whenever the outer burden levels were adapted to the viable playing time, the abberations between the playing time bunches disappear ($p > 0.05$). Wings, autonomous of playing time, covered more HSR/minutes with respect to playing positions than different positions ($p < 0.05$; significant effects). Moreover, in the high playing time bunch, moves beat wings with regards to ACC/minutes, while in the low playing time bunch, backs outflanked turns ($p < 0.05$, moderate impacts). Besides, in the short playing time bunch, moves outflanked wings in DEC/minutes ($p < 0.05$, moderate impacts). Subsequently, handball trainers ought to consider playing time a helpful instrument for expanding the dispersion of week after week stacks.

Dallegrave, E. J., et.al., (2024). Examine the chances of a Brazilian professional women's handball team succeeding in attacking circumstances. Utilizing a quantitative, descriptive, and case study methodology, a professional women's handball team with both national and international accomplishments was the subject of the research. The Handball Observation System, which was used for data gathering, made it possible to examine 726 game actions from the two target competitions—the global and national—of which there were 143 for the Women's Super-Globe and 583 for the national handball league. The data was examined using the SPSS 23.0 software and the Lince application, which aids in multinomial regression and optimizes data verification while analyzing video (games from various sports). According to the findings, the team's chances of scoring were 10.538 higher while using simple tactical means as opposed to 1-on-1 actions (CR = 1.061) and sophisticated tactical methods (CR = 1). The offensive organization shown higher odds (OR = 1.668) of scoring while using the whole squad, when attacking from smaller than 9-meter-squared areas in the middle of the court (OR = 1.917), and when taking shots between 21 and 40 minutes (OR = 1.393). Additionally, when the side used simple tactical attacks, the opposition goalkeeper had 7.968 more opportunities to make a save and 2.562 more opportunities to block a shot between minutes 21 and 40.

Piovesan, C. C., et.al., (2020). Indirect observation of the match recordings was used for analysis. The three final-place handball world championship teams' twenty-five matches were

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watched, and data on the court placements and numerical situations (equality, superiority, and inferiority) throughout the assaults was gathered. The findings revealed that 80.6% of the goals occur in numerical equality, and 57.6% of the shots were goals achieved. In 264 goals, or 55.2% of the total, Brazil scored. Norway scored 58.7% (193 goals) while France scored 59.6% (238 goals). In terms of goals scored, there are also variations between the numerical condition and the goalpost's distance; however, neither the numerical condition nor the regions of the court, nor the goals scored and the numerical condition of each side, showed any disparities. The results show that the number of players and the court's location during female handball matches might affect shots, making them crucial factors that coaches and teams should consider before the season begins. Comprehending this correlation is also crucial for training and game design organization. The factors under study illustrate the core concept of the winning team's game model, which is crucial to comprehending objectives and winners in handball matches.

Garcia-Sanchez, C., et.al., (2024). Analyze and contrast the effects of the match's final score—close, balanced, and unbalanced—on the physical demands made during official women's handball matches. You should also look into whether the final score has an impact on the physical demands of each playing position. Throughout 13 authority matches, 22 female semi-proficient players from the Spanish second Division were noticed. Utilizing a nearby situating framework (WIMU PROTM, Realtrack Frameworks S.L., Almería, Spain), the accompanying measurements were estimated: all out distance, rapid running, extreme focus slowing down distance, speed increases, decelerations, and player load (PL). The information was accumulated in outright and relative qualities. The varieties between playing positions and coordinate sorts were surveyed utilizing a two-way ANOVA with halfway estimated time of arrival squared and Cohen's d. Close matches (13.1±2.8 n·min−1) evoked lower DEC/min than imbalanced (16.4±4.1 n·min−1) and adjusted (15.2±3.8 n·min−1) matches ($p<0.05$, significant impacts).

Gómez-López, M., et.al., (2024). The reason for this study was to think about the spatial hostile execution records of laterality and profundity as per player orientation, considering the complete number of tosses made by the completing region. The concentrate likewise planned to complete an engaging examination of the key presentation factors of public groups that contended in the

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Men's (Germany-Denmark 2019) and Ladies' (Germany 2017) senior handball World Cups. In view of the complete number of tosses made in 192 games for men and 154 games for ladies by 48 public groups from 33 countries that have contended in past World Cups, a narrative examination was led. The Worldwide Handball Alliance (IHF) insights were the wellspring of the information. The middle and shallow parts of the field were where most of shots were taken in both World Cups, as per the information. There were some noticeable orientation incongruities. To be more exact, male groups endeavored significantly more from the left side than did female groups (information), with the last option completing from the right side. Men's groups frequently finished from the primary hostile line, while ladies' groups completed from the subsequent hostile line, as indicated by the profundity record, in spite of the way that profound hostile zones represented most of executions by orientation.

