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original article

Anthropometric, morphological and somatotype characteristics of athletes of the Brazilian Men's volleyball team: an 11-year descriptive study

Características antropométricas, morfológicas e somatotípicas de atletas da seleção brasileira masculina de voleibol: estudo descritivo de 11 anos

Edio Luiz Petroski[1]
Jefferson Del Fraro[2]
Yara Lucy Fidelix[1]
Diego Augusto Santos Silva[1]
Cândido Simões Pires-Neto[3]
Antônio Carlos Dourado[4]
Marcos Augusto Rocha[4]
Luiz Cláudio Reeberg Stanganelli[4]
Percy Oncken[5]
Filomena Soares Viera[2]

Abstract – This study analyzed the anthropometric and morphological characteristics of the adult male players in the Brazilian volleyball team for 11 years. The sample comprised 92 athletes selected for the national team from 1995 to 2005. Anthropometric measures were collected and body composition and somatotype components were estimated. One-way ANOVA and the Bonferroni test were used for descriptive statistical analysis, and the level of significance was set at $p<0.05$. Along the 11 years, there was a significant increase in the flexed arm perimeter, humerus diameter and lean mass. Skinfold thickness and percent body fat tended to decrease. Height increased and was greater than 1.97 m. The somatotype of the volleyball players in the Brazilian team changed along the years. Ectomorphic and mesomorphic somatotypes were the most frequent. In 11 years, the athletes selected for the Brazilian team had an increase in body mass and a decrease in skinfold thickness and percent body fat. The most frequent anthropometric classifications were mesomorph-ectomorph for five years, followed by mesomorphic-ectomorph for three years, which suggests that taller athletes and those with a low body fat percentage were more frequently selected for the national team.

Key words: Athletes; Body composition; Sports; Skinfold; Somatotype; Volleyball.

Resumo – *O presente estudo teve por objetivo analisar, no período de 11 anos, as características antropométricas e morfológicas de atletas da seleção brasileira masculina de voleibol. A amostra foi composta por 92 atletas convocados entre os anos de 1995 a 2005. Foram coletadas medidas antropométricas e estimados valores de composição corporal e componentes do somatotipo. Para a análise dos dados usou-se a estatística descritiva, a ANOVA one-way e Bonferroni, com significância de $p<0,05$. Ao longo dos 11 anos, houve aumento significativo nos perímetros do braço contraído, no diâmetro do úmero e na massa livre de gordura. Além disso, a espessura de pregas cutâneas e o percentual de gordura tenderam a diminuir. Estatura elevada foi uma característica presente ultrapassando na média 1.97 m. O somatotipo dos atletas da Seleção Brasileira modificou-se ao longo dos anos. As configurações mais presentes nos atletas foram a ectomorfismos e mesomorfismo. Conclui-se que, ao longo dos 11 anos, os atletas selecionados apresentaram um aumento da massa muscular, diminuição na espessura das pregas cutâneas e no percentual de gordura. As classificações antropométricas mais frequentes foram: Mesomorfo-ectomorfo durante cinco anos, seguida da classificação meso-ectomorfo com três anos. Sugerindo que nas convocações dos atletas, a estatura elevada e o baixo componente de gordura corporal foram considerados.*

Palavras-chave: *Atletas; Composição corporal; Esporte; Gordura subcutânea; Somatotipo; Voleibol.*

1 Federal University of Santa Catarina. Centre for Research in Kinanthropometry and Human Performance. Florianópolis, SC. Brazil

2 Univ Tecn Lisboa, Fac Motricidade Humana, CIPER, LBMF, P-1499-002 Lisbon, Portugal

3 Faculdades Integradas Superior Vale do Iguaçu. Curso de Educação Física. União da Vitória, PR. Brasil.

4 Universidade Estadual de Londrina. Centro de Educação Física e Desportos. Londrina. PR. Brasil.

5 Universidade Estadual de Londrina. Confederação Brasileira de Voleibol. Londrina, PR. Brasil

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INTRODUCTION

In contemporary volleyball, athletes should have highly developed defensive and attack skills, as well as great agility, reaction time and explosion force, all allied to height. The positive results obtained by both junior and adult Brazilian national volleyball teams gave Brazil an outstanding position in the international sports scenario.