3. METHODS

3.1. Participants

A sample of 2000 handball players in India—800 women and 1200 men—including individuals from different states and a few senior international players—were used for the research. There were 120 competitors in the senior age category (over the age of 18), 60 of them were female and the other 60 were male. The male players were associated with elite Indian clubs in the top category, including the Indian Handball Federation League, but the female competitors represented national teams from India and nearby nations. This varied representation demonstrates how handball is becoming more competitive in India and represents the growth of the sport on a national and worldwide scale.

Table 1 Shows In Detail The Characteristics Of The Sample.

Characteristics	**N (2000)**	**Sample %**
Sport		
Team Handball	2000	100.00

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Sex		
Women	800	40.00
Men	1200	60.00
Age Category		
Under 14	664	33.20
Under 16	618	30.90
Under 18	598	29.90
Senior (+18)	120	6.00
Sex and Age Category		
Women Under 14	320	16.00
Men Under 14	344	17.20
Women Under 16	240	12.00
Men Under 16	378	18.90
Women Under 18	240	12.00
Men Under 18	358	17.90
Women Senior (+18)	60	3.00
Men Senior (+18)	60	3.00

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3.2. Measure

instrument since we expected to quantify the hands of 2000 handball players in a short measure of time (utilizing different titles set up in a focus framework) and during contest. Still up in the air to utilize a technique that would consider the quick, legitimate, and productive assortment of information.

We used diagram paper scratch pad (100g/m2, A4 size, Guarro brand) with a millimeter network on both the level and vertical surfaces as our information gathering device. Furthermore, BIC brand ballpoint pens (fine point: 0.8mm, line width 0.4mm) and millimetered rules were utilized to guarantee most extreme estimation accuracy. Every athlete always utilized a table with graph paper spread out on it and their dominant hand with the palm fully exposed on the paper.

3.3. Procedure

We then felt free to make the accompanying moves: First, measure from an external perspective of the thumb's distal phalanx to the beyond the little finger's distal phalanx. A subsequent estimation ought to be taken between the beyond the thumb and the beyond the center finger's distal phalanx. The third estimation is made between the beyond the little finger's and center finger's distal phalanxes. The palm was fully exposed while taking these measurements. In order to analyze the data and make inferences based on sex and age group, we took these three measurements, calculated the means of each, and computed the coverage index of each athlete's hand as well as the means of each age group. In short, the following is an overview of the steps used to find and compute the "ball coverage index": The athlete's hand's three measurements triangulate in the plane before being translated to the space environment. We position the distal phalanx of the thumb (point O), the middle finger (point A), and the little finger (point B), as shown graphically in Figure 1. We utilize these points since that's how we're going to characterize an athlete's claw when they adjust the ball.

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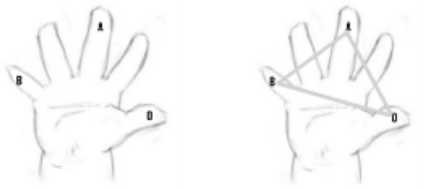

Figure 1. Points To Determine Athlete's Claw.

We might find an inside point, C, that addresses the circumcenter of the triangle OAB by utilizing these three estimations (OA, OB, and Stomach muscle) and their directions in the Cartesian pivot and its opposite bisectors. As displayed in Figure 2, the circumcenter, or point C, is where the three triangle bisectors cross and the focal point of the circumcircle that decides the ball's hold region.

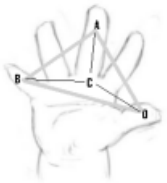

Figure 2. Circumcenter (C) Is Where Three Triangle Bisectors Meet. The Circumcircle Center Determines The Ball's Grip.

As displayed in Figures 3 and 4, we take the circumcenter to the distances CA, CB, and CO are equivalent. From that point, we might get the ball by being at its shaft, and the focuses O, A, and B will characterize a not-most extreme periphery and a lined up with the ball Ecuador.

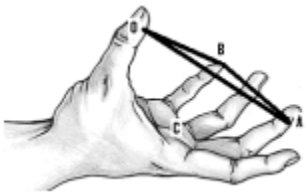

Figure 3. The Circumcenter (C) Is At The Ball's Pole, And O, A, And B Establish A Non-Maximum Circumference Parallel To Ecuador.