Characteristics such as height[1-3], associated with an ectomorphic mesomorph somatotype[4,5], contribute to greater movement amplitude in attack and block actions during a volleyball game and ensure better performances for the team[3].

The identification and selection of talented players from the base categories make it possible to prepare athletes capable of meeting the requirements of the adult categories, as well as to understand the technical and morphological requisites for inclusion and permanence in the previous categories[6-8].

The description of athlete morphology may lead to the development of training programs specific for each physical characteristic, which are different between sports and playing actions. Somatotypes describe the differences between athletes in the same sport according to adiposity, musculoskeletal robustness and linearity[6].

Several studies found differences in morphological components of athletes in different sports and modalities[2,4,9-12] but few studies have characterized the morphological components of volleyball players selected for successive championships.

A search in the main databases (PubMed, Scopus, Scielo) for publications up to January 2013 did not yield any studies that followed up a competitive team for a long time and evaluated the morphological changes that occurred along the years. This study analyzed anthropometric, morphological and somatotype characteristics of male volleyball players in the Brazilian national junior team during 11 years.

METHODS

Study participants

This descriptive study used data collected from the evaluations made in the Network of Sport Excellence Centers (*Rede de Centros de Excelência Esportiva*, CENESP) of Londrina, Brazil, during 11 years.

The study enrolled 92 male athletes of the Brazilian junior volleyball team from 1995 to 2005 who participated in South American and World Championships. In the even-numbered years (1996, 1998, 2000, 2002 and 2004), there was preparation for and participation in South American championships, and in the odd-numbered years (1995, 1997, 1999, 2001, 2003 and 2005), preparation for and participation in World Championships. Of the athletes, 38 were selected and evaluated more than once, that is, they participated in two or more championships as part of the Brazilian team. Therefore, 130 evaluations were made along 11 years.

The best results of the Brazilian junior team in the competitions that they participated were: first place in the World Championships of 1995, 2001 and 2003. In 1997, the team was 5th, in 1999, 7th, and in 2005, 2nd. In the South American championships, the team was the champion in all the years under study.

Variables under analysis

Anthropometric data were collected using standardized criteria[13]. Height was measured using a stadiometer to the nearest 0.1 mm. Body mass was measured using a 180-kg digital scale to the nearest 50 grams. The scale was calibrated after each 10 uses. Skinfolds were measured using a CESCORF caliper, which had an oblong contact surface, constant independent pressure of 10 g/mm2 and reading to the nearest 0.1 mm. Three measurements were made for each skinfold, and the intermediate or repeated value was recorded. Flexed arm perimeter at the largest perimeter under maximum voluntary contraction and the calf perimeter were measured using a non stretchable anthropometric tape to the nearest 0.1 cm. The humerus and femur diameters were measured using a Mitutoyo pachymeter to the nearest 0.1 mm.

The Carter-Heath[5] equations were used to calculate the components of endomorphic, mesomorphic or ectomorphic somatotypes.

Body fat was analyzed in two ways: fat mass (FM, kg) and lean mass (LM, kg), using the sum of five skinfold measurements (triceps, subscapular, suprailiac, abdominal and mid calf). Body mass was calculated using: (1) the Durnin and Womersley equation[13] to determine body density [*Bd = 1,1555-0,0607* log (triceps + subescapular + suprailiac)*]; (2) the transformation of the Bd value into %BF using the following equation: *%G = [(4,99/Bd) – 4,55] * 100* (Heyward & Stolarczyk[14]); the equation described by Slaughter et al.[15] was also used; and (3) *%G = 0,735* (triceps + calf)*. The final %BF value was the mean of equations (2) and (3). FM was calculated using the following equation: *FM = (BM * %BF)/100*. LM was calculated as the difference between BM and FM.

Statistical analysis

The SPSS 18.0, 2009 (SPSS Inc., an IBM Company, Chicago) was used for statistical calculations. Results of statistical analyses were described as means and standard deviations. Anthropometric variables and body composition were compared using one-way ANOVA and multiple Bonferroni comparisons. The level of statistical significance was set at 5%.