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The inclusion % of the player's hand over the ball according to the authority wad of his sex and age not entirely settled by the distance CA concerning the distance CE (quadrant of the ball's perimeter). Thus, the file I is figured to learn in the event that there are varieties in the level of ball inclusion for each age bunch in light of sex:

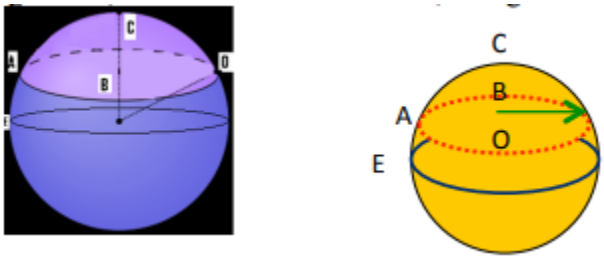

Figure 4. The Circumcenter (C) Is At The Ball's Pole, And O, A, And B Establish A Non-Maximum Circumference Parallel To Ecuador (Dashed Line In Images).

For instance, the ball's grasp points are represented by the first three triangle vertices (O, A, and B), which are located on the dotted line's perimeter and the ball's circumcenter (C) (Figure 4). The extent of the quadrant that the player's hand covers from (C) to the cutting point with the boundary focuses approaches the span of this triangle's circumcircle. Ultimately, the proportion of the extent of the quadrant (CA) to the entire quadrant ball (CE) is the ball inclusion file. Thusly, the length of the meridian quadrant of the area the hand covers corresponding to the absolute is utilized to decide the inclusion file of the player's hand over the ball.

4. RESULT AND DISCUSSION

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

Table 2. Averages Of All Toe-To-Toe Distance Measurements Broken Down By Age And Gender

Age Category	Sex	N	Thumb-Little Finger (Mean cm)	Thumb-Middle Finger (Mean cm)	Middle-Little Finger (Mean cm)

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Under 14	Women	320	19.84	16.31	10.01
	Men	344	20.93	16.95	10.20
Under 16	Women	240	20.06	16.52	10.06
	Men	378	21.63	17.86	10.29
Under 18	Women	240	19.69	16.28	9.71
	Men	358	21.88	17.93	10.41
Senior (+18)	Women	60	19.57	15.49	9.83
	Men	60	21.94	17.56	10.47

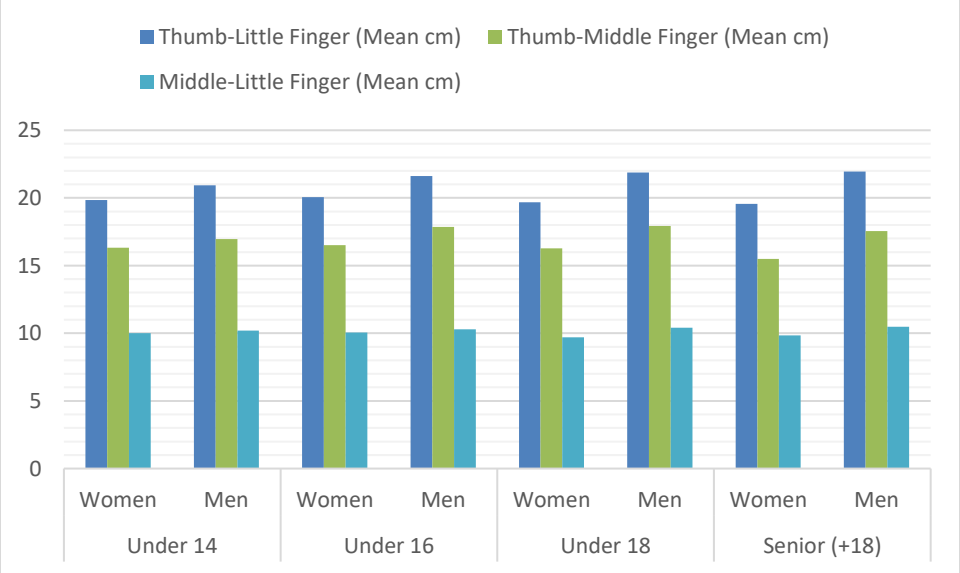

Figure 5: Averages Of All Toe-To-Toe Distance Measurements Broken Down By Age And Gender

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The findings shown in Table 3 are obtained by applying the ball coverage index calculation (described above) to the data in Table 2.

The typical distances between each toe for handball players are shown in Table 2, broken down by age and gender. The data shows that, across age groups, there are significant disparities in toe measurements between men and women. Boys have longer average distances in the thumb-little finger and thumb-middle finger comparisons in the under-14 age group, for example, indicating that male players may have bigger foot dimensions at a younger age. Men regularly show larger distances than women do, especially in the thumb-little finger measure. This pattern extends into the older age groups. Toe distance disparities seem to level out as athletes become older, but they still show a noticeable disparity, particularly in the senior division where both genders have shorter average lengths than in the younger division. This may suggest that male and female growth trends and foot development vary, which might affect how well a shoe fits and performs in athletic footwear. The findings highlight the need of specialized gear and training regimens that take into account these anatomical variations in order to maximize player performance and lower the risk of injury.

Table 3. Ball Coverage Index Broken Down By Age Group And Sex

Age Category	**Ball Size Used (cm)**	**Ball Coverage Index (%)**	
		Women	**Men**
Under 14	51 cm	78.30	77.05
Under 16	55 cm	73.40	79.43
Under 18	55 cm	72.16	75.03
Senior (+18)	55 cm	72.11	75.60

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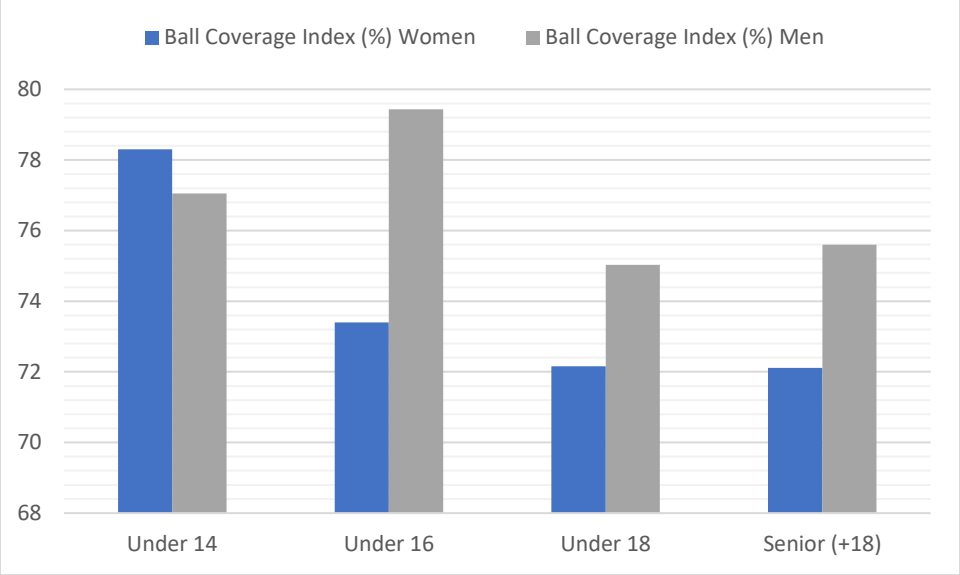

Figure 6: Ball Coverage Index Broken Down By Age Group And Sex

The Ball Coverage Index for handball players is shown in Table 3 and indicates how well players handle and control the ball depending on its size. The data shows that, in general, women have a lower C.I.B. than males do in all age groups, with the under-16 group showing the largest difference. This disparity could draw attention to variations in grip strength or hand size, which might have an impact on gaming performance. It's interesting to note that although men have a greater C.I.B. overall, as both sexes advance through the age groups, the index declines, indicating that experience and technique may be important variables in ball handling efficacy. For example, the drop in C.I.B. from the under-14 to senior categories may be due to increasing specialization and skill development, which might counteract the benefits of larger stature. Overall, the results from the two tables highlight how crucial it is to teach and develop handball players while taking both anatomical and performance elements into account. Enhancing player effectiveness and fostering a more inclusive athletic environment may be achieved by customizing training methods and equipment to account for these variations.

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5. CONCLUSION

The research offers insightful information on the performance and anatomical traits of handball players in different age and sex groups. The results show a substantial variation in toe measures, indicating that male athletes often have bigger feet, which may have an impact on their comfort and effectiveness in the game. The Ball Coverage Index also shows that women often score lower than males, which may indicate differences in grip strength and ball-handling abilities. Both charts highlight the value of technique and skill development over pure physicality by showing a fall in performance measurements as athletes become older. These findings highlight the need for specialized training plans and gear that take into account the unique physical characteristics and developmental requirements of male and female athletes. Stakeholders may improve player efficacy, encourage inclusion in the game, and eventually support the development and level of competition of handball at all levels by addressing these inequalities.

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