RESULTS

In each of the 11 years under study, 11 or 12 athletes (N=13) were selected for the World and South American championships. Their mean ages ranged from 16.5±0.4 to 18.1±0.4 years. Mean ages and standard deviations according to year were: 17.0±0.3 years in 1995 (n=11), 16.7±0.2 years in 1996 (n=12), 17.5±0.7 years in 1997 (n=12), 16.5±0.4 years in 1998 (n=12), 18.1±0.4

years in 1999 (n=12), 16.7±0.4 years in 2000 (n=12), 17.9±0.4 years in 2001 (n=11), 16.8±0.5 years in 2002 (n=12), 17.8±0.6 years in 2003 (n=12), 16.7±0.5 years in 2004 (n=12) and 17.7±0.7 years in 2005 (n=12).

Mean values and standard deviations for anthropometric variables of body composition and somatotype components are described in Table 1. Along the 11 years, there was a significant increase in the flexed arm perimeter, humerus diameter and lean mass. In addition, skinfold thickness and %BF tended to decrease. Increased height was a major anthropometric characteristic of the teams, and mean height was greater than 1.97 m.

The somatotype of the volleyball players in the Brazilian team changed along the years, and the most frequent were ectomorphic and mesomorphic (Table 1).

Table 1. Means and standard deviations of age, anthropometric and morphological characteristics and somatotype of male volleyball players of the Brazilian national team (1995-2005)

Variables	1995 (n=11)	1996 (n=12)	1997 (n=12)	1998 (n = 12)	1999 (n=12)	2000 (n=12)	2001 (n=11)	2002 (n=12)	2003 (n=12)	2004 (n=12)	2005 (n=12)
	μ(SD)	μ(SD)	μ(SD)	μ(SD)	μ(SD)	μ(SD)	μ(SD)	μ(SD)	μ(SD)	μ(SD)	μ(SD)
BM (kg)	84.3 (5.1)	81.1 (9.3)	83.5 (7.4)	83.0 (6.1)	85.3 (6.2)	86.8 (5.3)	91.0 (5.6)	85.2 (8.9)	86.3 (6.4)	87.3 (11.5)	90.3 (13.0)
Height (cm)	194.4 (6.2)	195.1 (6.8)	195.6 (6.5)	195.6 (6.0)	196.1 (6.7)	197.6 (6.4)	197.6 (5.8)	196.8 (4.5)	197.4 (3.9)	195.4 (8.1)	197.0 (8.0)
BMI (kg/m²)	22.3 (1.6)	21.3 (2.5)	21.8 (1.5)	21.7 (0.9)	22.2 (1.1)	22.2 (1.2)	28.2 (1.6)	22.0 (2.2)	22.1 (1.6)	22.8 (1.8)	23.2 (2.3)
Perimeters (cm)											
Flexed arm	32.3 (1.5)	30.9 (2.1)	32.0 (1.9)	32.1 (1.2)	34.0 (2.0)†	33.3 (1.4)	34.4 (2.0)†	32.0 (2.8)	33.2 (2.1)	32.7 (2.3)	35.0(2.3) ††‖††
Calf	38.6 (2.1)	38.1 (3.2)	37.5 (1.6)	37.2 (1.6)	38.0 (2.3)	39.1 (1.4)	39.6 (2.0)	38.8 (3.0)	38.6 (2.0)	39.3 (2.4)	39.5 (2.7)
Diameters (cm)											
Humerus	6.9 (0.4)	7.1 (0.4)	7.2 (0.4)	7.4 (0.3)	7.4 (0.3)	7.6 (0.4)*	7.6 (0.4)*	7.2 (0.5)	7.5 (0.4)*	7.2 (0.3)	7.5 (0.4)*
Femur	10.0 (0.5)	10.2 (0.5)	10.2 (0.4)	10.5 (0.2)	10.5 (0.3)	10.4 (0.5)	10.3 (0.4)	10.5 (0.5)	10.2 (0.3)	10.2 (0.5)	10.2 (0.3)
Skinfolds (mm)											
Triceps	10.5 (4.5)¶**	10.6 (2.6)¶**	9.6 (2.4)	8.3 (2.1)	9.2 (2.1)	7.1 (2.2)	6.9 (1.7)	8.3 (1.6)	7.8 (1.5)	7.7 (1.2)	7.9 (1.3)
Subscapular	10.5 (1.6)**	10.8 (2.8)‖¶**	10.1 (1.9)	8.6 (1.3)	8.4 (2.2)	8.3 (1.2)	8.1 (0.9)	8.9 (1.2)	8.6 (1.3)	8.8 (1.3)	9.0 (1.4)
Suprailiac	8.3 (2.3)	17.1 (7.9) *‖¶**‡‡§§‖‖	12.6 (3.7)	11.8 (4.0)	11.5 (3.1)	10.1 (3.0)	9.3 (2.9)	12.5 (3.6)	10.6 (2.2)	10.1 (2.4)	11.4 (3.5)
Abdomen	11.7 (4.0)	15.5 (6.3) §¶**††‡‡§§‖‖	13.2 (4.1)¶**	10.2 (3.1)	11.3 (2.6)	8.3 (2.7)	7.2 (1.2)	9.8 (2.1)	9.3 (1.5)	9.9 (2.1)	10.7 (2.9)
Calf	9.7 (3.4)¶**‡‡	11.3 (2.8) §‖¶**††‡‡§§‖‖	9.1 (2.3)**	7.3 (1.8)	7.7 (1.3)	6.5 (1.6)	5.7 (1.0)	7.6 (1.8)	6.3 (1.6)	7.0 (1.8)	7.3 (1.7)
Σ 5 Bd	50.5 (13.4)	65.3 (19.3) *§‖¶**††‡‡§§‖‖	54.7 (10.7)¶**	46.2 (10.1)¶**	48.1 (7.6)	40.3 (9.3)	37.2 (5.8)	47.0 (7.3)	42.7 (5.5)	43.6 (6.5)	46.2 (8.5)
Body composition											
%BF	14.2 (3.9)**	16.3 (3.4) §¶**††‡‡§§‖‖	14.3 (2.4)**	12.4 (2.6)	13.0 (1.9)	11.0 (2.5)	10.4 (1.8)	12.8 (1.9)	11.7 (1.4)	11.8 (1.5)	12.3 (1.8)
FM (kg)	12.0 (3.8)	13.4 (3.6)¶**	11.9 (2.2)	11.2 (2.0)	13.0 (1.9)	9.6 (2.6)	9.5 (2.0)	10.9 (2.3)	10.1 (1.7)	10.4 (2.3)	11.2 (2.8)
LM (kg)	72.3 (4.2)	67.7 (7.2)	71.6 (6.9)	74.1 (5.3)	11.2 (2.0)	77.1 (3.9)†	81.5 (4.5)†‡	74.3 (7.2)	76.2 (5.4)	76.9 (9.7)	79.1 (10.6)†
Somatotype											
Endomorphic	2.6 (0.8)	3.4 (1.1) §¶**‡‡§§‖‖	2.9 (0.7)	2.5 (0.5)	2.5 (0.5)	2.1 (0.5)	2.0 (0.5)‡	2.6 (0.5)	2.3 (0.3)	2.3 (0.4)	2.4 (0.4)
Mesomorphic	2.9 (1.1)	2.7 (1.2)	2.9 (0.9)	3.7 (1.1)	3.7 (1.1)	3.7 (0.8)	3.9 (0.9)	3.2 (1.2)	3.4 (1.1)	3.5 (0.8)	3.9 (1,0)
Ectomorphic	3.9 (1.0)	4.5 (1.6)	4.2 (0.9)	4.1 (0.7)	4.1 (0.7)	4.1 (0.8)	3.6 (0.8)	4.2 (1.1)	4.2 (0.9)	3.7 (0.8)	3.7 (1.0)
Somatotype category	Balanced ectomorphic	Endo-ecto-morphic	Balanced ectomorphic	Mesomorph-ectomorph	Mesomorph-ectomorph	Mesomorph-ectomorph	Mesomorph-ectomorph	Mesomorphic-ectomorph	Mesomorphic-ectomorph	Mesomorph-ectomorph	Mesomorph-ectomorph

μ = mean; SD = standard deviation BM = Body mass; BMI _ body mass index FM = fat mass; LM = lean mass *Difference from 1995 (p<0.05); † Difference from 1996 (p<0.05); ‡ Difference from 1997 (p<0.05); § Difference from 1998 (p<0.05); ‖ Difference from 1999 (p<0.05); ¶ Difference from 2000 (p<0.05); ** Difference from 2001 (p<0.05); †† Difference from 2002 (p<0.05); ‡‡ Difference from 2003 (p<0.05); §§ Difference from 2004 (p<0.05); ‖‖ Difference from 2005 (p<0.05).

Figure 1 shows that the mean somatotype of 130 measurements of athletes in the 11 years was mesomorphic-ectomorph (2.5-3.3-4.1). The most prevalent somatotype characteristics during the 11 years under analysis were mesomorph-ectomorph and mesomorphic-ectomorph, as shown in Figure 1.

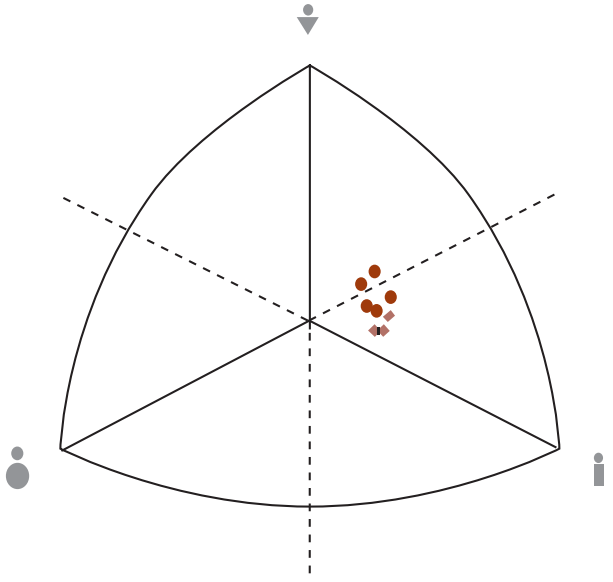

Figure 1. Most prevalent somatotype among junior athletes (1995-2005).
Where: ● = mesomorph-ectomorph; ◆ = mesomorphic-ectomorph

DISCUSSION

The main findings in this study showed that there was an increase of the components associated with lean mass and a decrease of variables associated with body fat in the 11 years under study. Moreover, ectomorph was the most frequent somatotype component in nine athlete selections.

The athletes in our study underwent specific changes along 11 years, possibly explained by recruiting and improvement of technical training. These changes resulted not only from the capacity of individuals to adapt, but also from the effect of the training programs, which promote more efficient actions and produce more rapid responses of upper and lower extremities[16].

The sport became faster, actions now have a shorter duration, the game rhythm has intensified and the involvement of the anaerobic component during the match has increased. To follow these advances, elite volleyball athletes must develop their muscles to increase their jumping capacity and their efficiency in decisive moments[17].

During the time of this study, there were significant morphological changes in LM, which increased in 20.4%, and in FM and %BF, which decreased in 20.2% and 36.2%. At the same time, body adiposity (sum of the five skinfold measurements in mm) decreased 43.04% from 1996 to 2001, whereas there was an increase of 13.2% in the flexed arm perimeter from 1996 to 2005. These changes optimize the actions inherent to volleyball and add power to the most effective actions, such as greater jump capacity

(muscle power), greater power of contact with the ball and advantages in block height and hits.

In general, the changes in mean height along the 11 years, after which it reached 1.97m, were a major characteristic of the sample, and 11 and 12% body fat were the most prevalent percentages (Table 1). In the 11 evaluations, the highest relative %BF reduction (-36.2%) occurred between 1996 e 2001. At the same time, BM increased 13.3% between 1996 and 2005, which reflects the increase of LM, and height increased 1.6% from 1995 to 2000 and 2001. The analysis of bone structure revealed a 10.6% increase in the diameter of the humerus (from 1996 to 2000 and 2001) and of 8.6% in the femur (1998-99 and 2002).

Duncan et al.[6] evaluated junior elite athletes in England according to their position in the court and found that mean muscle mass ranged from 43.4±5.2 kg to 50.9±7.1 kg, and that the hitters and the centers had the greatest muscle mass values. The amount of muscle mass associated with high ectomorphy may be an advantage because endurance in the opposing attack, in the form of blocks, is one of the main concerns during the game[6].

Mean %BF of Brazilian athletes ranged from 10.4 to 16.3% in the 11 years of the study. These values are within the limits for volleyball players, as the recommended %BF values range from 6 to 15%[18]. A comparison with other collective sports reveals that soccer players have about 10%BF, but there may be differences between players depending on their playing position[19]. Brazilian basketball players that participated in the 2003 National League had a mean %BF of 10.3%, and, as in soccer, the values varied according to playing position during the game[20].

The Italian junior team had slightly lower %BF (10.9±1.8 %) and BMI (21.7±1.3 kg/m^2) values than the athletes in our study, but the methods in the two studies were different. Similar but less variable values were found among English junior players: %BF ranged from 11.5±2.2% to 12.9±3.4%, and centers had the lowest %BF, followed by opposites, hitters and setters[6].

Mean somatotype along the 11 years was mesomorphic-ectomorph (2.5-3.4-4.0), which suggests a predominance of linearity over physical robustness. The elevated height and the predominantly ectomorphic profile were the most frequent anthropometric and morphological characteristic of these athletes. Muscle power, fundamentally important for a good performance in volleyball, is confirmed by the actions of the upper extremities during service, hits and blocks, and of the lower extremities, determinant for vertical jumps. These actions characterize muscularity, that is, the second somatotype component, mesomorphy. A similar result was found in the Brazilian junior team of 2000, whose players were classified as mesomorphic-ectomorph and whose somatotype values were 2.0-3.5-4.1[21]. Some studies[6,22] have found a trend towards mesomorphy when comparing with the ectomorphic component. Almagià et al.[4] analyzed the morphological profile of adult players in the Colombian, Paraguayan, Uruguayan and Venezuelan teams and of junior players in the Chilean team, and found an ectomorphic-mesomorphic somatotype.

A study with 12 volleyball players of the Brazilian adult team that participated in the Athens Olympics in 2004 found a mean balanced mesomorphic somatotype (2.6-4.2-2.6)[22]. The analysis of somatotype components of 234 players in the Italian championship (Series A and B) revealed that the mean somatotype was 2.2-4.2-3.2, and the athletes were classified as ecto-mesomorphic. Another important finding was that Series A players had a greater ectomorphic component (2.1-4.1-3.3) than those in Series B (2.3-4.3-2.0), which confirms the need to have athletes with greater linearity and more muscle mass to achieve high performances[9]. The junior athletes evaluated in our study had morphological characteristics that are adequate for volleyball. During the 11 years under study, the most prevalent classification was mesomorph-ectomorph, found in 45.5% of the cases, that is, in 5 of the 11 championships. There was also a trend towards a quantitative decrease of the ectomorphic component and an increase of the mesomorphic component. This may be explained by the fact that athletes are young and, as they advance towards maturity, may undergo morphological changes, which are expected to result in greater musculoskeletal robustness.

Although this study evaluated the characteristics of the male volleyball players in the Brazilian junior team for 11 years, some limitations should be mentioned. First, body composition was evaluated using a doubly indirect method (skinfolds), in which case examiner errors are likely to occur. However, as this is an efficient and affordable method, it has been largely used in scientific studies. Another limitation was the fact that the athletes were not classified according to their playing position, although studies in the literature indicate that somatotype varies according to the player's position[6].

This study has the following positive aspects: (1) 11-year follow-up of elite athletes selected for a Brazilian team with very successful participations in the most competitive international championships; (2) analysis of anthropometric and somatotype components, which may help coaches in different countries in the preparation of the morphological characteristics of elite junior volleyball athletes. Our results add anthropometric and morphological parameters of elite male volleyball players to the data available in international literature.

CONCLUSIONS

During 11 years, the most evident morphological changes among athletes were the increase of muscle mass and the decrease of skinfold thickness and %BF. The most frequent mean somatotype during evaluation was mesomorphic-ectomorph during five years, followed by mesomorph-ectomorph in three years. These findings suggest that morphological characteristics were taken into consideration when selecting tall players with a low %BF. They also show that greater muscle mass is a very frequent component in players characterized by body linearity and who participate in elite competitions.

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Corresponding author

Edio Luiz Petroski
Universidade Federal de Santa Catarina – Centros de Desportos
Núcleo de Cineantropometria e Desempenho Humano
Campus Universitário – Trindade – Caixa Postal 476
CEP 88040-900 – Florianópolis, SC, Brasil.
E-mail: petroski@cds.ufsc.br